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Supplementary Materials for

Changes in contact patterns shape the dynamics of the COVID-19 outbreak in China

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Other Supporting Online Material for this manuscript includes the following:
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1. Timeline of contact surveys and interventions in Wuhan and Shanghai

We conducted two social contact surveys from February 1, 2020 to February 10, 2020, as the novel coronavirus 2019 outbreak (COVID-19) was starting to spread widely across China. At that time several control strategies were implemented. A timeline of the main events in Wuhan and Shanghai is shown in Fig. S1 and S2. Wuhan was put on lock down on January 23, 2020, with most of its commercial activity suspended until March 10, 2020. Close community management and social distancing were gradually introduced starting on January 28, 2020 (e.g. only one household member was allowed to purchase supplies every three days). In Shanghai, as in other provinces outside Hubei, private firms had to stop operations from January 28, 2020 to February 9, 2020, and close community management was put in place. In both locations additional restrictions were put in place, including extension of the traditional Chinese New Year holidays until February 2, 2020, suspension of group tours, closure of public cultural institutions (e.g., libraries, museums), and postponement of the spring semester for schools of all levels (*30-32*). The main control measures implemented in Wuhan and Shanghai are summarized in Fig. S1-2 and Tab. S1.

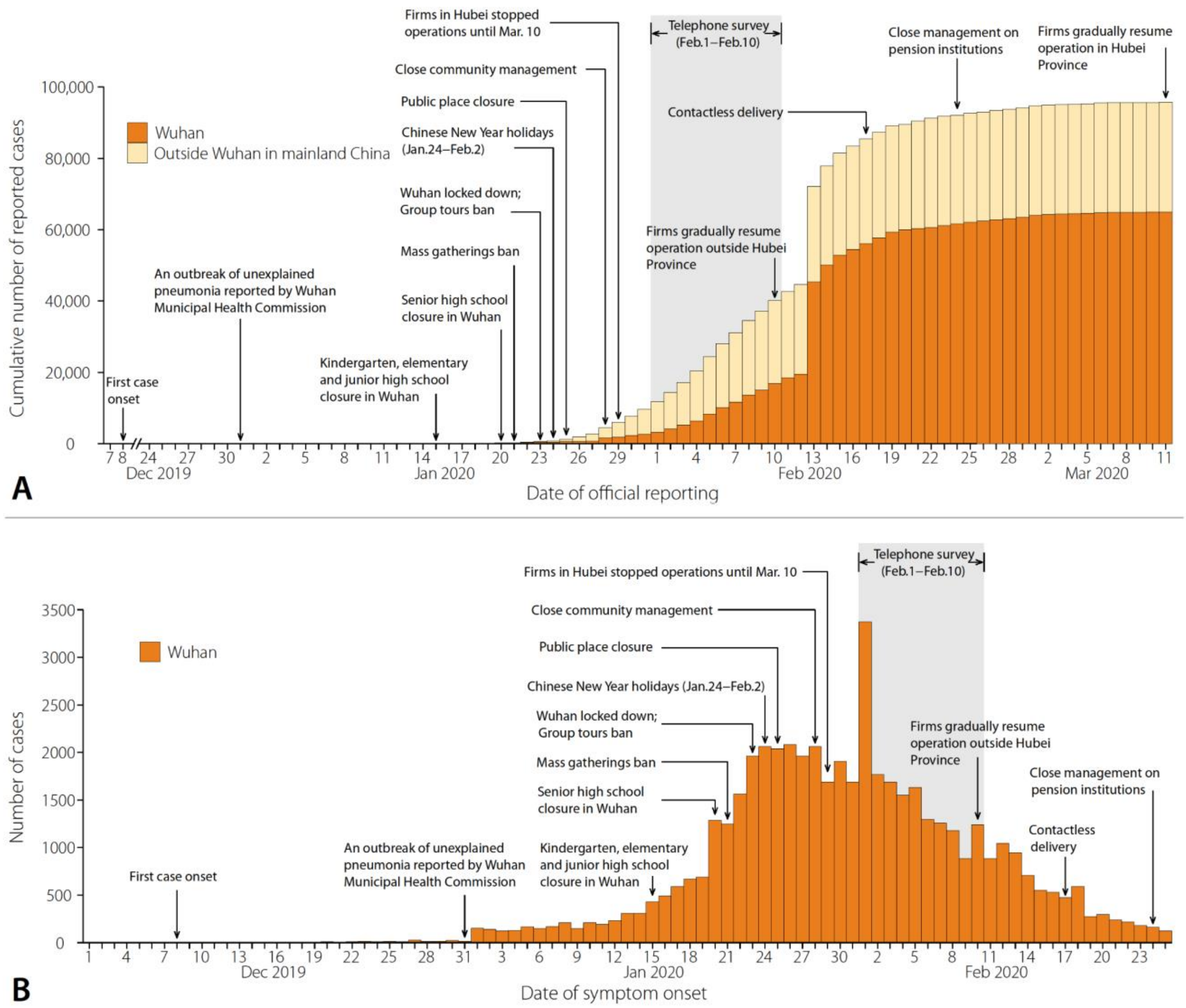

Figure S1. A Cumulative number of reported cases in Wuhan, timeline of key events, and timeline of the survey. **B** Same as A, but showing the epidemic curve (i.e., the daily number of cases by date of symptom onset).

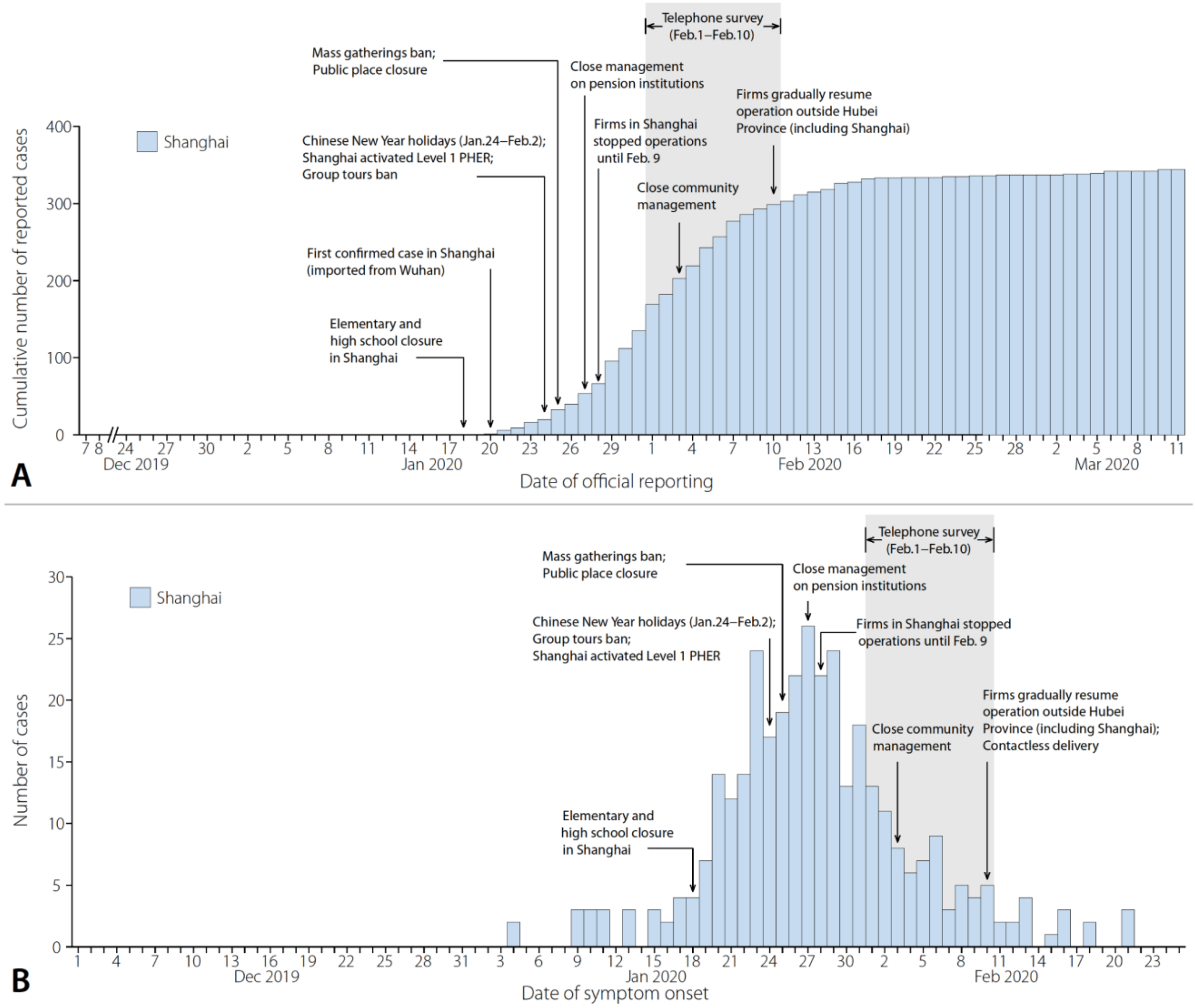

Figure S2. A Cumulative number of reported cases in Shanghai, timeline of key events, and timeline of the survey. **B** Same as A, but showing the epidemic curve (i.e., the daily number of cases by date of symptom onset)

Table S1. *Main control measures implemented in Wuhan and Shanghai.*

Location	Type	Target population	Subtype	Intervention	Start date	End date	Source
Wuhan							
	Case isolation and close contact management	confirmed cases	isolation	designated hospitals for cases	2020/1/20		http://wjw.wuhan.gov.cn/front/web/showDetail/2020012009078
	Case isolation and close contact management	suspected cases	isolation	centralized isolation on suspected cases	2020/2/2		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200203_304370.html
	Case isolation and close contact management	close contacts	isolation	centralized isolation on close contacts	2020/2/2		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200203_304370.html
	Case isolation and close contact management	fever patients	isolation	centralized isolation on patients with fever	2020/2/2		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200203_304370.html
	Case isolation and close contact management	cured cases	isolation	isolation on recovered patients	2020/2/22		https://www.thepaper.cn/newsDetail_forward_6088503
	Environmental/general sanitation	general population	disinfection	disinfection on public transportation	2020/1/7		www.wuhan.gov.cn/2019_web/whyw/202001/t20200123_304125.html
	Environmental/general sanitation	general population	disinfection	disinfection in public places	2020/1/22		http://wh.bendibao.com/live/2020121/106813.shtm
	Environmental/general sanitation	general population	disinfection	disinfection in the whole city	2020/2/9		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200210_304586.html
	Environmental/general sanitation	general population	wear masks	wear masks in public places	2020/1/22		http://www.wuhan.gov.cn/2019_web/whyw/202001/t20200123_304073.html
	Increase interpersonal distance	general population	activity ban	close community management	2020/1/28-2020/2/11		http://www.bzdc.cn/bzms/65296.html
	Increase interpersonal distance	general population	activity ban	mass gatherings ban	2020/1/21		http://www.xinhuanet.com//2020-01/21/c_1125490833.htm
	Increase interpersonal distance	general population	activity ban	group tours ban	2020/1/23		http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202001/t20200123_2014602.shtml
	Increase interpersonal distance	general population	activity ban	public place closure	2020/1/25		https://www.mct.gov.cn/whzx/whyw/202002/t20200204_850635.htm
	Increase interpersonal distance	general population	activity ban	contactless delivery	2020/2/17		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200218_305034.html
	Increase interpersonal distance	general population	activity ban	close management on pension institutions	2020/2/24		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200225_305500.html
	Increase interpersonal distance	general population	workplace closure	extension of the Spring Festival holiday	2020/2/1	2020/2/13	http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202002/t20200201_2017564.shtml
	Increase interpersonal distance	general population	workplace closure	detention of enterprise re-work	2020/1/29	2020/3/10	http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202002/t20200220_2143275.shtml http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202001/t20200129_2016284.shtml
	Personnel quarantine	general population	temperature measurement	temperature measurement at public transportation	2020/1/15		www.wuhan.gov.cn/2019_web/whyw/202001/t20200123_304125.html
	Personnel quarantine	general population	temperature measurement	temperature measurement at public places	2020/1/29		http://www.wh.gov.cn/hbgovinfo/zwgk_8265/tzgg/202001/t20200130_304277.html

