Data Analysis: Methods and Results

L Heron

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Results

Proportion of asymptomatic SARS-CoV-2 infections

We included 102 studies that reported empirical data about 22,780 people with SARS-CoV-2 infection (7,264 defined as having asymptomatic infection).

The sex distribution of the people with asymptomatic infection was reported in 25/102 studies, and the median age was reported in 17/102 studies (Table 1).

The overall estimate of the proportion of people who become infected with SARS-CoV-2 and remain asymptomatic throughout the course of infection was 0.25 (95% CI 0.2 – 0.31, 102 studies), with a prediction interval of 0.017 – 0.86 (Fig 1).

Table 1: Characteristics of studies reporting on proportion of asymptomatic SARS-CoV-2 infections

Record ID	Author	Location	Total SARS-CoV-2, n	Asymptomatic SARS-CoV-2, n	Sex of asymptomatic individuals	Age of asymptomatic individuals, median	Follow-up method[a]
122	Luo, L	China, Guangzhou	129	8	NR	NR	
152	Yang, N	China, Flight to Xiaoshan	10	2	1 F 1 M	NR	
170	Chang, L	China, Wuhan	4	2	0 F 2 M	45; IQR 37-53	
224	Arima, Y	Japan	12	4	NR	NR	
242	Danis, K	France	13	1	NR	NR	
249	Wang, Z	China, Wuhan	47	4	NR	NR	
265	Tian, S	China, Shandong	24	7	NR	NR	
294	Lavezzo, E	Italy, Veneto	73	29	NR	NR	
317	Hoehl, S	Germany, Germersheim	2	1	0 F 1 M	58	
354	Park, SY	South Korea, Seoul	97	4	NR	NR	
376	Arons, MM	USA, Seattle, WA	47	3	NR	NR	
396	Schwierzeck, V	Germany, Muenster	12	2	NR	NR	
443	Bi, Q	China, Shenzhen	87	17	NR	NR	
477	Cheng, HY	Taiwan	22	4	NR	NR	
506	Wong, J	Brunei	138	16	NR	NR	
593	Lombardi, A	Italy, Milan	138	41	NR	NR	
597	Wu, J	China, Zhuhai	83	8	NR	NR	
598	Rivett, L	UK, Cambridge	30	5	NR	NR	
599	Hijnen, D	Germany, Munich	11	1	0 F 1 M	49	
622	Treibel, TA	UK, London	44	12	NR	NR	
665	Brandstetter, S	Germany, Regensburg	36	2	NR	NR	
696	Pham, TQ	Vietnam	208	89	NR	31; IQR 23-45	
713	Böhmer, MM	Germany, Bavaria	16	1	NR	NR	
729	London, V	USA, New York City	68	22	22 F 0 M	30.5; IQR 24.5-34.8	
763	Roxby, AC	USA, Washington	6	3	NR	NR	
821	Zhang, W2	China, Guangzhou	12	4	NR	NR	
832	Andrikopoulou, M	USA, New York	158	46	46 F 0 M	NR	
849	Dora, AV	USA, Los Angeles	19	6	NR	75; IQR 72-75	
899	Solbach, W	Germany, Luebeck	97	10	NR	NR	
908	Yang, R	China, Wuhan	78	33	22 F 11 M	37; IQR 26-45	

Table 1: Characteristics of studies reporting on proportion of asymptomatic SARS-CoV-2 infections *(continued)*

