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Clusters of 2019 coronavirus disease (COVID-19) cases in Chinese tour groups

Running title: Clusters of COVID-19 in Chinese tourists

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37

38 **Summary**

39 International travel may facilitate the spread of the novel coronavirus disease
40 (COVID-19). The study describes clusters of COVID-19 cases within Chinese tour
41 groups travelling in Europe January 16-28. We compared characteristics of cases and
42 non-cases to determine transmission dynamics. The index case travelled from
43 Wuhan, China, to Europe on January 16, 2020, and to Shanghai, China, on January
44 27, 2020, within a tour group (group A). Tour groups with the same outbound flight
45 (group B) or the same tourism venue (group D), and all Chinese passengers on the
46 inbound flight (group C) were investigated. The outbreak involved 11 confirmed
47 cases, 10 suspected cases, and 6 tourists who remained healthy. Group A, involving 7
48 confirmed cases and 6 suspected cases, consisted of familial transmission followed
49 by propagative transmission. There was less pathogenicity with propagative
50 transmission than with familial transmission. Disease was transmitted in shared
51 outbound flights, shopping venues within Europe, and inbound flight back to China.
52 The novel coronavirus caused clustered cases of COVID-19 in tour groups. When
53 tourism and travel opens up, governments will need to improve screening at airports
54 and consider increased surveillance of tour groups – particularly those with older
55 tour members.

56 **Key words:** coronavirus; virulence; China; severe acute respiratory syndrome
57 coronavirus 2; travel; disease outbreaks

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58 **Introduction**

59 A novel coronavirus (SARS-CoV-2) was discovered in mainland China in December
60 2019 (Harapan et al., 2020; Wu et al., 2020). The World Health Organization (WHO)
61 declared coronavirus disease (COVID-19) a pandemic on March 11, 2020 (World
62 Health Organization, 2020e, 2020d). In many countries outside of China, the first
63 cases were identified as tourists and students from the city of Wuhan traveling
64 abroad. Similarly, the spread of SARS-CoV-2 throughout southwestern and central
65 Asia has been facilitated by Iranian citizens and residents who were traveling outside
66 of Iran (Tuite et al., 2020).

67
68 The Chinese Center for Disease Control and Prevention has shown that there is
69 person-to-person transmission among close contacts since the middle of December
70 2019 (Li et al., 2020). In recent studies, clusters of COVID-19 cases have been
71 principally identified in family settings (Bai et al., 2020; Chan et al., 2020). These
72 patterns suggest that familial transmission – through living and eating together – is a
73 key contributor to the spread of COVID-19. How disease is spread outside of close
74 contacts is less clear.

75
76 Other infectious diseases with airborne transmission have reported clusters of cases
77 outside of family settings. In 2009, a cluster of influenza A/H1N1 cases occurred in a
78 tour group in tour bus in Sichuan province, China (Han et al., 2009). In the current
79 COVID-19 pandemic, two cases were reported at a conference in Germany (Rothe et
80 al., 2020). Another notable example has been the *Diamond Princess* cruise ship,
81 which initially carried approximately 3,700 passengers and crew from more than 50
82 countries and regions. There have been more than 700 confirmed cases of COVID-19
83 in the ship. The spread of disease thought to be attributable to inappropriate
84 containment measures in the ship (World Health Organization, 2020a).

85
86 The outbreak of COVID-19 in China coincided with Chinese New Year, or the Spring
87 Festival, the most important holiday in China. During this time, Chinese people often

88 travel domestically and abroad. Before Wuhan was closed off, it is believed that a
89 couple of million local people left the city for travel, which could have facilitated the
90 spread of COVID-19 to foreign countries. It is not as clear how well the infection is
91 transmitted in tour groups outside of the familial setting. Our study describes
92 clusters of COVID-19 cases within tour groups travelling in European countries from
93 January 16 through 28.

94 95 **Materials and Methods**

96 This study conducted a retrospective look at four cohorts of individuals. The index
97 case was a 69-year old male Chinese who had travelled from the city of Wuhan,
98 China, to Paris, France, on January 16, 2020 and back to Shanghai, China, on January
99 27, 2020, within a tour group of totally 34 members (group A). During the travel, a
100 total of 7 confirmed cases and 6 suspected cases were documented within the tour
101 group. Group A were on three flights, AF139 (Wuhan – Paris), AF1004 (Paris – Rome),
102 and AF116 (Paris – Shanghai). We examined two other groups based on these flights
103 and travel plans. Group B consisted of 25 Chinese tourists from Wuhan to Paris,
104 sharing the flight AF139 with the group A. Group C was composed of approximately
105 200 Chinese passengers from Paris to Shanghai, sharing the flight AF116 with the
106 group A. We also examined group D, tour group sharing the same tourism venue of
107 Interlaken, Switzerland as the group A on January 22, 2020 (Figure 1).

108
109 We retrospectively tabulated the number of confirmed cases, suspected cases, and
110 other non-cases in the four groups to determine potential transmission dynamics.
111 This epidemiological investigation was conducted by experienced investigators in
112 Pudong New Area Center for Disease Control and Prevention (CDC), Huangpu District
113 CDC, Hongkou District CDC, and Shanghai Municipal CDC. First, we extracted detailed
114 travel information from the investigation reports, including arrival and departure
115 dates of cities, hotels, and seats in flight, which were provided and checked by both
116 tour group members and travel agencies. Second, we compared travel itineraries to
117 determine if there was connection between groups. Third, we collected routine

118 clinical examinations and virological testing results from hospitals for suspected
119 cases and the Shanghai Public Health Clinical Center for confirmed cases.