Personnel quarantine	general population	cross-examination	first-round cross-examination on all residents	2020/1/24	2020/2/10	http://www.hubei.gov.cn/zhuanti/2020/xgfyyqfkzszq/fwzq/zclxx/202001/t20200124_2014779.shtml http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200211_304661.html
Personnel quarantine	general population	cross-examination	second-round cross-examination on all residents	2020/2/17	2020/2/19	http://www.wh.gov.cn/2019_web/whyw/202002/t20200220_305176.html
Personnel quarantine	general population	cross-examination	health surveillance on all residents	2020/2/7		http://www.wuhan.gov.cn/2019_web/whyw/202002/t20200207_304509.html
Traffic restrictions	general population	inter-province/city travel ban	city lockdown	2020/1/23		http://www.wuhan.gov.cn/hbgovinfo/zwgk_8265/tzgg/202001/t20200123_304065.html
Traffic restrictions	general population	inner-province/city travel limitation	taxi limitation	2020/1/24		https://baijiahao.baidu.com/s?id=1656567890994404313&wfr=spider&for=pc
Traffic restrictions	general population	inner-province/city travel limitation	partial road closure	2020/1/25		http://www.wuhan.gov.cn/2019_web/whyw/202001/t20200125_304153.html
Traffic restrictions	general population	inner-province/city travel ban	motor vehicle ban	2020/1/26		http://www.wuhan.gov.cn/2019_web/whyw/202001/t20200127_304182.html
Personnel quarantine	returnees	cross-examination	health surveillance on returnees	2020/1/31		http://www.wh.gov.cn/hbgovinfo/zwgk_8265/tzgg/202002/t20200201_304332.html
Personnel quarantine	population with fever	cross-examination	health surveillance on population with fever	2020/2/17		http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202002/t20200218_2096672.shtml
Other restrictions	wild animal	—	wild animal market closure	2020/1/29		http://www.wh.gov.cn/hbgovinfo/zwgk_8265/tzgg/202001/t20200130_304277.html
Other restrictions	wild animal	—	live poultry market closure	2020/1/29		http://www.wh.gov.cn/hbgovinfo/zwgk_8265/tzgg/202001/t20200130_304277.html
Other restrictions	population with fever	—	registration when buying medicine	2020/1/30		http://www.wh.gov.cn/hbgovinfo/zwgk_8265/tzgg/202001/t20200130_304278.html
Shanghai						
Case isolation and close contact management	confirmed cases	isolation	designated hospitals for cases	2020/1/21		http://news.cngold.org/gundong/2020-01-22/c6824823.html
Case isolation and close contact management	close contacts and fever patients	isolation	centralized isolation on close contacts and fever patients	2020/1/21		http://news.sina.com.cn/bn/society/2020-01-21/detail-iihnzhha4003623.d.html
Case isolation and close contact management	people from severe epidemic areas	isolation	isolation on people from severe epidemic areas	2020/1/24		http://wsjkw.sh.gov.cn/xwfb/20200126/bf3a84555c1b4bde839e56db7e610cbc.html
Environmental/general sanitation	general population	disinfection	disinfection on public transportation	2020/1/22		http://sh.people.com.cn/n2/2020/0122/c176737-33739894.html
Environmental/general sanitation	general population	disinfection	disinfection in public places	2020/1/22		https://new.qq.com/omn/20200130/20200130A04WA700.html?pc
Environmental/general sanitation	general population	wear masks	wear masks in public transportation	2020/2/5		https://m.weibo.cn/status/4468666932004021
Environmental/general sanitation	general population	wear masks	wear masks in public places	2020/2/8		https://baijiahao.baidu.com/s?id=1657964155677045855&wfr=spider&for=pc
Increase interpersonal	general population	activity ban	group tours ban	2020/1/24		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw4

distance						8539/u21aw1423565.html
Increase interpersonal distance	general population	activity ban	mass gatherings ban	2020/1/25		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423526.html
Increase interpersonal distance	general population	activity ban	public place closure	2020/1/25		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423526.html
Increase interpersonal distance	general population	activity ban	contactless delivery	2020/1/27		http://sh.sina.com.cn/news/m/2020-01-28/detail-iihnzhha5133716.shtml
Increase interpersonal distance	general population	activity ban	close management on pension institutions	2020/1/27		http://www.shweilao.cn/cms/cmsDetail?uuid=f72e75a2-687f-4db4-94ed-1db37c1e1b98
Increase interpersonal distance	general population	activity ban	close community management	2020/2/3-2020/2/8		https://web.shobserver.com/news/detail?id=219178 https://baijiahao.baidu.com/s?id=1657956799138015813&wfr=spider&for=pc
Increase interpersonal distance	general population	workplace closure	extension of the Spring Festival holiday	2020/2/1	2020/2/2	http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48545/nw48635/u26aw63482.html
Increase interpersonal distance	general population	workplace closure	detention of enterprise re-work	2020/1/28	2020/2/9-2/28	http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423599.html http://www.shanghai.gov.cn/nw2/nw2314/nw9819/nw9822/u21aw1431364.html
Personnel quarantine	general population	temperature measurement	temperature measurement at public transportation	2020/1/23		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423542.html
Personnel quarantine	general population	temperature measurement	temperature measurement at public places	2020/2/8		http://m.gmw.cn/2020-02/08/content_1300927367.htm
Traffic restrictions	general population	from/ to Hubei travel ban	interprovincial bus travel from/ to Hubei ban	2020/1/23		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423542.html
Traffic restrictions	general population	inter-province/city travel ban	interprovincial and interurban bus travel ban	2020/1/26	2020/2/20	http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1423571.html http://jtw.sh.gov.cn/tpxw/20200221/a4e04d9299bd40d190bf71ed926f49e8.html
Other restrictions	population with fever	—	registration when buying medicine	2020/1/23		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48539/u21aw1426132.html
Other restrictions	wild animal	—	wild animal market closure	2020/1/26		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48545/nw48607/u26aw63618.html
Other restrictions	wild animal	—	live poultry market closure	2020/1/26		http://www.shanghai.gov.cn/nw2/nw2314/nw32419/nw48516/nw48545/nw48607/u26aw63618.html

2. Survey design

2.1 Structure of the contact survey questionnaire

Questionnaires were administered by phone by trained staff; a summary of the sampling scheme is provided below. The questionnaire consisted of three sections: 1) general information (e.g., sex, age, type of profession, and household size); 2) contact diary for a regular weekday between December 24, 2019 and December 30, 2019 before the outbreak of unexplained pneumonia was officially announced by the Wuhan Municipal Health Commission (period used as baseline); and 3) contact diary during the COVID-19 outbreak. In line with the POLYMOD study(*5*), a contact was defined as either, (1) a two-way conversation involving three or more words in the physical presence of another person (conversational contact), or (2) a direct physical contact (e.g., a handshake, hug, kiss or performing contact sports). For the contact diary during the outbreak, participants were requested to record each contact they had within a 24-hour period from 5:00am of the day before the telephone interview to 5:00am the day of the interview. For each contact, the following information was recorded: age, sex, relation, social setting where the contact took place (e.g., home, workplace), and type of contact (conversational or physical). For the contact diary related to regular days, contacts were aggregated by age group.

2.2 Survey sampling

The survey was conducted by using a platform well-established by the authors during the outbreak of human infection with avian influenza A(H7N9), which uses a computerized random digital dialing system(*33*). Only mobile phone numbers were used. The sample size was calculated based on the same methodology used in our previous survey(*7*). We planned to recruit 500 adults in each location. To obtain an age-representative sample, we planned to recruit an additional 88 and 62 participants under 18 years in Wuhan and Shanghai, respectively. Accounting for 90% response rate, we targeted about 650 participants per study site. The effective number of participants was 636 in Wuhan and 557 in Shanghai. Eligibility criteria were defined as: 1) being a local resident of Shanghai or Wuhan of any age; 2) having lived in the selected city for more than six months in the past year; 3) being present in the city at the time of interview. Proportional quota sampling based on age and sex was used to ensure a demographically representative sample of the general population in each city. Calls were placed three times at different hours on the same day before being classified as invalid. Interviews of underaged individuals took place after the approval of the legal guardian who assisted the child in responding to the questionnaire. Who completed the questionnaire depended on the participant's age following: 1) parental-proxy completion for ages 0 to 10 yrs; 2) self-completion for individuals aged 11 to 17 years, subject to informed parental consent; and 3) self-completion and informed consent for participants above 18 yrs of age. Fig. S3 shows the flow chart of the participant recruitment process.

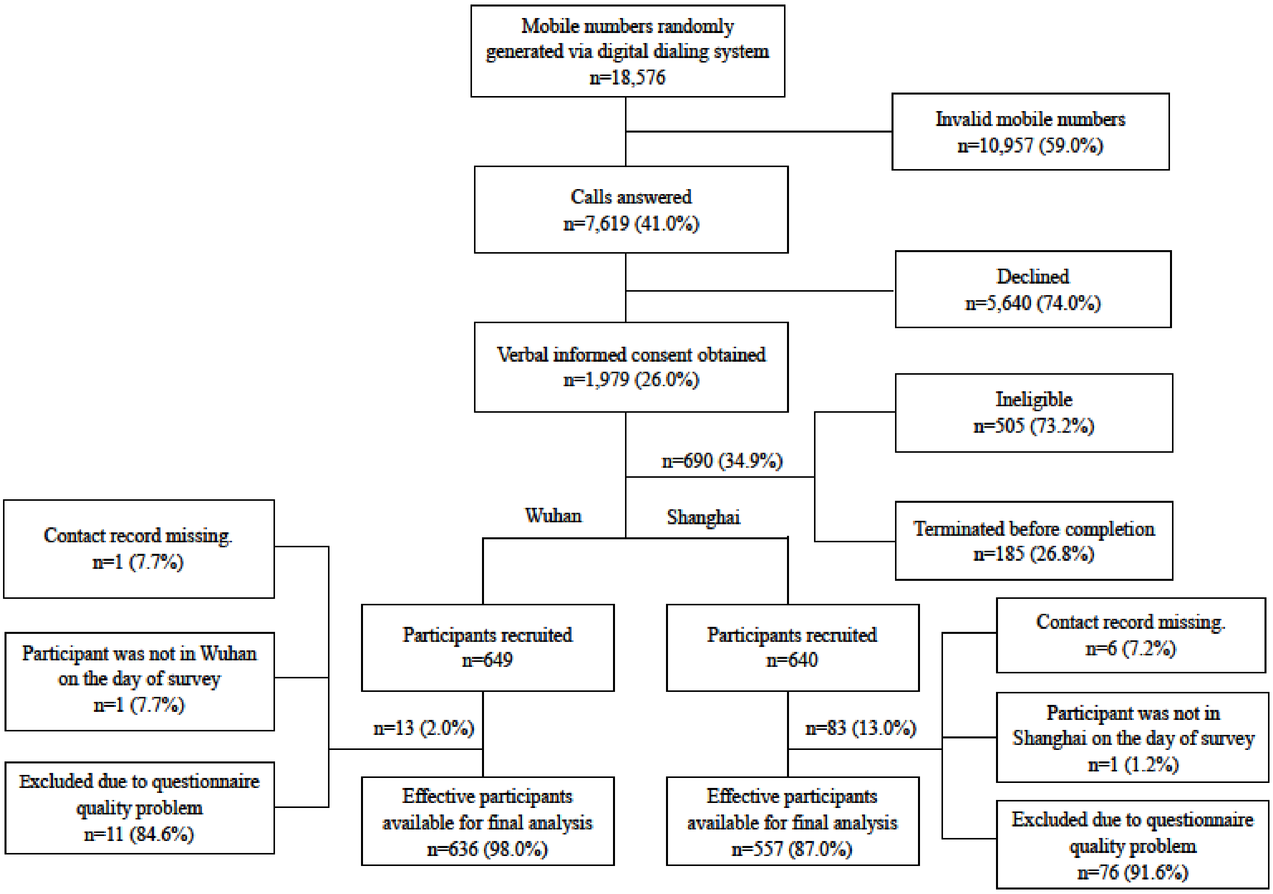

Figure S3. *Flow chart of the sampling telephone* survey.

2.3 Data representativeness

Overall, 1,193 participants (636 in Wuhan and 557 in Shanghai) were included in the analysis. In Wuhan, 329 (51.7%) of participants were female, the average age was 36 years (range 1-82), and the average household size was 3 (range 1-11). In Shanghai, 271 (48.7%) of participants were female, the average age was 37 years (range 1-85), and the average household size was 3 (range 1-8). We also included 965 individuals from a previous contact survey conducted in Shanghai by the same team (*7*).

The demographics of enrolled participants in Wuhan and Shanghai aligned well with the actual populations of the two cities (Tab. S2-3, and Fig. S4), although in both locations individuals aged between 0 and 4 years and above aged 65 years were slightly undersampled.

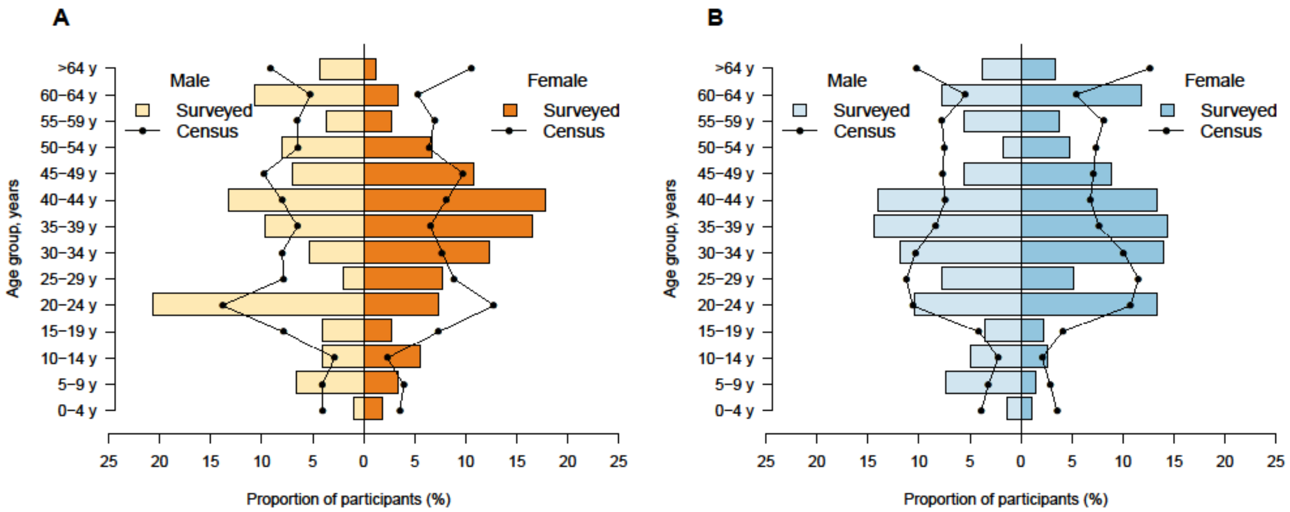

***Figure S4. A** Study population demographics by age and gender for Wuhan. **B** Same as A, but for Shanghai. Black dotted lines denote expected distributions based on age-gender distributions derived from census 2016.*

***Table S2.** Comparison between the total population and contact survey participants in Wuhan.*

Characteristics	Total population (%) (n= 10,766,200)	Effective participants (%) (n=636)
Sex		
Female	5,250,583 (48.77)	329 (51.73)
Male	5,515,617 (51.23)	307 (48.27)
Age group		
[0,10)	839,016 (7.79)	40 (6.29)
[10,20)	1,099,717 (10.21)	51 (8.02)
[20,30)	2,326,297 (21.61)	118 (18.55)
[30,40)	1,543,492 (14.34)	139 (21.86)
[40,50)	1,914,285 (17.78)	161 (25.31)
[50,60)	1,417,978 (13.17)	66 (10.38)
[60,70)	921,259 (8.56)	57 (8.96)
[70,100)	704,156 (6.54)	4 (0.63)

***Table S3.** Comparison between the total population and contact survey participants in Shanghai.*

Characteristics	Total population (%) (n= 24,197,001)	Effective participants (%) (n=557)
Sex		
Female	11,628,822 (48.06)	271 (48.65)
Male	12,568,179 (51.94)	286 (51.35)
Age group		
[0,10)	1,710,754 (7.07)	32 (5.75)
[10,20)	1,524,899 (6.30)	37 (6.64)
[20,30)	5,205,172 (21.51)	102 (18.31)
[30,40)	4,308,547 (17.81)	152 (27.29)
[40,50)	3,435,732 (14.20)	116 (20.83)
[50,60)	3,625,168 (14.98)	44 (7.9)
[60,70)	2,212,111 (9.14)	69 (12.39)
[70,100)	2,174,618 (8.99)	5 (0.9)

3. Contact patterns

3.1 Descriptive characteristics of contact patterns

Fig. S5 shows the average number of daily contacts (including physical contacts and conversational contacts) by 5-year age groups. We observed that in the baseline non-epidemic period, Shanghai residents report more contacts than Wuhan. In both cities, the average number of contacts per participant was significantly reduced during the COVID-19 outbreak and this was consistent across all age groups. During the outbreak, the number of contacts was similarly low in the two cities (2-3 contacts/day) and age differences essentially disappeared. The distributions of contacts, including the median and interquartile ranges (IQR), are reported in Fig. S6 and Tab. S4. No significant gender difference was found in the contacts of any age group.