Record ID	Author	Location	Total SARS-CoV-2, n	Asymptomatic SARS-CoV-2, n	Sex of asymptomatic individuals	Age of asymptomatic individuals, median	Follow-up method[a]
1003	Graham, N	UK	126	46	NR	NR	
1049	Romao	Portugal, Lisboa	14	0	NR	NR	3
1103	Kennelly	Ireland	869	239	NR	NR	2
1155	Bogani	Italy	19	10	10 F 0 M	NR	3
1159	Alshukry	Kuwait	417	164	78 F 86 M	NR	3
1164	Meyers	USA, Indianapolis	81	58	NR	NR	2
1196	Chamie	USA, San Francisco	83	23	NR	NR	2
1207	Deng	China, Chongqing	61	38	NR	NR	3
1225	Han	China, Wuhan	17	17	8 F 9 M	30; IQR 27-30	2
1232	Patel	USA	35	13	NR	NR	2
1264	Lombardi	Italy	139	17	NR	NR	1
1268	Choi	South Korea, Daegu	568	138	NR	NR	2,3
1293	Borras-Bermejo	Spain	1171	630	NR	NR	1
1335	Pavli	Greece	48	7	NR	NR	1
1349	Pongpirul	Thailand	193	10	5 F 5 M	43; IQR 31.3-56.3	3
1438	Njuguna	USA	98	29	NR	NR	1,2
1440	Lewis, M	USA	64	14	NR	NR	1,2,3
1532	Mei	China, Shanghai	494	31	16 F 15 M	26; IQR 18-55	3
1541	Daniells	Australia, New South Wales	279	19	9 F 10 M	37; IQR 9-83	1
1556	Almazeedi	Kuwait	1096	473	NR	NR	3
1654	Yau	Canada	22	7	NR	NR	2
1714	Lee	South Korea, Daegu	694	80	NR	NR	2
1834	Yousaf	USA, Utah	47	0	NR	NR	2
1837	Tsou	China, Taiwan	100	10	NR	NR	3
1839	Cariani	Italy	182	32	NR	NR	2,3
1926	Smith	UK	103	42	NR	NR	2
1929	Kutsuna	Japan, Tokyo	11	3	1 F 2 M	NR	2,3
1960	Tanacan	Turkey, Ankara	3	0	0 F NA M	NR	3
1972	Rauch	USA, California	6	2	NR	NR	2

Table 1: Characteristics of studies reporting on proportion of asymptomatic SARS-CoV-2 infections *(continued)*

Record ID	Author	Location	Total SARS-CoV-2, n	Asymptomatic SARS-CoV-2, n	Sex of asymptomatic individuals	Age of asymptomatic individuals, median	Follow-up method[a]
2051	Starling	UK	31	29	NR	NR	1,2
2054	Eythorsson	Iceland	1797	49	NR	NR	2
2091	Luo	China, Guangzhou	127	8	NR	NR	1
2218	Kittang	Norway, Bergen	40	0	NR	NR	1
2231	Chamie	USA, San Francisco	81	23	NR	NR	1,2
2246	Hurst	USA, North Carolina	293	87	NR	NR	1,2
2249	Corcorran	USA, Washington	17	3	NR	NR	2,3
2263	Aherfi	France, Marseille	63	9	NR	NR	1
2470	Pirnay	Belgium	9	4	0 F 4 M	34.5; IQR 24-44.5	1
2473	van Buul	Netherlands	15	3	NR	NR	1,2
2540	García-Sierra	Spain, Barcelona	323	33	NR	NR	1
2650	Stock	USA, New York City	19	6	NR	NR	1
2705	Ladhani	UK	105	46	30 F 16 M	84; IQR 78-90	1,2
2751	van den Besselaar	Netherlands	167	8	NR	NR	2
2774	Viñuela	Spain, Madrid	8	8	8 F 0 M	32	3
2802	Bender	USA, Philadelphia, PA	8	6	6 F 0 M	NR	1,2
2826	Taylor	USA, Minnesota	279	16	NR	NR	1
2892	Kennelly	Ireland	1105	290	NR	NR	2
2907	Shi	USA, Boston, MA	146	21	NR	NR	1,2
2909	AbdulRahman	Bahrain	6	3	0 F 3 M	25	2,3
2932	Berghoff	Austria, Vienna	4	2	NR	NR	1,2,3
2987	Edelstein	UK, London	20	4	NR	NR	1,3
3074	Chaw	Brunei	71	9	3 F 6 M	33; IQR 30-35	1,3
3224	Chau	Vietnam, Ho Chi Minh City	12	6	NR	NR	1,2
3299	White	USA	5403	2194	NR	NR	1,2
3359	Aslam	USA, New York	65	38	NR	NR	1,2
3487	Pray	USA, Wisconsin	78	1	NR	NR	2
3622	Malagón-Rojas	Colombia, Bogota	35	11	NR	NR	1,2
3674	Al-Qahtani	Bahrain	188	116	NR	NR	1,3

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Table 1: Characteristics of studies reporting on proportion of asymptomatic SARS-CoV-2 infections *(continued)*

Record ID	Author	Location	Total SARS-CoV-2, n	Asymptomatic SARS-CoV-2, n	Sex of asymptomatic individuals	Age of asymptomatic individuals, median	Follow-up method[a]
3719	Ladhani	UK	158	72	NR	NR	1,2,3
3721	Letizia	USA	51	46	NR	NR	1,2
3722	Kasper	USA	1271	572	NR	NR	1,2
3921	Adhikari	USA, Texas	252	98	98 F 0 M	NR	1
3951	Cao	China, Wuhan	300	300	168 F 132 M	NR	1,3
4045	Migisha	Uganda	54	20	NR	NR	1
4090	Shi	China, Wanzhou District	183	60	NR	NR	1,3
4140	Ghinai	USA, Chicago	406	293	NR	NR	1,2
4154	Wadhwa	USA, Chicago	17	6	NR	NR	2
4200	Balestrini	UK, London	17	11	NR	NR	3
4265	Redditt	Canada, Toronto	24	3	NR	NR	1
4377	Ralli	Italy, Vatican City	12	9	NR	NR	1
4391	Park	South Korea	30	4	NR	NR	1,2
4407	Hcini	French Guiana, West French Guiana territory	137	87	87 F 0 M	NR	1,2
4479	Harada	Japan, Tokyo	73	33	NR	NR	1,2
4663	Mahajan	India, Mumbai	467	58	NR	NR	3
4674	Alshahrani	Saudi Arabia	18	12	NR	NR	3
4880	Ferreira	Canada, Toronto	9	5	5 F 0 M	33; IQR 4.75	1,2
4968	van Buul	Netherlands	25	3	NR	NR	1,2