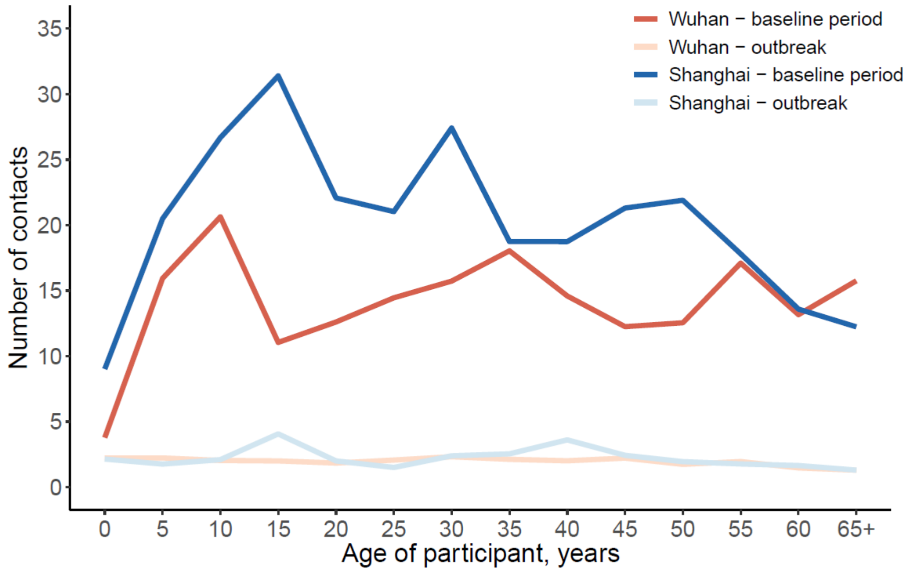

Figure S5. *Average daily number of reported contacts in two large cities (Wuhan City and Shanghai City), by period (baseline period and COVID-19 outbreak).*

Table S4. *Median number of reported contacts by respondent characteristics, city, and time period.*

Characteristics	Wuhan				Shanghai			
	Baseline period		COVID-19 Outbreak		Baseline period		COVID-19 Outbreak	
	N (%)[a]	Median (IQR)	N (%)[a]	Median (IQR)	N (%)	Median (IQR)	N (%)	Median (IQR)
Overall	624 (100.0)	7 (3, 15)	627 (100.0)	2 (1, 2)	965 (100.0)	10 (4, 30)	557 (100.0)	2 (1, 3)
Sex								
Male	300 (48.1)	6 (2, 18)	301 (48)	2 (1, 2)	474 (49.1)	10 (4.2, 31)	286 (51.3)	2 (1, 2.8)
Female	324 (51.9)	7.5 (3, 15)	326 (52)	2 (2, 2)	491 (50.9)	10 (4, 29.5)	271 (48.7)	2 (1, 3)
Age group								
0-6 y	12 (1.9)	4.5 (2, 6.5)	12 (1.9)	2 (2, 2)	88 (9.1)	5 (4, 15.2)	14 (2.5)	2 (2, 2)
7-19 y	79 (12.7)	9 (5, 23.5)	79 (12.6)	2 (2, 2)	141 (14.6)	28 (6, 40)	55 (9.9)	2 (2, 3)
20-39 y	254 (40.7)	7 (3, 19)	256 (40.8)	2 (1, 2.2)	236 (24.5)	12.5 (5, 34)	254 (45.6)	2 (1, 3)
40-59 y	221 (35.4)	6 (2, 13)	220 (35.1)	2 (1, 2)	233 (24.1)	12 (5, 31)	160 (28.7)	2 (1, 3)
⩾60 y	58 (9.3)	3.5 (1, 11.8)	60 (9.6)	1 (1, 2)	267 (27.7)	6 (4, 16)	74 (13.3)	1 (1, 2)
Type of profession								
Pre-school	12 (1.9)	4.5 (2, 6.5)	12 (1.9)	2 (2, 2)	79 (8.2)	5 (4, 11)	14 (2.5)	2 (2, 2)
Student	107 (17.1)	8 (3.5, 14)	107 (17.1)	2 (2, 2)	173 (17.9)	28 (6, 39)	71 (12.7)	2 (2, 3)
Employed	391 (62.7)	8 (3, 19)	390 (62.2)	2 (1, 2)	400 (41.5)	14 (6, 34)	354 (63.6)	2 (1, 3)
Unemployed	30 (4.8)	4 (2, 7.5)	31 (4.9)	2 (1, 2)	29 (3)	6 (3, 13)	24 (4.3)	2 (0.8, 3)
Retired	84 (13.5)	4 (1.8, 9.2)	87 (13.9)	1 (1, 2)	278 (28.8)	6 (3, 15)	94 (16.9)	1 (1, 2)
Household size								
1	45 (7.2)	4 (1, 8)	45 (7.2)	0 (0, 0)	35 (3.6)	10 (3.5, 22.5)	61 (11)	0 (0, 0)
2	73 (11.7)	5 (1, 11)	76 (12.1)	1 (1, 1)	244 (25.3)	7 (3.8, 19)	138 (24.8)	1 (1, 1)
3	282 (45.2)	7.5 (3, 18.8)	283 (45.1)	2 (2, 2)	432 (44.8)	12 (5, 32)	216 (38.8)	2 (2, 2)
4	133 (21.3)	6 (3, 12)	132 (21.1)	2 (2, 3)	117 (12.1)	10 (4, 33)	78 (14)	3 (3, 3)
⩾5	91 (14.6)	10 (4, 26)	91 (14.5)	3 (2, 4)	137 (14.2)	12 (5, 33)	64 (11.5)	4 (4, 4.2)

[a]Can differ from total sample size (n=636) as it also includes participants who had not recorded contacts during regular weekdays or during the COVID-19 outbreak. Note that reduced denominators indicate missing data. Percentages may not total 100 because of rounding.

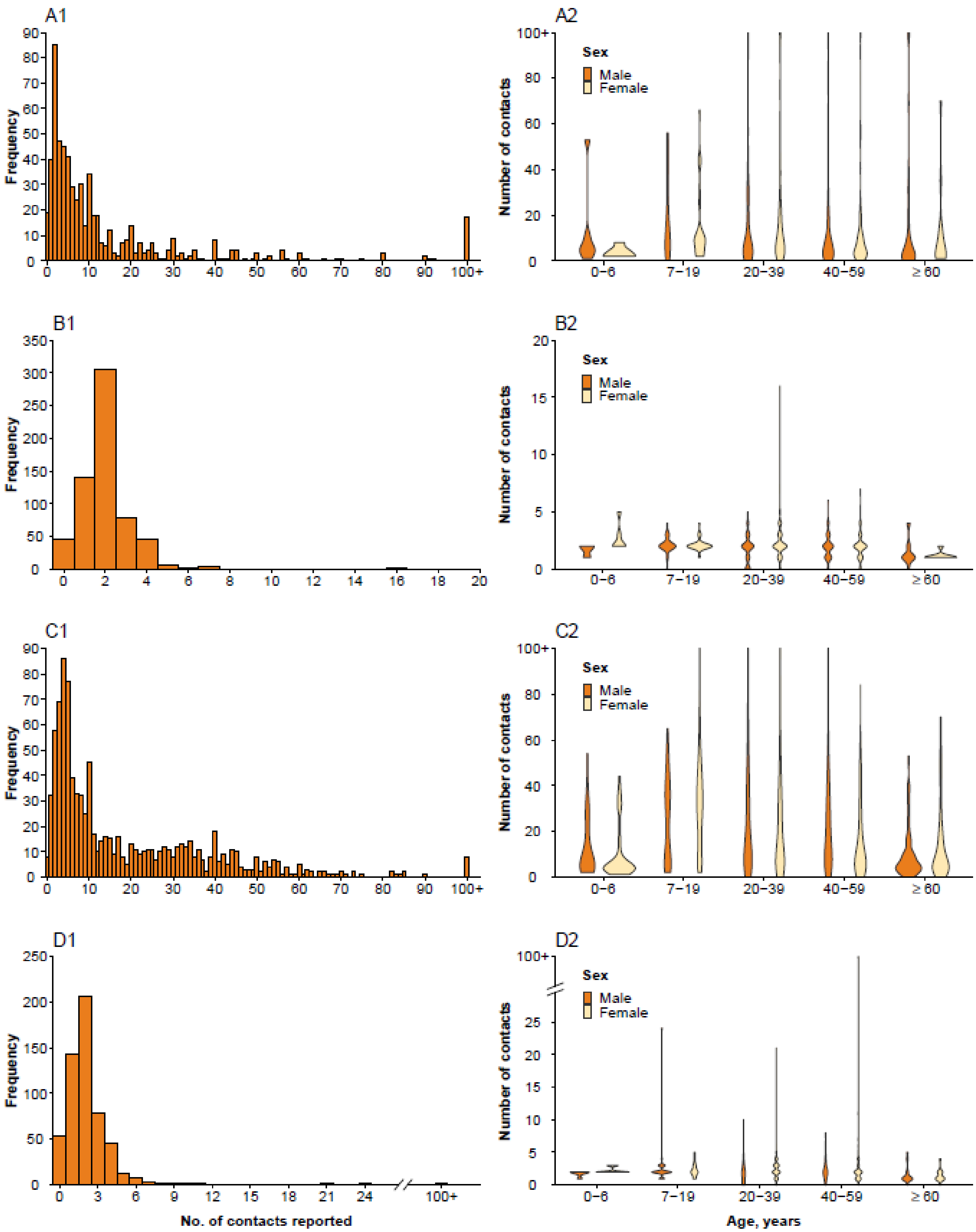

***Figure S6. A1** Distribution of contacts reported during baseline period for Wuhan. **A2** Distribution of contacts reported by age group and sex during baseline period for Wuhan. **B1** Same as A1, but for Wuhan during outbreak. **B2** Same as A2, but for Wuhan during outbreak. **C1** Same as A1, but for Shanghai. **C2** Same as A2, but for Shanghai. **D1** Same as B1, but for Shanghai. **D2** Same as B2, but for Shanghai. Number of contacts were censored by 100.*

3.2 Physical contacts

We analyzed the contact diaries for both locations and both time periods. Difference between two time periods was calculated by the subtraction of the number of contacts during the outbreak from the number of contacts during the baseline period. P-values were taken from a negative binomial regression with a single binary variable distinguishing the baseline period from the outbreak. The same method was used for the difference between two locations.

We found that during the COVID-19 outbreak, survey participants reported on average 1.2 (95%CI 1.2-1.3) and 1.3 (95%CI 1.2-1.5) physical contacts in Wuhan and Shanghai, respectively. In Wuhan, the number of physical contacts dropped 2.8-fold during the outbreak (p<0.001). No comparable data on physical contacts was available for Shanghai. Tab. S5 provides details on the number of physical contacts by characteristics of study participant, city and time period.

Table S5. *Number of physical contacts for Wuhan and Shanghai.*

Characteristics	Wuhan					Shanghai		Difference[c]
	Baseline period		COVID-19 Outbreak		Difference[b]	COVID-19 Outbreak		
	N (%)[a]	Mean (95% CI)[d]	N[a] (%)	Mean (95% CI)[d]		N (%)	Mean (95% CI)[d]	
Overall	622 (100.0)	3.3 (2.8, 3.8)	627 (100.0)	1.2 (1.2, 1.3)	2.1***	557 (100.0)	1.3 (1.2, 1.5)	0.1
Sex								
Male	299 (48.1)	2.7 (2.2, 3.4)	301 (48)	1.2 (1, 1.3)	1.6***	286 (51.3)	1.3 (1.1, 1.5)	0.1
Female	323 (51.9)	3.8 (2.9, 4.7)	326 (52)	1.3 (1.2, 1.5)	2.5***	271 (48.7)	1.4 (1.2, 1.5)	0.1
Age group								
0-6 y	12 (1.9)	2.9 (1.6, 4.7)	12 (1.9)	1.8 (1.2, 2.8)	1.1	14 (2.5)	1.8 (1.4, 2.1)	0
7-19 y	79 (12.7)	4.3 (3.3, 5.5)	79 (12.6)	1.3 (1, 1.5)	3***	55 (9.9)	1.5 (1, 2.7)	0.2
20-39 y	254 (40.8)	4 (3, 5.2)	256 (40.8)	1.3 (1.2, 1.5)	2.6***	254 (45.6)	1.3 (1.2, 1.5)	0
40-59 y	219 (35.2)	2.7 (1.7, 4.1)	220 (35.1)	1.2 (1, 1.4)	1.6**	160 (28.7)	1.3 (1.2, 1.6)	0.2
⩾60 y	58 (9.3)	0.9 (0.5, 1.5)	60 (9.6)	0.9 (0.6, 1.2)	0.2	74 (13.3)	1 (0.8, 1.2)	0.1
Type of profession								
Pre-school	12 (1.9)	2.9 (1.4, 4.3)	12 (1.9)	1.8 (1.2, 2.6)	1.1	14 (2.5)	1.8 (1.5, 2.1)	0
Student	107 (17.2)	3.8 (2.8, 4.8)	107 (17.1)	1.3 (1, 1.5)	2.6***	71 (12.7)	1.5 (1, 2.1)	0.2
Employed	389 (62.5)	3.4 (2.7, 4.2)	390 (62.2)	1.3 (1.2, 1.4)	2.2***	354 (63.6)	1.4 (1.2, 1.5)	0.1
Unemployed	30 (4.8)	5.7 (1.6, 16)	31 (4.9)	1.5 (0.9, 2)	4.2***	24 (4.3)	1.5 (0.9, 2)	0
Retired	84 (13.5)	1.2 (0.8, 1.8)	87 (13.9)	0.8 (0.6, 1.1)	0.5	94 (16.9)	1 (0.8, 1.3)	0.2
Household size								

Characteristics	Wuhan					Shanghai		Difference[c]
	Baseline period		COVID-19 Outbreak		Difference[b]	COVID-19 Outbreak		
	N (%)[a]	Mean (95% CI)[d]	N[a] (%)	Mean (95% CI)[d]		N (%)	Mean (95% CI)[d]	
1	45 (7.2)	1.1 (0.1, 3.8)	45 (7.2)	0.1 (0, 0.5)	1	61 (11)	0.2 (0.1, 0.4)	0.1
2	73 (11.7)	1.6 (0.8, 2.6)	76 (12.1)	0.6 (0.4, 0.8)	1***	138 (24.8)	0.7 (0.6, 0.8)	0.1
3	281 (45.2)	3.9 (3.2, 4.8)	283 (45.1)	1.3 (1.1, 1.4)	2.6***	216 (38.8)	1.3 (1.2, 1.5)	0.1
4	133 (21.4)	2.5 (2, 3.1)	132 (21.1)	1.3 (1.2, 1.5)	1.2***	78 (14)	2 (1.7, 2.2)	0.6***
⩾5	90 (14.5)	5.1 (3.3, 8.2)	91 (14.5)	2.1 (1.9, 2.5)	3.1***	64 (11.5)	3 (2.3, 4.2)	0.9*

Note that percentages may not total 100 because of rounding.