[a] Follow-up according to protocol (1: 14 days after last possible exposure; 2: 7 days after diagnosis; 3: until negative RT-PCR result).
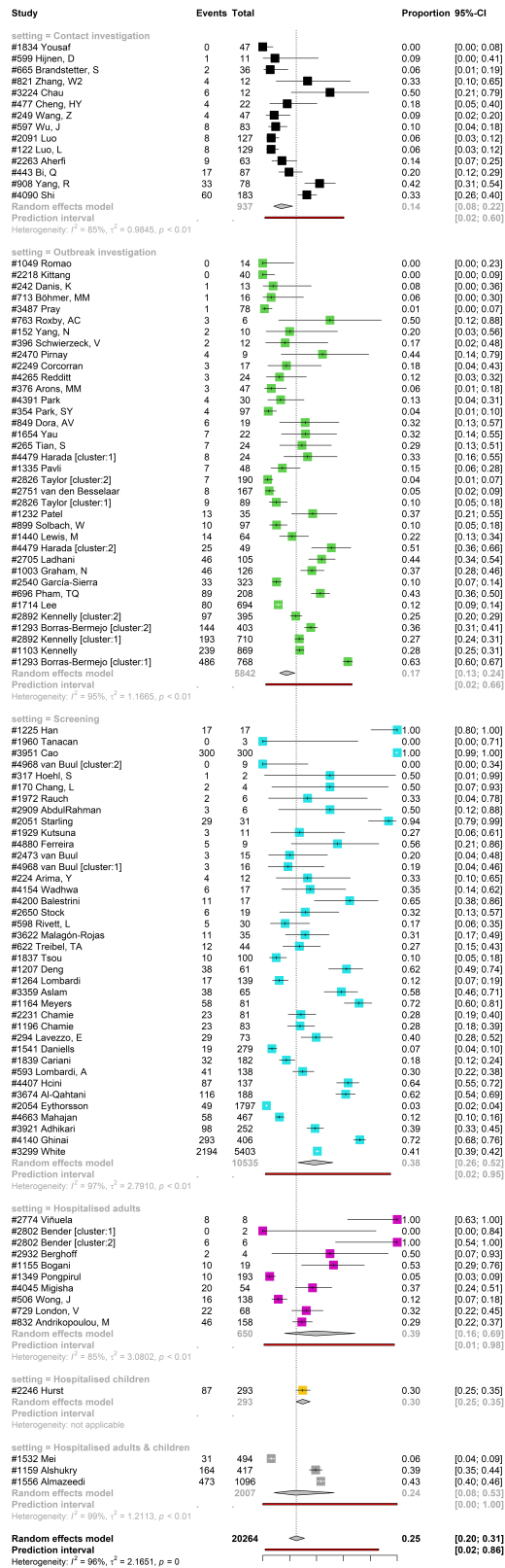
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Study	Events	Total		Proportion	95%-CI
setting = Contact investigation					
#1834 Yousaf	0	47		0.00	[0.00; 0.08]
#599 Hijnen, D	1	11		0.09	[0.00; 0.41]
#665 Brandstetter, S	2	36		0.06	[0.01; 0.19]
#821 Zhang, W2	4	12		0.33	[0.10; 0.65]
#3224 Chau	6	12		0.50	[0.21; 0.79]
#477 Cheng, HY	4	22		0.18	[0.05; 0.40]
#249 Wang, Z	4	47		0.09	[0.02; 0.20]
#597 Wu, J	8	83		0.10	[0.04; 0.18]
#2091 Luo	8	127		0.06	[0.03; 0.12]
#122 Luo, L	8	129		0.06	[0.03; 0.12]
#2263 Aherfi	9	63		0.14	[0.07; 0.25]
#443 Bi, Q	17	87		0.20	[0.12; 0.29]
#908 Yang, R	33	78		0.42	[0.31; 0.54]
#4090 Shi	60	183		0.33	[0.26; 0.40]
Random effects model		937		0.14	[0.08; 0.22]
Prediction interval					[0.02; 0.60]
Heterogeneity: $I^2 = 85\%$, $\tau^2 = 0.9845$, $p < 0.01$					
setting = Outbreak investigation					
#1049 Romao	0	14		0.00	[0.00; 0.23]
#2218 Kittang	0	40		0.00	[0.00; 0.09]
#242 Danis, K	1	13		0.08	[0.00; 0.36]
#713 Böhmer, MM	1	16		0.06	[0.00; 0.30]
#3487 Pray	1	78		0.01	[0.00; 0.07]
#763 Roxby, AC	3	6		0.50	[0.12; 0.88]
#152 Yang, N	2	10		0.20	[0.03; 0.56]
#396 Schwierzeck, V	2	12		0.17	[0.02; 0.48]
#2470 Pirnay	4	9		0.44	[0.14; 0.79]
#2249 Corcorran	3	17		0.18	[0.04; 0.43]
#4265 Redditt	3	24		0.12	[0.03; 0.32]
#376 Arons, MM	3	47		0.06	[0.01; 0.18]
#4391 Park	4	30		0.13	[0.04; 0.31]
#354 Park, SY	4	97		0.04	[0.01; 0.10]
#849 Dora, AV	6	19		0.32	[0.13; 0.57]
#1654 Yau	7	22		0.32	[0.14; 0.55]
#265 Tian, S	7	24		0.29	[0.13; 0.51]
#4479 Harada [cluster:1]	8	24		0.33	[0.16; 0.55]
#1335 Pavli	7	48		0.15	[0.06; 0.28]
#2826 Taylor [cluster:2]	7	190		0.04	[0.01; 0.07]
#2751 van den Besselaar	8	167		0.05	[0.02; 0.09]
#2826 Taylor [cluster:1]	9	89		0.10	[0.05; 0.18]
#1232 Patel	13	35		0.37	[0.21; 0.55]
#899 Solbach, W	10	97		0.10	[0.05; 0.18]
#1440 Lewis, M	14	64		0.22	[0.13; 0.34]
#4479 Harada [cluster:2]	25	49		0.51	[0.36; 0.66]
#2705 Ladhani	46	105		0.44	[0.34; 0.54]
#1003 Graham, N	46	126		0.37	[0.28; 0.46]
#2540 García-Sierra	33	323		0.10	[0.07; 0.14]
#696 Pham, TQ	89	208		0.43	[0.36; 0.50]
#1714 Lee	80	694		0.12	[0.09; 0.14]
#2892 Kennelly [cluster:2]	97	395		0.25	[0.20; 0.29]
#1293 Borras-Bermejo [cluster:2]	144	403		0.36	[0.31; 0.41]
#2892 Kennelly [cluster:1]	193	710		0.27	[0.24; 0.31]
#1103 Kennelly	239	869		0.28	[0.25; 0.31]
#1293 Borras-Bermejo [cluster:1]	486	768		0.63	[0.60; 0.67]
Random effects model		5842		0.17	[0.13; 0.24]
Prediction interval					[0.02; 0.66]
Heterogeneity: $I^2 = 95\%$, $\tau^2 = 1.1665$, $p < 0.01$					
setting = Screening					
#1225 Han	17	17		1.00	[0.80; 1.00]
#1960 Tanacan	0	3		0.00	[0.00; 0.71]
#3951 Cao	300	300		1.00	[0.99; 1.00]
#4968 van Buul [cluster:2]	0	9		0.00	[0.00; 0.34]
#317 Hoehl, S	1	2		0.50	[0.01; 0.99]
#170 Chang, L	2	4		0.50	[0.07; 0.93]
#1972 Rauch	2	6		0.33	[0.04; 0.78]
#2909 AbdulRahman	3	6		0.50	[0.12; 0.88]
#2051 Starling	29	31		0.94	[0.79; 0.99]
#1929 Kutsuna	3	11		0.27	[0.06; 0.61]
#4880 Ferreira	5	9		0.56	[0.21; 0.86]
#2473 van Buul	3	15		0.20	[0.04; 0.48]
#4968 van Buul [cluster:1]	3	16		0.19	[0.04; 0.46]
#224 Arima, Y	4	12		0.33	[0.10; 0.65]
#4154 Wadhwa	6	17		0.35	[0.14; 0.62]
#4200 Balestrini	11	17		0.65	[0.38; 0.86]
#2650 Stock	6	19		0.32	[0.13; 0.57]
#598 Rivett, L	5	30		0.17	[0.06; 0.35]
#3622 Malagón-Rojas	11	35		0.31	[0.17; 0.49]
#622 Treibel, TA	12	44		0.27	[0.15; 0.43]
#1837 Tsou	10	100		0.10	[0.05; 0.18]
#1207 Deng	38	61		0.62	[0.49; 0.74]
#1264 Lombardi	17	139		0.12	[0.07; 0.19]
#3359 Aslam	38	65		0.58	[0.46; 0.71]
#1164 Meyers	58	81		0.72	[0.60; 0.81]
#2231 Chamie	23	81		0.28	[0.19; 0.40]
#1196 Chamie	23	83		0.28	[0.18; 0.39]
#294 Lavezzo, E	29	73		0.40	[0.28; 0.52]
#1541 Daniells	19	279		0.07	[0.04; 0.10]
#1839 Cariani	32	182		0.18	[0.12; 0.24]
#593 Lombardi, A	41	138		0.30	[0.22; 0.38]
#4407 Hcini	87	137		0.64	[0.55; 0.72]
#3674 Al-Qahtani	116	188		0.62	[0.54; 0.69]
#2054 Eythorsson	49	1797		0.03	[0.02; 0.04]
#4663 Mahajan	58	467		0.12	[0.10; 0.16]
#3921 Adhikari	98	252		0.39	[0.33; 0.45]
#4140 Ghinai	293	406		0.72	[0.68; 0.76]
#3299 White	2194	5403		0.41	[0.39; 0.42]
Random effects model		10535		0.38	[0.26; 0.52]
Prediction interval					[0.02; 0.95]
Heterogeneity: $I^2 = 97\%$, $\tau^2 = 2.7910$, $p < 0.01$					
setting = Hospitalised adults					
#2774 Viñuela	8	8		1.00	[0.63; 1.00]
#2802 Bender [cluster:1]	0	2		0.00	[0.00; 0.84]
#2802 Bender [cluster:2]	6	6		1.00	[0.54; 1.00]
#2932 Berghoff	2	4		0.50	[0.07; 0.93]
#1155 Bogani	10	19		0.53	[0.29; 0.76]
#1349 Pongpirul	10	193		0.05	[0.03; 0.09]
#4045 Migisha	20	54		0.37	[0.24; 0.51]
#506 Wong, J	16	138		0.12	[0.07; 0.18]
#729 London, V	22	68		0.32	[0.22; 0.45]
#832 Andrikopoulou, M	46	158		0.29	[0.22; 0.37]
Random effects model		650		0.39	[0.16; 0.69]
Prediction interval					[0.01; 0.98]
Heterogeneity: $I^2 = 85\%$, $\tau^2 = 3.0802$, $p < 0.01$					
setting = Hospitalised children					
#2246 Hurst	87	293		0.30	[0.25; 0.35]
Random effects model		293		0.30	[0.25; 0.35]
Prediction interval					
Heterogeneity: not applicable					
setting = Hospitalised adults & children					
#1532 Mei	31	494		0.06	[0.04; 0.09]
#1159 Alshukry	164	417		0.39	[0.35; 0.44]
#1556 Almazeedi	473	1096		0.43	[0.40; 0.46]
Random effects model		2007		0.24	[0.08; 0.53]
Prediction interval					[0.00; 1.00]
Heterogeneity: $I^2 = 99\%$, $\tau^2 = 1.2113$, $p < 0.01$					
Random effects model		20264		0.25	[0.20; 0.31]
Prediction interval					[0.02; 0.86]
Heterogeneity: $I^2 = 96\%$, $\tau^2 = 2.1651$, $p = 0$					