[a]Can differ from total sample size (n=636) as it also includes participants who had not recorded contacts during regular weekdays or during the COVID-19 outbreak.

[b]Difference is calculated by the subtraction of the number of contacts during the outbreak from the number of contacts during the baseline period. P-values are taken from a negative binomial regression with a single binary variable distinguishing the baseline period from the outbreak.

[c]Difference of the number of contacts during the outbreak between Shanghai and Wuhan.

[d]The 95% confidence interval on the mean are calculated by bootstrap sampling.

*p<0.05, **p<0.01, ***p<0.001.

3.3 Comparison of contact patterns between two locations

Compared with the participants in Wuhan, Shanghai residents recorded more contacts during baseline period and COVID-19 outbreak, although a small difference was also observed during the COVID-19 outbreak. In particular, during the outbreak, workers in Shanghai made reported a larger number of contacts than those in Wuhan (Tab. S6).

Table S6. *Number of contacts during regular days and during outbreak.*

Characteristics	Baseline period					COVID-19 Outbreak				
	Shanghai		Wuhan		Difference[b]	Shanghai		Wuhan		Difference[b]
	N (%)	Mean (95% CI)[c]	N[a] (%)	Mean (95% CI)[c]		N (%)	Mean (95% CI)[c]	N (%)[a]	Mean (95% CI)[c]	
Overall	965 (100.0)	18.8 (17.6, 19.9)	624 (100.0)	14.6 (13, 16.5)	4.2***	557 (100.0)	2.3 (2, 2.8)	627 (100.0)	2 (1.9, 2.1)	0.3***
Sex										
Male	474 (49.1)	19 (16.7, 21.6)	300 (48.1)	14.5 (12, 17.1)	4.5***	286 (51.3)	2.1 (1.8, 2.4)	301 (48)	1.8 (1.7, 2)	0.3*
Female	491 (50.9)	18.5 (17.1, 20.6)	324 (51.9)	14.7 (12.4, 16.7)	3.9**	271 (48.7)	2.6 (2, 3.7)	326 (52)	2.1 (2, 2.3)	0.5**
Age group										
0-6 y	88 (9.1)	11.6 (9.4, 14.3)	12 (1.9)	8.6 (2.8, 17)	3	14 (2.5)	1.9 (1.6, 2.1)	12 (1.9)	2.2 (1.6, 2.8)	-0.2

Characteristics	Baseline period					COVID-19 Outbreak				
	Shanghai		Wuhan		Difference[b]	Shanghai		Wuhan		Difference[b]
	N (%)	Mean (95% CI)[c]	N[a] (%)	Mean (95% CI)[c]		N (%)	Mean (95% CI)[c]	N (%)[a]	Mean (95% CI)[c]	
7-19 y	141 (14.6)	27 (23.9, 30.4)	79 (12.7)	16.2 (12.6, 19.9)	10.9***	55 (9.9)	2.6 (2, 3.8)	79 (12.6)	2.1 (2, 2.3)	0.5
20-39 y	236 (24.5)	22.4 (19.9, 25.1)	254 (40.7)	15.3 (12.9, 17.9)	7.1***	254 (45.6)	2.2 (2, 2.4)	256 (40.8)	2.1 (1.9, 2.2)	0.1
40-59 y	233 (24.1)	19.9 (17.4, 22.5)	221 (35.4)	13.8 (11.3, 17.3)	6.1***	160 (28.7)	2.8 (1.9, 4.1)	220 (35.1)	2 (1.9, 2.1)	0.8***
⩾60 y	267 (27.7)	12.6 (10.9, 14.1)	58 (9.3)	13.9 (7.7, 21.2)	-1.3	74 (13.3)	1.6 (1.4, 1.9)	60 (9.6)	1.4 (1.2, 1.7)	0.1
Type of profession										
Pre-school	79 (8.2)	10.4 (7.3, 13.5)	12 (1.9)	8.6 (3.3, 19.9)	1.8	14 (2.5)	1.9 (1.7, 2.1)	12 (1.9)	2.2 (1.6, 2.8)	-0.2
Student	173 (17.9)	26.2 (23, 29.3)	107 (17.1)	14.6 (10.6, 18.4)	11.5***	71 (12.7)	2.5 (2.1, 3.2)	107 (17.1)	2.1 (2, 2.3)	0.3
Employed	400 (41.5)	22.5 (20.3, 25.2)	391 (62.7)	15.4 (13.3, 17.4)	7.1***	354 (63.6)	2.5 (2.1, 3.2)	390 (62.2)	2.1 (1.9, 2.2)	0.5***
Unemployed	29 (3)	14.5 (7.9, 27.1)	30 (4.8)	14.1 (5.3, 25.3)	0.4	24 (4.3)	1.8 (1.4, 2.3)	31 (4.9)	1.8 (1.3, 2.6)	0
Retired	278 (28.8)	11.8 (9.9, 13.2)	84 (13.5)	12.1 (8.3, 18)	-0.3	94 (16.9)	1.6 (1.3, 1.8)	87 (13.9)	1.5 (1.3, 1.7)	0.1
Household size										
1	35 (3.6)	15.2 (10.2, 21.4)	45 (7.2)	10.5 (5.4, 17.4)	4.7	61 (11)	0.3 (0.1, 0.5)	45 (7.2)	0.6 (0.1, 1.6)	-0.2
2	244 (25.3)	14.5 (12, 17.3)	73 (11.7)	12.6 (7.5, 17.1)	1.8	138 (24.8)	1.4 (1.1, 1.8)	76 (12.1)	1.1 (0.9, 1.3)	0.3
3	432 (44.8)	20.3 (18.3, 22.2)	282 (45.2)	14.8 (12.4, 17)	5.4***	216 (38.8)	2.2 (2, 2.3)	283 (45.1)	1.9 (1.8, 2)	0.3*
4	117 (12.1)	20.3 (16.3, 23.7)	133 (21.3)	11.9 (9.3, 14.3)	8.3***	78 (14)	3 (2.8, 3.2)	132 (21.1)	2.3 (2.2, 2.5)	0.7**
⩾5	137 (14.2)	21.4 (17.7, 25)	91 (14.6)	21.5 (16.2, 26.1)	-0.1	64 (11.5)	5.9 (3.9, 10.7)	91 (14.5)	3.2 (2.9, 3.4)	2.7***

Note that reduced denominators indicate missing data. Percentages may not total 100 because of rounding.

[a]Can differ from total sample size (n=636) as it also includes participants who had not recorded contacts during regular weekdays or during the COVID-19 outbreak.

[b]Difference is calculated by the subtraction of the number of contacts in Wuhan from the number of contacts in Shanghai. P-values are taken from a negative binomial regression with a single binary variable distinguishing the Shanghai and Wuhan.

[c]The 95% confidence interval on the mean are calculated by bootstrap sampling.

*p<0.05, **p<0.01, ***p<0.001.

3.4 Number of contacts given household size

We regressed the number of contacts on participant age and household size using multiple generalized additive model, separately for each location and time period (baseline period and COVID-19 outbreak). We assumed that the number of contacts followed a negative binomial distribution. Penalized spline was used to explore potential nonlinear relationships between participant age (continuous variable) and number of contacts.

In the regression model, household size had significant contribution to the number of contacts. Further, the number of contacts had a significant nonlinear association with participant age for the Shanghai baseline period. After adjusting for nonlinear association between the participant age and the number of contacts, participants in larger households had significantly greater number of contacts, especially during the outbreak (see Tab. S7 and Fig. S7).

Table S7. *Generalized additive model regression coefficient.*

Household size	Wuhan		Shanghai	
	Baseline period	**COVID-19 Outbreak**	**Baseline period**	**COVID-19 Outbreak**
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Intercept	11.8 (9.5, 14.6)	0.9 (0.8, 1.1)	15.7 (13.9, 17.8)	1.1 (0.9, 1.3)
1-2	Ref	Ref	Ref	Ref
3-4	1.2 (0.9, 1.5)	2.2 (1.8, 2.7) ***	1.1 (1, 1.3)	2.2 (1.8, 2.6) ***
>4	1.8 (1.3, 2.5) ***	3.5 (2.8, 4.4) ***	1.3 (1.1, 1.7) **	5.3 (4.3, 6.5) ***

*p<0.05, **p<0.01, ***p<0.001.

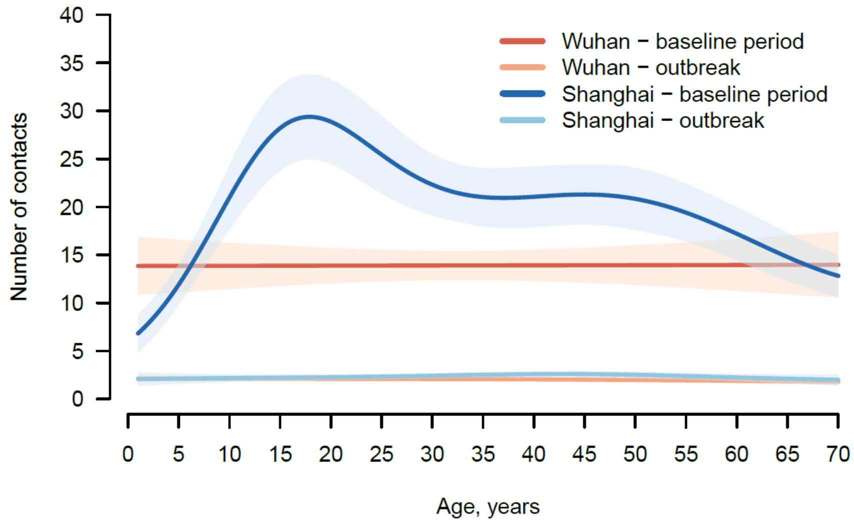

Figure S7. *Estimated number of contacts in regression models assuming the household size is 3~4. 95% confidence intervals are denoted by a shaded region.*

3.5 Analysis of contact setting and relationship during the COVID-19 outbreak

We analyzed the recorded contacts by social setting where the interaction took place (e.g., home, workplace, hospital) and by the type of relationship between the participant and his/her contacts (e.g., member of the same household, work colleague). We found that, in both cities, the vast majority of contacts during the outbreak period occurred at home and with household members (Fig. S8).

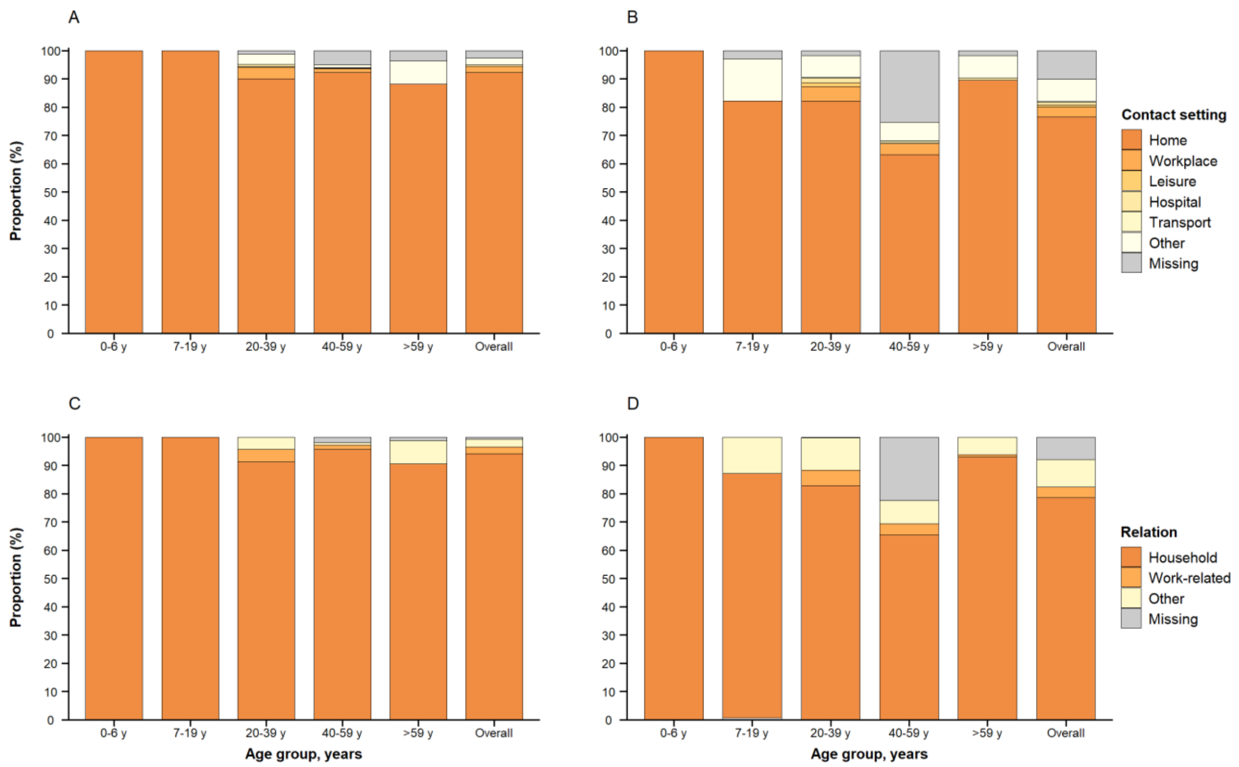

***Figure S8. A** Frequency of settings where contacts took place during the COVID-19 outbreak in Wuhan. **B** Same as A, but in Shanghai. **C** Frequency of relationships between contacts during the COVID-19 outbreak in Wuhan. **D** Same as C, but in Shanghai.*

3.6 Construction of the contact matrices and related uncertainty

We defined 14 age groups (0-4 y, 5-9 y, 10-14 y, 15-19 y, 20-24 y, 25-29 y, 30-34 y, 35-39 y, 40-44 y, 45-49 y, 50-54 y, 55-59 y, 60-64 y, 65 y and over) to build age-specific contact matrices. We estimated the age-specific contact rate per person per day using the "socialmixr" package in R 3.6.0. Contact matrices representing contact patterns during a regular day (referred to as "baseline period contact matrix") and during the COVID-19 outbreak (referred to as "outbreak contact matrix") were estimated for both Wuhan and Shanghai(*7*). We also built within-household contact matrices for COVID-19 and calculated the correlation between the household-specific and full contact matrices during the outbreak.