Figure 1: Forest plot of proportion of people with asymptomatic SARS-CoV-2 infection, stratified by setting

Figure 2

Study	Experimental Events	Total	Control Events	Total	Risk Ratio	RR	95%-CI	Weight (fixed)	Weight (random)
Luo, L	1	305	117	2305		0.06	[0.01; 0.46]	45.6%	19.7%
Park, SY	0	4	34	210		0.68	[0.05; 9.42]	2.1%	14.5%
Cheng, HY	0	91	22	2644		0.64	[0.04; 10.51]	2.4%	13.4%
Chaw, L	15	691	28	1010		0.78	[0.42; 1.46]	38.0%	33.3%
Zhang, W2	1	119	11	250		0.19	[0.02; 1.46]	11.8%	19.1%
Fixed effect model		1210		6419		0.35	[0.20; 0.62]	100.0%	--
Random effects model						0.35	[0.10; 1.27]	--	100.0%
Prediction interval							[0.01; 20.58]		

Heterogeneity: $I^2 = 60\%$, $\tau^2 = 1.2057$, $p = 0.04$
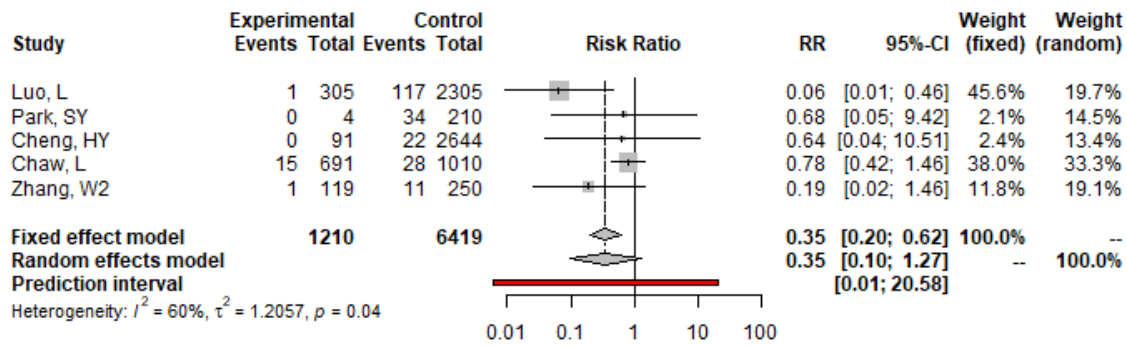
0.01 0.1 1 10 100

Figure 2: Forest plot of secondary attack rate comparing infections in contacts of asymptomatic index cases with infections in contacts of symptomatic cases

Figure 3

Study	Experimental Events	Total	Control Events	Total	Risk Ratio	RR	95%-CI	Weight (fixed)	Weight (random)
Park, SY	0	11	34	210		0.27	[0.02; 4.06]	43.1%	21.9%
Cheng, HY	2	299	22	2644		0.80	[0.19; 3.40]	56.9%	78.1%
Fixed effect model		310		2854		0.46	[0.11; 1.92]	100.0%	--
Random effects model						0.63	[0.18; 2.26]	--	100.0%