To account for the uncertainty of the contact matrices and sample representativeness, we performed bootstrap sampling with replacement of survey participants weighted by the age distribution of the actual population of Wuhan or Shanghai. Each cell of the contact matrix thus represents an average of 100 bootstrapped realizations. All analyses in this study were based on the bootstrapped contact matrices.

i Comparison between the COVID-19 outbreak contact matrices and the within-household contact matrices

We found that the contact matrices during the COVID-19 outbreak were nearly identical to the within-household contact matrices both in Wuhan and Shanghai (Fig. S9A and S9C). We calculated the Pearson's coefficient between these two matrices and found highly significant correlations (0.99 for Wuhan and 0.96 for Shanghai, Fig. S9B and S9D). The comparison between Fig. S9B and Fig. S9D suggests that during the COVID-19 outbreak when control measures were in place, contacts outside of household have been more numerous in Shanghai than in Wuhan. In fact, we also estimated that a larger fraction of workers reported contacts in the workplace in Shanghai (see Section 3.5).

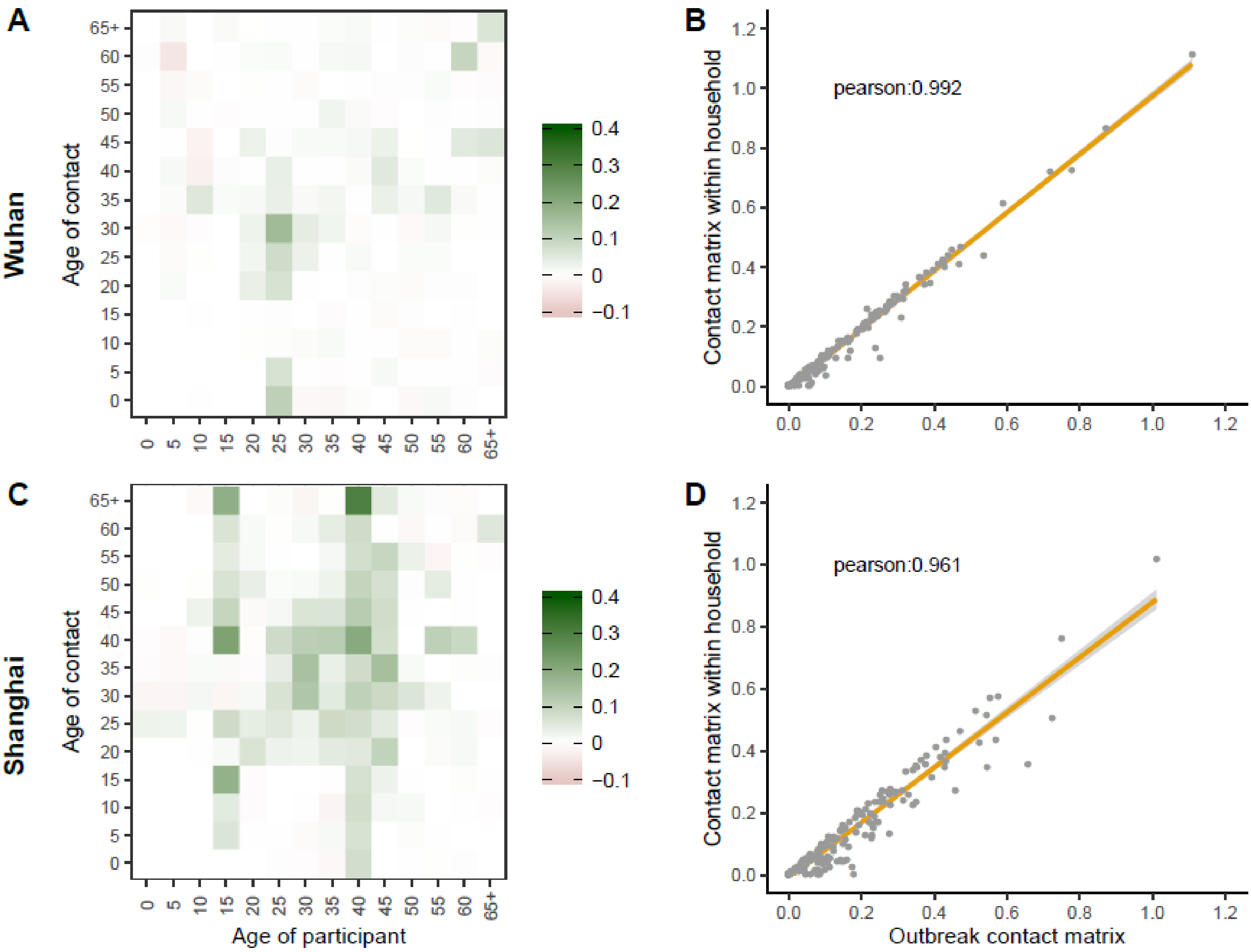

***Figure S9. A** Difference between the outbreak contact matrix and the within-household contact matrix for Wuhan. **B** Correlation between the elements of the outbreak contact matrix and the within-household contact matrix for Wuhan. The panel also reports the value of the Pearson correlation coefficient. **C** and **D** Same as A and B, but for Shanghai.*

ii Assortativity of contacts

In order to assess the degree of age assortativity of the estimated contact matrices, we calculated the *q-index*, a measure representing departures from proportionate mixing, ranging from zero (proportionate) to one (fully assortative)(*34*). In particular,

$$\text{q-index } = \widehat{\lambda_2}/\widehat{\lambda_1}$$

where $(\widehat{\lambda_1}, \dots, \widehat{\lambda_M})$ is the vector of the absolute values of the real part of the eigenvalues of the contact matrix, ordered from the largest (i.e., the dominant eigenvalue) to the smallest.

We found that in Wuhan, age-mixing patterns were slightly more assortative (i.e., contacts mostly with individuals of the same age group) for the baseline period (q-index=0.59, 95% CI: 0.49-0.64) than those during the COVID-19 outbreak (q-index=0.46, 95% CI: 0.4-0.54). During the outbreak, participants aged 0-14 years reported no contacts with individuals of the same age group (see Fig. S10). In Shanghai, a much larger drop in assortativity was found during the COVID-19 outbreak. For the baseline period, the q-index was 0.79 (95% CI: 0.69-0.89) and it dropped to 0.38 (95% CI: 0.33-0.52) during the outbreak. For participants aged 0-19 years, no contacts where recorded with individuals of the same age group. Both in Wuhan and Shanghai we observed an increase in contacts with individuals of the same age group among the elderly (Fig. S10).

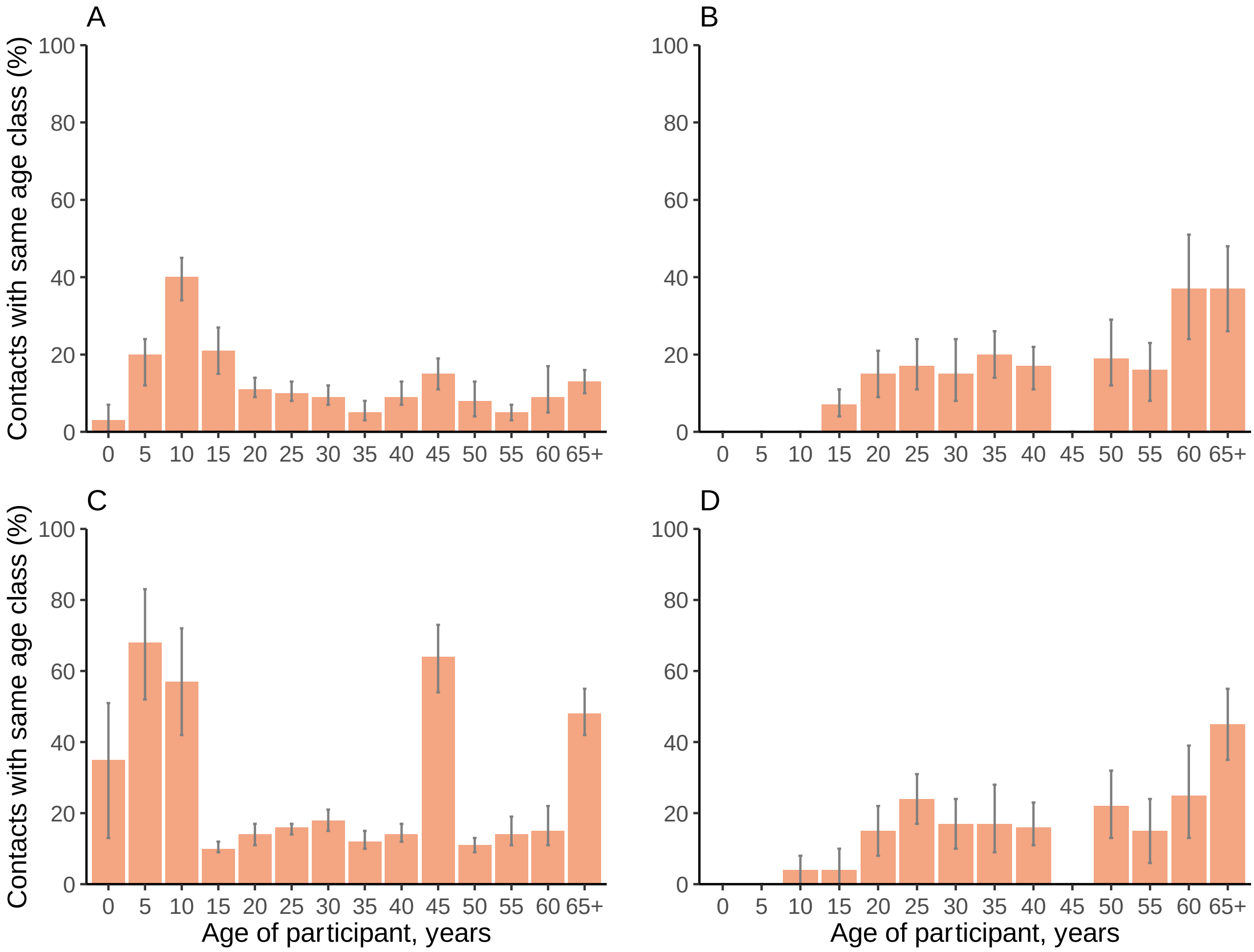

***Figure S10. A** The proportion of contacts with the same age class during baseline period in Wuhan. **B** Same as A, but during the COVID-19 outbreak. **C** Same as A, but in Shanghai. **D** Same as B, but in Shanghai. The vertical lines correspond to the 95% bootstrapped CI.*

iii Contact matrix data

The mean of 100 bootstrapped contact matrices for the baseline period and for the COVID-19 outbreak, both for Wuhan and Shanghai are provided in Tab. S8-S11.

Table S8*. Contact matrix (5-year age bands) of reported contacts for participants in Wuhan during baseline period, consisting of the average number of contacts per day recorded by the survey participant, stratified by the age group of the contact.*

		Age of contact													
		0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Age of participant	**0-4**	0.11	0.35	0.42	0.55	0.88	0.35	0.58	0.12	0.00	0.00	0.00	0.00	0.11	0.33
	5-9	1.69	2.31	2.27	5.84	0.61	0.58	0.62	0.55	0.21	0.23	0.29	0.17	0.16	0.18
	10-14	0.06	3.76	4.08	8.39	0.65	0.75	0.43	0.31	0.47	0.60	0.20	0.31	0.03	0.16
	15-19	0.00	1.35	1.62	4.41	0.56	0.43	0.40	0.24	0.61	0.47	0.24	0.28	0.23	0.14
	20-24	0.31	0.38	0.16	0.82	2.66	1.65	1.67	1.37	0.81	0.98	0.61	0.67	0.18	0.41
	25-29	1.41	0.70	0.37	0.99	3.08	1.67	1.66	1.43	0.75	0.97	0.43	0.48	0.20	0.45
	30-34	1.33	1.29	0.35	1.11	2.65	1.82	1.60	1.26	0.81	1.15	0.76	0.62	0.29	0.48
	35-39	0.84	0.99	0.53	1.36	3.10	1.92	1.83	1.70	1.33	1.45	0.83	0.83	0.50	0.86
	40-44	0.84	0.60	0.33	0.83	2.37	1.20	1.21	1.23	0.78	1.30	0.76	0.58	0.76	1.60
	45-49	0.43	0.88	0.42	1.39	1.41	0.76	0.94	0.91	1.03	1.18	0.97	0.79	0.49	0.88
	50-54	0.37	0.58	0.22	0.75	1.26	0.94	0.80	0.60	0.92	1.20	0.89	0.66	1.00	2.03
	55-59	0.55	0.69	0.24	1.07	1.92	0.98	1.02	1.34	1.16	0.62	0.95	0.84	1.64	4.10
	60-64	0.40	0.24	0.13	0.39	1.33	0.73	0.78	0.61	1.01	1.76	0.89	0.76	1.18	2.76
	65+	1.06	0.68	0.31	0.86	2.06	1.50	1.31	0.69	1.11	1.17	0.74	1.22	0.98	1.91

***Table S9**. Contact matrix (5-year age bands) of reported contacts for participants in Wuhan during the COVID-19 outbreak, consisting of the average number of contacts per day recorded by the survey participant, stratified by the age group of the contact.*

		Age of contact													
		0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Age of participant	**0-4**	0.00	0.11	0.00	0.00	0.00	0.00	1.11	0.44	0.23	0.00	0.00	0.00	0.21	0.11
	5-9	0.00	0.00	0.00	0.00	0.06	0.05	0.45	0.87	0.20	0.10	0.07	0.09	0.22	0.09
	10-14	0.00	0.00	0.00	0.04	0.00	0.00	0.03	0.78	0.59	0.32	0.16	0.03	0.00	0.07
	15-19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.47	0.72	0.15	0.00	0.05	0.20
	20-24	0.04	0.02	0.01	0.05	0.13	0.05	0.06	0.02	0.19	0.43	0.42	0.21	0.11	0.10
	25-29	0.24	0.16	0.03	0.04	0.10	0.31	0.25	0.10	0.10	0.04	0.36	0.21	0.10	0.03
	30-34	0.29	0.38	0.16	0.01	0.00	0.07	0.39	0.24	0.10	0.02	0.06	0.11	0.28	0.19
	35-39	0.14	0.30	0.29	0.06	0.00	0.02	0.22	0.31	0.28	0.04	0.03	0.04	0.17	0.19
	40-44	0.05	0.07	0.32	0.27	0.08	0.01	0.02	0.11	0.40	0.27	0.07	0.02	0.05	0.30
	45-49	0.00	0.08	0.03	0.24	0.27	0.16	0.02	0.08	0.17	0.37	0.28	0.09	0.02	0.41
	50-54	0.04	0.01	0.03	0.03	0.24	0.23	0.09	0.05	0.03	0.13	0.32	0.25	0.05	0.21
	55-59	0.26	0.00	0.05	0.00	0.11	0.20	0.16	0.05	0.20	0.00	0.15	0.31	0.10	0.36
	60-64	0.06	0.10	0.01	0.01	0.05	0.01	0.08	0.08	0.02	0.06	0.08	0.14	0.53	0.23
	65+	0.00	0.06	0.06	0.00	0.00	0.00	0.12	0.12	0.06	0.06	0.06	0.06	0.23	0.47

Table S10. *Contact matrix (5-year age bands) of reported contacts for participants in Shanghai during the baseline period, consisting of the average number of contacts per day recorded by the survey participant, stratified by the age group of the contact.*

		Age of contact													
		0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Age of participant	**0-4**	3.17	0.24	0.06	0.03	0.07	0.82	1.21	0.68	0.17	0.11	0.26	0.53	0.63	0.62
	5-9	0.29	13.03	1.76	0.04	0.13	0.36	0.93	1.41	0.26	0.16	0.04	0.30	0.57	0.86
	10-14	0.00	1.14	17.50	2.51	0.25	0.29	0.47	1.04	0.92	0.49	0.23	0.13	0.16	0.69
	15-19	0.00	0.05	0.97	17.64	0.85	1.03	1.64	2.57	1.65	1.59	0.94	0.71	0.28	0.92
	20-24	0.10	0.00	0.08	0.07	2.15	2.67	2.44	3.04	2.95	3.17	1.72	1.27	0.61	0.82
	25-29	0.16	0.07	0.07	0.21	1.14	2.76	2.56	3.29	2.05	2.41	1.86	1.74	0.87	1.27
	30-34	0.42	0.41	0.06	0.32	1.44	2.65	4.11	4.53	2.81	3.38	1.98	1.86	1.05	1.17
	35-39	0.11	0.29	0.33	0.18	0.76	1.57	2.30	3.07	2.17	2.32	1.31	1.33	0.69	0.63
	40-44	0.04	0.08	0.37	0.45	0.76	1.55	2.20	3.23	2.21	2.82	1.34	0.90	0.37	1.51
	45-49	0.04	0.09	0.25	0.27	1.42	1.95	2.64	2.81	2.78	2.91	2.03	1.18	0.58	1.53
	50-54	0.09	0.06	0.12	0.24	1.04	1.77	1.48	2.70	2.15	2.57	2.10	1.68	1.48	2.56
	55-59	0.10	0.09	0.04	0.07	0.61	1.24	1.66	1.96	1.32	1.75	1.46	2.37	1.08	2.79
	60-64	0.05	0.03	0.10	0.05	0.26	0.72	0.96	1.10	0.82	0.93	1.03	1.57	1.78	2.46
	65+	0.03	0.12	0.06	0.06	0.13	0.27	0.25	0.56	0.69	0.74	0.68	0.88	1.48	5.56

***Table S11**. Contact matrix (5-year age bands) of reported contacts for participants in Shanghai during the COVID-19 outbreak, consisting of the average number of contacts per day recorded by the survey participant, stratified by the age group of the contact.*

		Age of contact													
		0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65+**
Age of participant	**0-4**	0.00	0.00	0.00	0.00	0.00	0.29	0.55	1.01	0.14	0.00	0.14	0.00	0.00	0.00
	5-9	0.04	0.00	0.00	0.00	0.00	0.26	0.51	0.75	0.11	0.08	0.00	0.00	0.00	0.00
	10-14	0.00	0.00	0.00	0.00	0.14	0.05	0.38	0.47	0.34	0.54	0.09	0.00	0.00	0.09
	15-19	0.12	0.06	0.19	0.18	0.25	0.43	0.11	0.20	0.72	0.52	0.43	0.23	0.09	0.46
	20-24	0.02	0.02	0.06	0.04	0.08	0.09	0.05	0.09	0.25	0.32	0.42	0.26	0.13	0.18
	25-29	0.05	0.06	0.00	0.03	0.09	0.22	0.11	0.08	0.08	0.07	0.35	0.27	0.04	0.06
	30-34	0.18	0.20	0.05	0.01	0.08	0.12	0.57	0.28	0.16	0.07	0.10	0.17	0.25	0.19
	35-39	0.15	0.26	0.19	0.08	0.05	0.10	0.15	0.43	0.35	0.11	0.04	0.03	0.31	0.28
	40-44	0.16	0.23	0.31	0.24	0.11	0.08	0.15	0.23	0.54	0.34	0.14	0.09	0.21	0.66
	45-49	0.00	0.00	0.28	0.29	0.23	0.12	0.11	0.17	0.25	0.39	0.33	0.14	0.00	0.10
	50-54	0.02	0.03	0.07	0.05	0.24	0.36	0.07	0.06	0.00	0.10	0.43	0.19	0.22	0.12
	55-59	0.03	0.04	0.00	0.00	0.16	0.08	0.22	0.00	0.23	0.08	0.16	0.26	0.35	0.15
	60-64	0.02	0.06	0.02	0.03	0.06	0.08	0.21	0.12	0.13	0.00	0.02	0.10	0.40	0.38
	65+	0.00	0.04	0.01	0.05	0.00	0.05	0.10	0.09	0.06	0.00	0.00	0.05	0.28	0.58

4. Contacts and mobility

For comparison with our survey data, we estimated population mobility in Wuhan and Shanghai for the same period as the contact surveys. We leveraged aggregated and de-identified mobility data from Baidu users, the largest Chinese search engine. Baidu offers location-based service (LBS), based on the global positioning system (GPS), IP address, location of signaling towers and WIFI during online searching, mapping, usage of a large variety of apps and software on mobile devices. This data has been used to visualize population migratory patterns around Chinese New Year(*35*) and quantify the mobility network for COVID-19 research(*36*). Indices of intra-city traffic volumes were obtained from https://qianxi.baidu.com/ . The Baidu mobility index of intra-city traffic volume is a normalized ratio of a city's population with intra-city movement within 24 hours to a city's residential population, although the details of the normalization algorithm have not been made available by the company. The Baidu mobility index has been used to represent the resumption of economic activities and normal societal functions in Leung et al (*37*).

To be comparable with our contact survey, we considered the period from January 6 to January 12, 2020 (Monday to Sunday) to measure mobility for the baseline period. We considered the period from January 31 to February 9 for the outbreak period (Fig. S11). We found that the mobility was reduced by 86.9% between these periods in Wuhan, and by 74.5% in Shanghai (Tab. S12). These reductions were similar to the reduction in numbers of contacts reported in our contact survey between baseline and outbreak periods (i.e., 86.3% for Wuhan and 87.8% for Shanghai).

Within-city mobility and population contact patterns reflect different phenomena. However, during the special event of a lockdown, they may be correlated. In fact, in the contact survey we found that during the lockdown the vast majority of contacts occurred between household members and the drastic decrease in mobility highlighted by Baidu data suggests that people mainly remained in the same location (likely, the place of residence). Nevertheless, it is important to stress the limitation of the mobility data we analyzed, such as possible biases of the mobile phone user population, coverage, and Baidu user self-selection. Although a high percentage of the population owns mobile phones in China, the users are still underrepresented among specific subgroups, namely children and the elderly.

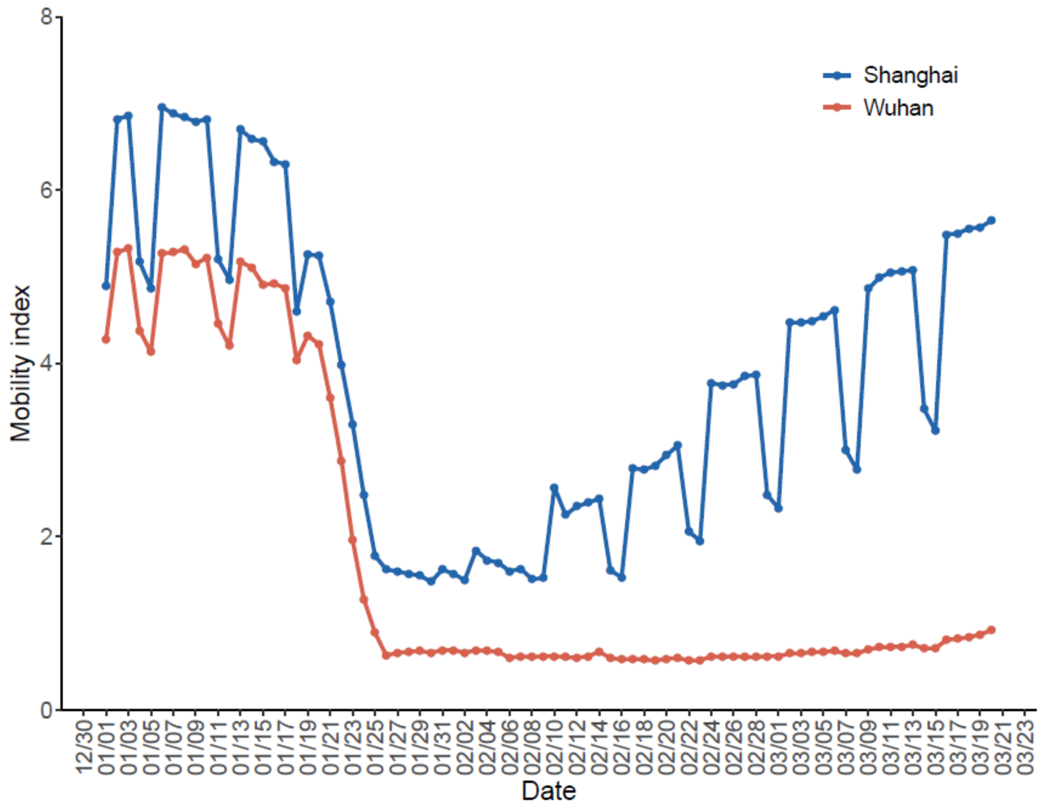

Figure S11. *Baidu mobility index.*

Table S12. *Changes in within-city mobility index in Wuhan and Shanghai.*

Location	Regular days	COVID-19 outbreak	Reduction (%)
Wuhan	5.0	0.7	86.9
Shanghai	6.4	1.6	74.5

5. Age profile of susceptibility to SARS-CoV-2 infection

Our analysis of susceptibility to infection by age is based on the analysis of contact tracing data for Hunan province, using the official line list of patient-level information and contact data collected by the Hunan CDC.

Case definitions

A suspected COVID-19 case was defined as a person with pneumonia who fulfilled the following clinical criteria (fever; respiratory symptoms; radiographic evidence of COVID-2019; low or normal white-cell count and low lymphocyte count in early onset) and within 14 days preceding symptom onset, had the following: 1) travel history to or resided in epidemic regions (e.g., Hubei Province including Wuhan city or other communities with laboratory-confirmed cases); or 2) was in close contact with a laboratory-confirmed case.

A confirmed case was defined as an individual who met the criteria for a suspected case and was diagnosed with SARS-CoV2 based on positive viral nucleic acid test results of throat swab samples.

An asymptomatic infected individual was defined as an individual who was diagnosed through positive viral nucleic acid test, but had no COVID-19 symptoms (e.g., no fever, no dry cough). Asymptomatic cases were generally discovered through contact tracing of index cases.

The sum of symptomatic and asymptomatic subjects identified through contact tracing is hereafter referred to as the number of infections that we used in our analysis.

Data collection and contact tracing

On January 16, 2020, Hunan CDC identified the first case of 2019 novel coronavirus. Since then, Hunan CDC actively initiated field investigations to monitor the contacts of identified cases. Contacts were followed for 14 days after the last known exposure.

Contacts of COVID-19 cases were divided into close and general contacts. Close contacts were defined as: 1) individuals who had been within 1 meter of confirmed and suspected cases in the two days before the onset of illness of their suspected symptomatic infector and thereafter, AND did not take effective precautions during their contacts; OR 2) individuals who had been within 1 meter of confirmed and suspected cases in the two days before the sample collection of their suspected asymptomatic infector and thereafter, AND did not take effective precautions during their contacts.

Close contacts included 1) household members living with a case; 2) relatives who had been in close contact with a case; 3) healthcare workers who diagnosed, treated, or nursed a case; 4) other patients and caregivers in the same ward as a case; 5) friends, coworkers, or classmates who studied, worked, or had been in close contact with a case; 6) staff who were in contact with a case in public places; 7) persons who took the same vehicle and were in close contact with a case.

General contacts included those who had been exposed to the index case during work, study, or public transportation, but did not meet the criteria for close contacts.

All close contacts were tested for SARS-CoV2 according to the official guidelines of Hunan province. During the study period, general contacts were not tested and were thus excluded from the analysis.