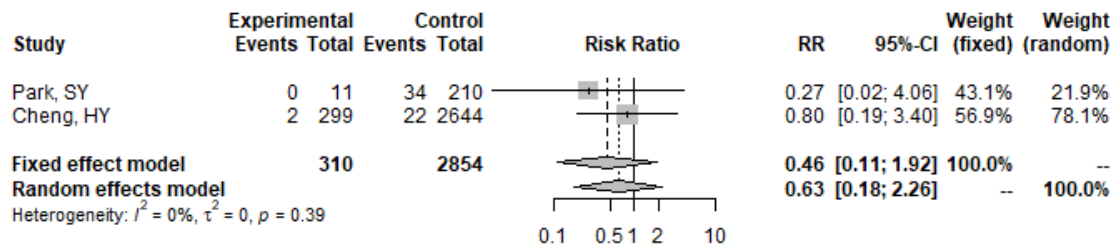Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 0.39$

0.1 0.5 1 2 10

Figure 3: Forest plot of secondary attack rate comparing infections in contacts of presymptomatic index cases with infections in contacts of symptomatic cases

Figure 4

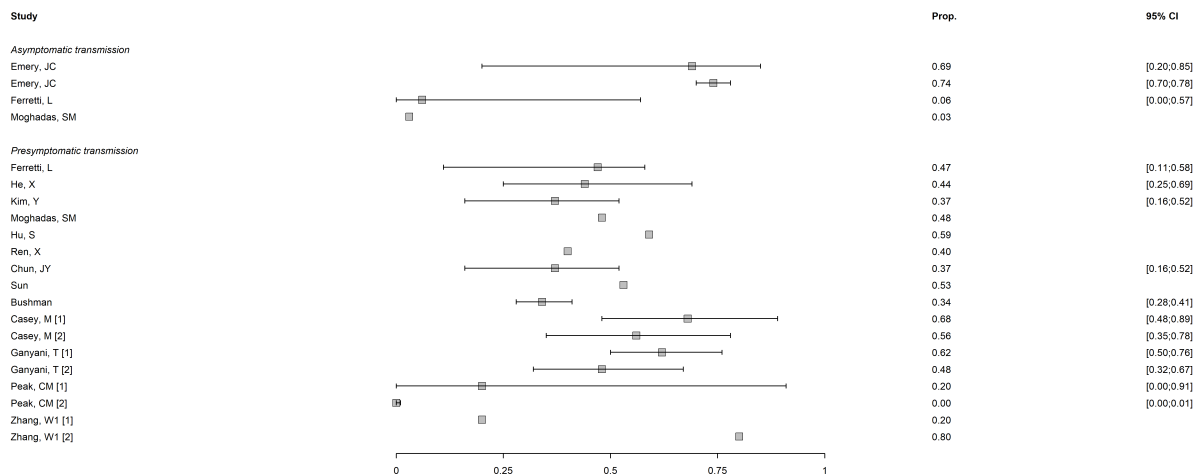| Study	Prop.	95% CI
Asymptomatic transmission		
Emery, JC	0.69	[0.20;0.85]
Emery, JC	0.74	[0.70;0.78]
Ferretti, L	0.06	[0.00;0.57]
Moghadas, SM	0.03	
Presymptomatic transmission		
Ferretti, L	0.47	[0.11;0.58]
He, X	0.44	[0.25;0.69]
Kim, Y	0.37	[0.16;0.52]
Moghadas, SM	0.48	
Hu, S	0.59	
Ren, X	0.40	
Chun, JY	0.37	[0.16;0.52]
Sun	0.53	
Bushman	0.34	[0.28;0.41]
Casey, M [1]	0.68	[0.48;0.89]
Casey, M [2]	0.56	[0.35;0.78]
Ganyani, T [1]	0.62	[0.50;0.76]
Ganyani, T [2]	0.48	[0.32;0.67]
Peak, CM [1]	0.20	[0.00;0.91]
Peak, CM [2]	0.00	[0.00;0.01]
Zhang, W1 [1]	0.20	
Zhang, W1 [2]	0.80	

0 0.25 0.5 0.75 1

Figure 4: Forest plot of proportion of SARS-CoV-2 infection resulting from asymptomatic or presymptomatic transmission