Statistical analysis

We analyzed the official line list of confirmed cases as well as their close contacts identified by the Hunan CDC between January 16, 2020 and March 1, 2020. A total of 146 clusters for confirmed cases were identified by contact tracing investigations. Among them, for 32 clusters of median size 2 (IQR 1-4.22) no contacts were identified other than the linked cases and no unique index case was identified. Out of these clusters, 4 contained only a single case and the other 18 included only individuals who visited or resided in Wuhan/Hubei with no other identified contacts (median number per cluster: 2, IQR: 2-4). Therefore, to provide the estimates of susceptibility to infection, we analyzed 114 clusters representing 136 index cases, their contacts, and the contacts of infected contacts. Details of index case characteristics are presented in Tab. S13. Excluding the index cases, we analyzed the records of 7,375 individuals.

We categorized contacts in 4 age groups (0-14 years, 15-64 years, 65+ years, and unknown age). Other covariates included gender, the type of connection with the probable infector (Household, Healthcare, Transport, Other), whether they were exposed before or after the introduction of the strict social distancing measures, and whether contacts had traveled to/from Wuhan/Hubei (Tab. S14).

We analyzed the odds ratios of being infected given the covariates. To account for the clustering in the binary data, we explored three models: (i) a fixed effect logit model(*9*), in particular we consider a cluster-stratified Cox model, (ii) a mixed effect logit model (generalized linear mixed-effects model, GLMM, for binary data with logit link), and (iii) a generalized estimation equation (GEE) model.

In the main text, we report only the results of the GLMM model as it represents the preferable choice given the structure of the analyzed data (*38, 39*). The specification of the GLMM is the following:

$$g(\mu_{ic}) = \alpha \ + \beta_1 A_{ci} + \beta_2 T_{ci} + \beta_3 S_{ci} + \beta_4 M_{ci} + \beta_5 W_{ci} + u_c$$

where g is a logit link function, α is the intersect, A_{ci} denotes the fixed effects of age group of contact i, T_{ci} stands for the type of contact between contact i and the infector, S_{ci} is the gender of contact i, M_{ci} differentiates whether the exposure of contact i took place before or after the introduction of strict measures, W_{ci} differentiates whether contact i traveled to/from Wuhan/Hubei, u_c represents cluster-specific random effects, and $\mu_{ic} = E(Y_{ci}|u_c)$ is the mean of the response variable Y_{ci} for a given value of the random effects.

The GEE model relies on a similar specification for the initial GLM fitting, but with no u_c term and $\mu_{ic} = E(Y_i)$. To further account for clustering and possible correlation structure GEE uses u_c to define the clustering structure of the data with a working correlation matrix that defines the correlation within each cluster. We provide the results for the exchangeable correlation matrix, but independent and AR-1 matrices were explored as well and gave very similar results.

The cluster-stratified Cox model is provided for comparison. This model does not provide intercept α estimates and u_c defines the stratification.

***Table S13**. Characteristics of the index cases of 114 clusters in Hunan.*

Characteristics	Number of index cases[a]
Age of index case(s)	
0-14 y	1
15-64 y	116
65+ y	19
Unknown	0
Exposure relative to the introduction of strict control measures (January 23, 2020)	
After	5
Before	58
Unclear	73
Sex	
Male	76
Female	60
Traveled to/from Wuhan/Hubei	
Yes	71
No	64
Unknown	1

[a]The same cluster may have more than one index case. 32% of clusters have multiple index cases.

***Table S14**. Characteristics of the contacts based on 114 clusters in Hunan.*

Characteristics	Not infected	Infected	% Infected
Age			
0-14 y	709	47	6.2
15-64 y	5242	491	8.6
65+ y	589	115	16.3
Unknown	175	7	3.8
Type of contact			
Household contacts	617	339	35.5
Healthcare contacts	565	7	1.2
Contacts on means of transportation	304	22	6.7
Other contacts	5229	292	5.3
Exposed relative to the introduction of strict measures (January 23, 2020)			
After	3107	168	5.1
Before	3196	323	9.2
Unclear	412	169	29.1
Sex			
Male	3531	305	8.0
Female	3184	355	10.0
Traveled to/from Wuhan/Hubei			
Yes	4612	540	10.5
No	2053	117	5.4
Unknown	50	3	5.7

Results

In Tab. S15, we report the results of the regression analysis. All models provide very similar results for age groups, both in terms of the magnitude of the coefficient and the level of significance. Our results highlight a lower probability of infection among younger individuals (0-14 years old) and a higher probability of infection among elderly (65+ years old), given exposure. Household contacts were infected more often that other contacts (including work contacts, friends, other family contacts, transportation-related and healthcare contacts). Contacts with travel history to/from Wuhan/Hubei tended to be infected more frequently while those exposed after the introduction of strict social distancing measures tended to be infected less frequently.

Table S15*. Results of regression models.*

Characteristics	Stratified Cox		GLMM[a]		GEE[b]	
	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
Intercept	-	-	0.79 (0.60, 1.05)	0.0972	0.72 (0.50, 1.04)	0.0762
Age						
0, 14 y	0.33 (0.23, 0.48)	<0.0001	0.34 (0.24, 0.49)	<0.0001	0.38 (0.22, 0.65)	<0.0001
15, 64 y	Reference	-	Reference	-	Reference	-
65+ y	1.44 (1.10, 1.90)	0.0085	1.47 (1.12, 1.92)	0.0045	1.45 (1.02, 2.07)	0.0373
Unknown	0.40 (0.17, 0.94)	0.0360	0.42 (0.17, 0.90)	0.0413	0.47 (0.20, 1.13)	0.0924
Type of contact						
Household	Reference	-	Reference	-	Reference	-
Healthcare contacts	0.03 (0.01, 0.07)	<0.0001	0.03 (0.01, 0.06)	<0.0001	0.03 (0.02, 0.08)	<0.0001
Contacts on means of transportation	0.43 (0.24, 0.78)	0.0051	0.32 (0.18, 0.55)	<0.0001	0.29 (0.13, 0.65)	0.0026
Other contacts	0.14 (0.11, 0.17)	<0.0001	0.12 (0.10, 0.15)	<0.0001	0.14 (0.09, 0.20)	<0.0001
Sex						
Female	Reference	-	Reference	-	Reference	-
Male	0.81 (0.67, 0.98)	0.0265	0.81 (0.67, 0.97)	0.0240	0.83 (0.68, 1.01)	0.0633
Whether traveled to/from Wuhan/Hubei						
No	Reference	-	Reference	-	Reference	-
Yes	0.57 (0.41, 0.79)	<0.0001	0.52 (0.39, 0.70)	<0.0001	0.58 (0.40, 0.84)	0.0035
Unknown	0.61 (0.14, 2.62)	0.5028	0.48 (0.09, 1.80)	0.3223	0.55 (0.21, 1.49)	0.2431
Whether exposed after the introduction of strict measures (January 23, 2020)						
Before	Reference	-	Reference	-	Reference	-
After	0.43 (0.33, 0.57)	<0.0001	0.47 (0.36, 0.60)	<0.0001	0.54 (0.35, 0.83)	0.0053
Unclear	2.55 (1.89, 3.44)	<0.0001	2.67 (2.01, 3.54)	<0.0001	2.53 (1.63, 3.94)	<0.0001

[a]The random effects' variance is estimated to be 0.548 (Standard Deviation = 0.74).

[b]Table shows the results for the model assuming exchangeable working correlation matrix. Other assumptions were explored and provided similar results.

6. Modeling SARS-CoV-2 transmission

To simulate COVID-19 transmission dynamics using the information previously described on age-specific contact patterns, susceptibility, we used a classic age-structured SIR model(*40*). Briefly, susceptible individuals can acquire the infection through contacts with infectious individuals. Infectious individuals, who are infected and able to transmit the infection, can either recover or die. Each of these compartments is divided into 14 5-year age groups (0–4, 5–9, …, 60–64, 65+ years old). Susceptible individuals are exposed to an age-specific force of infection regulated by the average number of contacts per day that individuals of a given age group have with individuals of all age groups (i.e., the contact matrix – see Tab. S8-S11). We used the following set of differential equations to simulate this process:

$$\begin{cases} \dot{S_i} = -\beta \sum_{j=1}^{n} M_{ij} \frac{I_j}{N_j} \sigma_i S_i \\ \dot{I_i} = \beta \sum_{j=1}^{n} M_{ij} \frac{I_j}{N_j} \sigma_i S_i - \gamma I_j \\ \dot{R_i} = \gamma I_j \end{cases}$$

where,

- i represents the age group;
- n=14 is the total number of age classes;
- S_i the number of susceptible individuals in age group i;
- I_i the number of infectious individuals in age group i;
- R_i the number of recovered individuals in age group i;
- N_i the total number of individuals in age class i (i.e., $N_i = S_i + I_i + R_i$). The number of individuals in each age group was derived from official records(*19*).
- β is the transmission rate;
- γ is the recovery rate. In a SIR model, the recovery rate is equivalent to the inverse of the duration of the generation time(*41*). Therefore, we set $1/\gamma$ =5.1 days(*3*).
- M_{ij} is the average number of contacts between individuals in age group i with individuals in age group j. The matrix of elements M_{ij} represents the contact matrix for regular weekdays and the COVID-19 outbreak period, as estimated from our survey in Wuhan and Shanghai.
- σ_i is the susceptibility to infection of individuals in age group i.

The basic reproduction number R_0 was computed through the next-generation approach(*11*), following

$$R_0 = \frac{\beta}{\gamma} \rho(K)$$

where $\rho(K)$ is the spectral radius of matrix K and the elements of K are defined as $K_{ij} = \sigma_i M_{ij}$.

7. Limiting school contacts

To estimate the possible effect of limiting school-related contacts, we rely on the contact diaries collected by Zhang et al. (7) in Shanghai over the period from December 2017 to May 2018. In particular, we estimated an age-specific contact matrix for off-school days and vacations (hereafter referred as to "vacation" contact matrix) based on contact diaries relating to winter school holidays, public holidays (3 days for New Year, and 3 days for Labor Day) and weekends. We excluded contacts recorded during the Chinese New Year holidays, as contact patterns in that period are highly peculiar of that period only. In addition, we considered a second scenario based on the diaries of regular school/work days, after removing all contacts occurring at schools. The resulting contact matrix ("Baseline period, no contacts at school") represents a very crude approximation of the possible change in contact patterns due to school closures. In fact, it does not account for changes in contact patterns of child-caring members of families with school-age children, and for a possible increase in contacts among students in social settings other than school.

Those two additional contact matrices as well as those for the baseline period and outbreak period are shown in Fig. S12. The matrices were used in the transmission model introduced in Sec. 6.

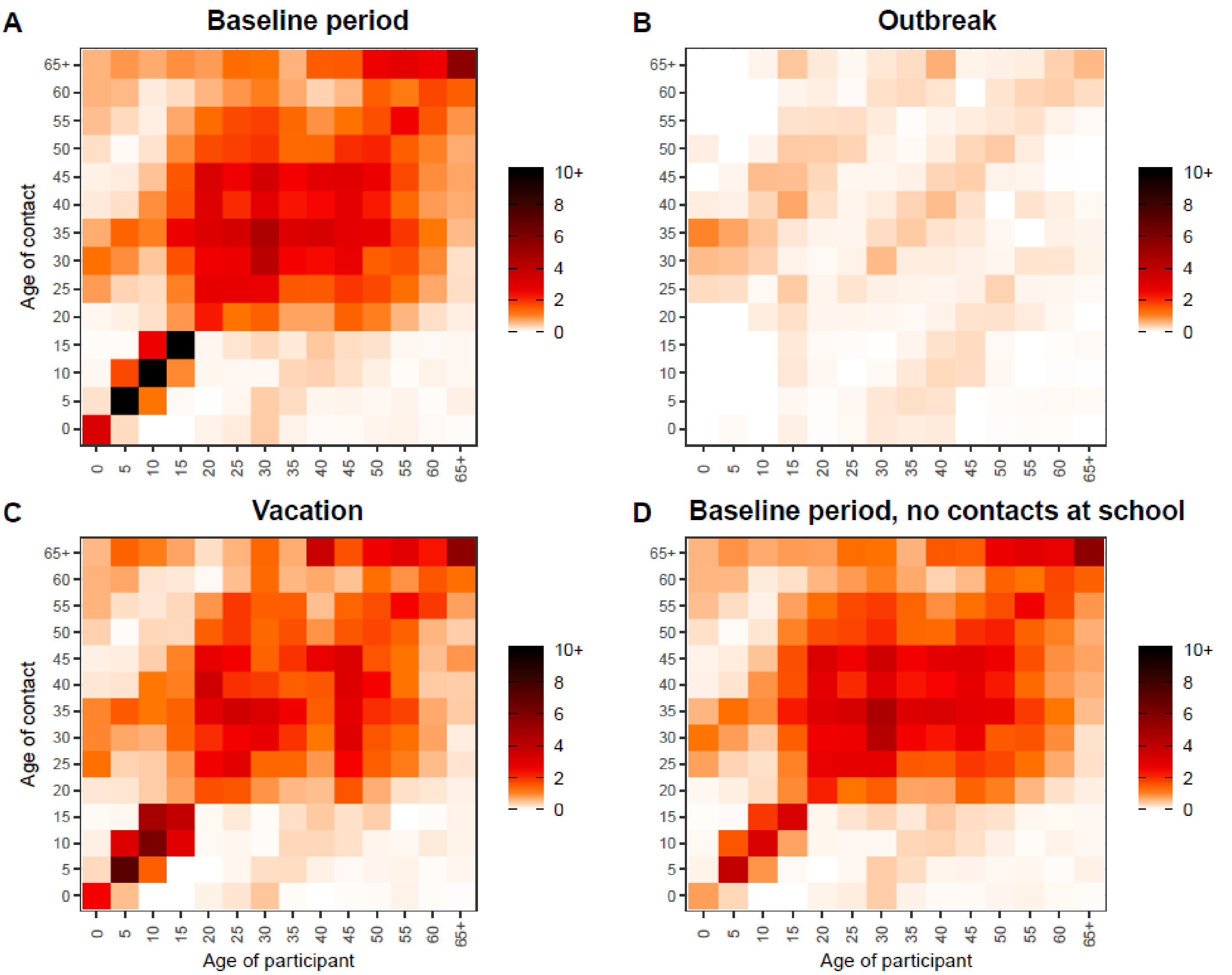

***Figure S12. A** Baseline period contact matrix for Shanghai. **B** Outbreak contact matrix for Shanghai. **C** Contact matrix estimated in Shanghai during vacations(7) **D** Contact matrix estimated in Shanghai during baseline period, suppressing all contacts occurring in school setting(7)*

8. Sensitivity analysis

8.1 Sensitivity analysis of the definition of contact

In the baseline analysis of the contact diary, a contact was defined as either (1) a two-way conversation with three or more words in the physical presence of another person (conversational contact), or (2) direct physical contact (e.g., a handshake, hug, kiss or performing contact sports). Here we performed a sensitivity analysis in Shanghai using an alternative definition of contact. In particular, for Shanghai we have collected (both for the baseline and outbreak periods) the self-reported duration of the contact, categorized as <5 mins, 5-14 mins, 15-59 mins, 1-4 hours, and 4+ hours. We calculated the (bootstrapped) contact matrices for the two periods considering only contacts lasting more than 5 minutes (Fig. S13A). We then use these matrices in the SARS-CoV-2 transmission model and found that the results obtained with this alternative definition of contact were very consistent with those obtained with the baseline definition (Fig. S13B).

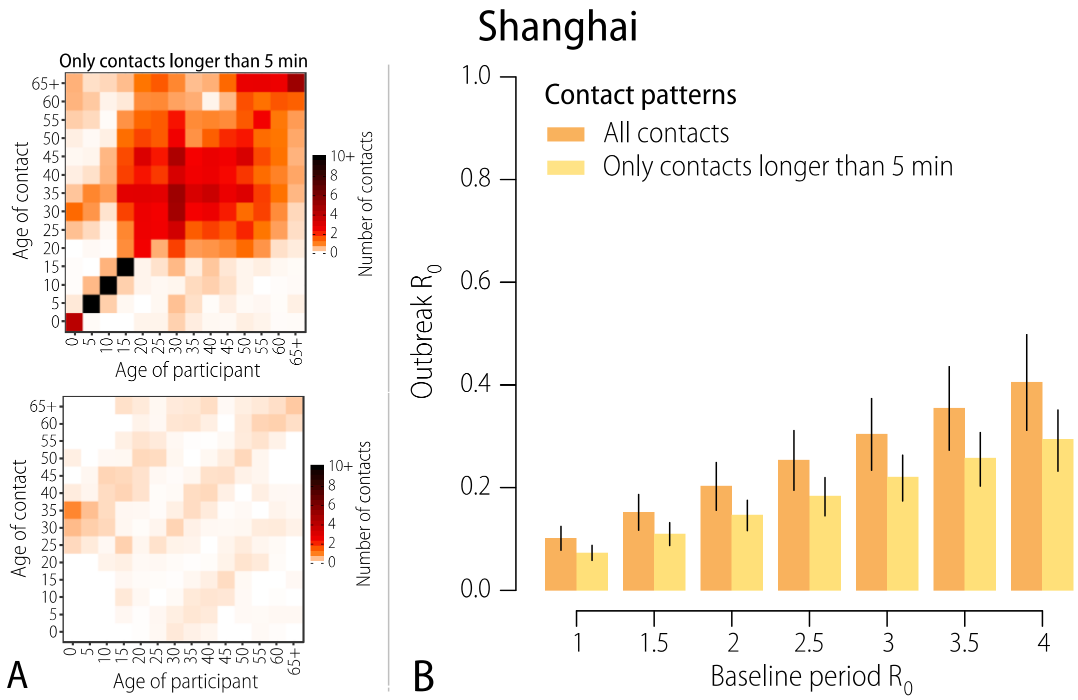

***Figure S13. A** Baseline period and outbreak contact matrix for Shanghai for contacts lasting longer than 5 minutes. Each cell of the matrix represents the mean number of contacts that an individual in a given age group has with other individuals, stratified by age groups. The color intensity represents the number of contacts. **B** Estimated R_0 during the outbreak (mean and 95%CI), as a function of baseline R_0 (i.e., derived by using the contact matrix estimated for the baseline period). Both baseline period and outbreak matrices are used either for all contacts (illustrated in Fig.1D of the main text) or for contacts lasting longer than 5 minutes (illustrated in A). The figure refers to Shanghai and shows the scenario assuming that all individuals are equally susceptible to infection.*

8.2 Sensitivity analysis of a possible compliance bias in contact surveys

We cannot entirely rule out that contacts reported during the outbreak period were minimized by survey participants due to fear of retaliation, since social distancing interventions were strictly enforced. To account for the potential compliance or social desirability bias of study participants, we assumed that the contacts occurring within household were properly reported, while only a fraction of non-household contacts was reported. Therefore, as a sensitivity analyses, we multiplied reported contacts outside the household by 150%, 200%, 250%, and 300%. The same procedure was used both for Wuhan and Shanghai. The resulting outbreak contacts matrices accounting for the 300% underreporting factor are shown in Fig. S14A,B. These matrices are used in a sensitivity analysis of the SARS-CoV-2 transmission model. We found that, even considering a 300% multiplication factor, social distancing would block SARS-CoV-2 transmission for the entire range of baseline R0 values considered (range: 1-4, see Fig. S14C).

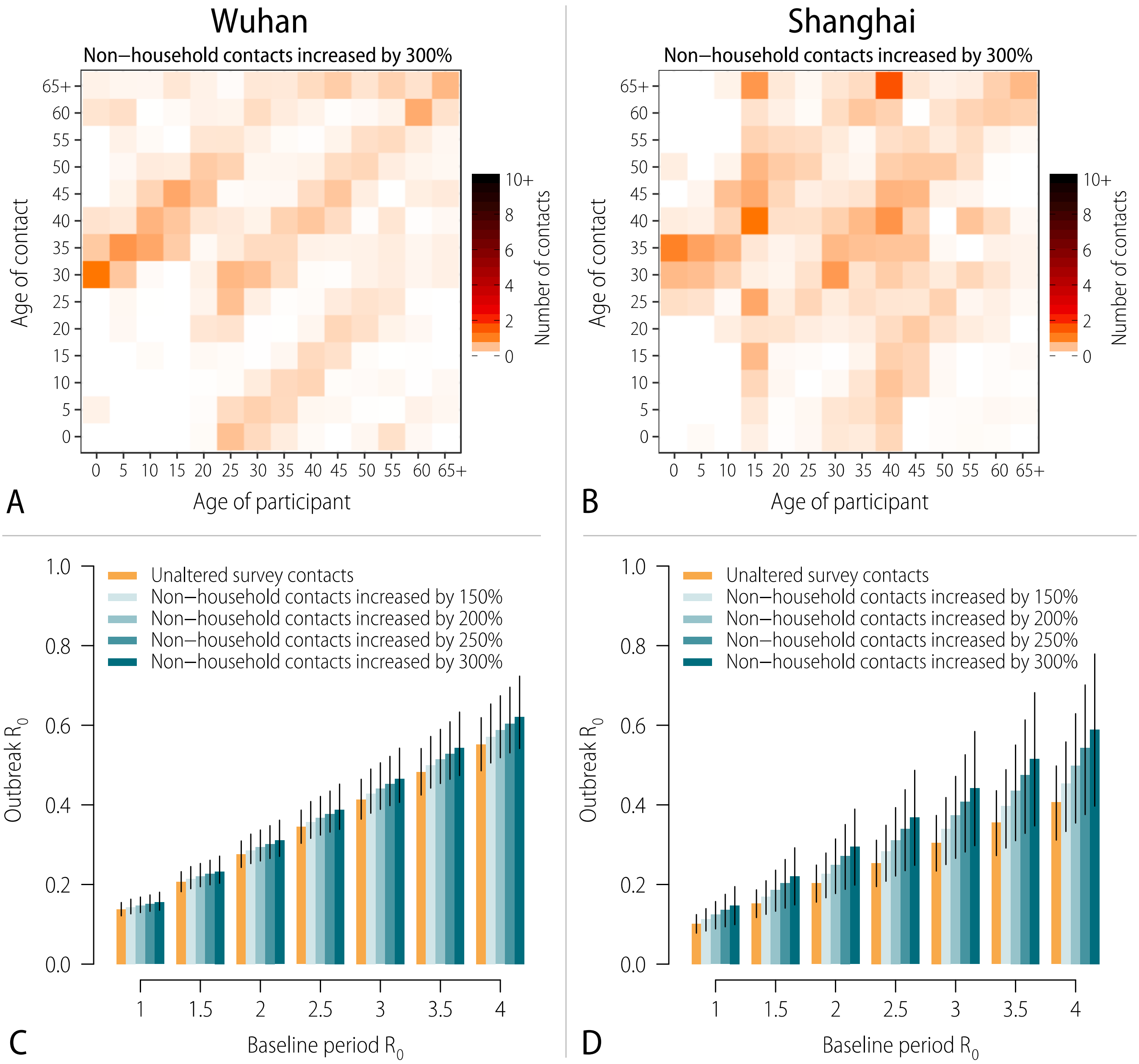

Figure S14. A** Outbreak contact matrix for Wuhan (regular weekday only) adjusted to contrast possible compliance or social desirability bias by increasing the number of non-household contacts by 300%. Each cell of the matrix represents the mean number of total contacts that an individual in a given age group has* *with other individuals, stratified by age groups. The color intensity represents the number of contacts.* ***B *Same as A, but for Shanghai* ***C*** *Estimated R_0 during the outbreak (mean and 95%CI), as a function of baseline R_0 (i.e., derived by using the contact matrix estimated for the baseline period adjusted for possible compliance or social desirability bias by increasing non-household contacts by 150%, 200%, 250% and 300%). The figure refers to Wuhan and shows the scenario assuming that all individuals are equally susceptible to infection.* ***D*** *Same as A, but for Shanghai.*

8.3 Sensitivity analysis accounting for a possible recall bias in Wuhan

To account for a potential recall bias for Wuhan participants reporting on contacts during the baseline period, we assumed that household contacts were properly remembered, while non-household contacts may have been misreported. The baseline contacts for Shanghai were not affected by this bias as for the baseline period we relied on previous survey data (while in Wuhan we relied on retrospective assessment of contacts about a month prior to the survey). Therefore, to construct the contact matrix for the baseline period in Wuhan, we performed a bootstrap procedure and sampled a Wuhan participant of a certain age and match her/him with a Shanghai participant of the same age group. We then use contacts of the Wuhan participant with her/his household members and contacts of the matched Shanghai participant outside the household to approximate the total number of contacts Wuhan participants would report in the absence of recall bias. Cleary, this approach does not aim at inferring the real number of contacts in Wuhan for regular days, but rather to estimate an upper bound for the contact matrix (not affected by downward recall bias). The obtained contact matrix is shown in Fig. S15A. The matrix is used for a sensitivity analysis of the transmission model. The obtained results show that effective R_0 for the outbreak period is even lower than using the original contact matrix (Fig. S15B).

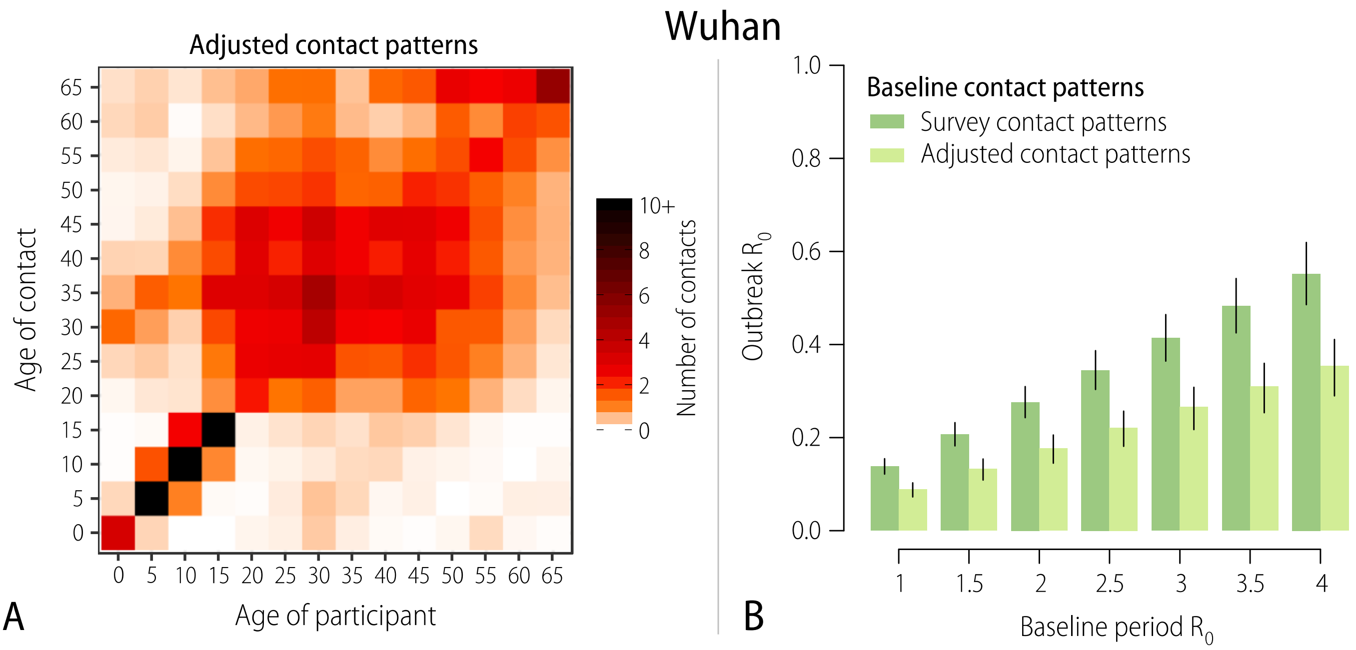

Figure S15. A *Baseline period contact matrix for Wuhan, adjusted to contrast possible recall bias. Each cell of the matrix represents the mean number of contacts that an individual in a given age group has with other individuals, stratified by age groups. The color intensity represents the number of contacts.* ***B*** *Estimated R_0*

during the outbreak (mean and 95%CI), as a function of baseline R_0 (i.e., derived by using the contact matrix estimated for the baseline period). Both baseline period and outbreak matrices are used either as estimated directly from the survey data or adjusted for possible recall bias as illustrated in A. The figure refers to Wuhan and shows the scenario assuming that all individuals are equally susceptible to infection.

9. References and Notes

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