120

121 The case definition of COVID-19 came from national guidelines (General Office of
122 National Health Commission, 2020). Cases could have epidemiological evidence, i.e.
123 traveling or living in Hubei province or communities with a confirmed case of
124 COVID-19, or having contact with a confirmed case of COVID-19, or having contact
125 with patients with fever and/or respiratory symptoms from Hubei province or
126 communities with confirmed case of COVID-19 within 14 days. Cases' clinical
127 evidence could include fever and/or respiratory symptoms, pneumonia-related
128 radiological finding, normal or reduced white blood cell count, or reduced
129 lymphocyte count. A suspected case was defined by at least one of epidemiological
130 criterion combined with at least two clinical criteria, or clinical evidence combined
131 with zero epidemiological evidence. A confirmed case was defined by a positive
132 RT-PCR test.

133

134 Based on their exposure history, we categorized cases as having familial or
135 propagative (i.e., within tour group) transmission. We calculated the proportion of
136 pathogenicity by group by counting the number of individuals with a sign or
137 symptom of disease.

138

139 This study involved the use of existing, routinely-collected data from a public health
140 outbreak investigation, under the National Health Commission of the People's
141 Republic of China. All data included in the study were kept confidential without
142 person identifiers. No additional interviews were conducted, and no data were
143 collected independently for this study. Thus, this study is exempt from ethical review
144 and there was no need of obtaining informed consent.

145

146 The data that support the findings of this study are available on request from the
147 corresponding author. The data are not publicly available due to privacy or ethical

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148 restrictions.

149

150 **Results**

151 **Transmission dynamics in group A**

152 ***Exposure***

153 The index case and his wife and parents-in-law lived in two separate apartments in a
154 city 310 km away from Wuhan, in Hubei province. On January 10, they went to
155 Wuhan for a Schengen visa application and then had a dinner taking wild eel
156 (*Monopterus albus*) at the aquatic food corner of Huanan Seafood Wholesale Market
157 where initial cases were reported in the beginning of the COVID-19 epidemic (Li et
158 al., 2020). It is likely that some of the family members were exposed to SARS-CoV-2.

159

160 ***Familial transmission***

161 On January 16, the family joined the tour group A and boarded the flight AF139. The
162 index case's father-in-law (zero case), the index case, the index case's wife (case 2)
163 and mother-in-law (case 1) successively had symptoms on January 22, 26, 27, and
164 28. The zero case developed severe symptoms and was hospitalized in Paris on
165 January 25, and was taken care of by his daughter (case 2). These two were labeled
166 as the 4th and 5th cases in France. The index case and case 1 went back to China on
167 January 27 and were immediately diagnosed as COVID-19 confirmed cases. The
168 timeline was listed in Figure 2.

169

170 ***Tour group transmission***

171 Group A was placed under quarantine once they arrived back in Shanghai, China.
172 Among the rest (n=30) of the group, a total of 9 members successively developed
173 symptoms from January 28 through February 9 in quarantine, including 3 confirmed
174 cases and 6 suspected cases. The cases and their family members / accompanying
175 friends are described in Figure 2. Clinical examinations and virological testing results
176 are presented in Table 1. Pathogenicity in the group transmission (9/30) was lower
177 compared to the familial transmission (3/3). Similarly, pathogenicity seemed to be

178 weakened as all of the family were confirmed cases (3/3), whereas the following
179 cases in the group transmission included both confirmed (3/9) and suspected (6/9)
180 cases.

181
182 Tour group transmission may have occurred in the following scenarios. 1) On the
183 outbound flight Wuhan – Paris and connecting flight Paris – Rome, the 9 cases had
184 inconsistent seat proximity to the family (Figure 3) and no contact with one another,
185 except for the guide (case 3). 2) During the tour, the members moved by bus.
186 Generally, they gathered in smaller groups including family members and
187 accompanying friends. They reported inconsistent and limited contact with one
188 another, and did not precisely recall the seat proximity in bus. The guide had regular
189 contact with adult members and helped arrange the hospital admission of the zero
190 case in Paris. 3) On the inbound flight Paris – Shanghai, all of the confirmed and
191 suspected cases had seats within 2 rows (Figure 3). Furthermore, suspected cases
192 had nearer seat proximity to the family cases, compared to the other three
193 confirmed cases (case 3, 4, 5) which may be attributable to the suspected cases
194 being less contagious. Considering time sequence of onset and exposure / contact
195 history, we inferred that there was initially a familial transmission, followed by a
196 propagative transmission within the group, which possibly occurred during the tour
197 and on the inbound flight.

198
199 In addition, we identified that five members had close contact with the cases, who
200 remained healthy during the 12-day tour in Europe and in 14-day quarantine in
201 Shanghai (Figure 2). Similarly, some members who had seats close to the confirmed
202 cases remained healthy (Figure 3).

203

204 **Group A connection to group B, C and D**

205 ***Outbound flight Wuhan – Paris***

206 On AF139, there was a cluster consisting of two COVID-19 confirmed cases and one
207 suspected case, which all belonged to tour group B (Table 1). They shared the same

208 outbound flight from Wuhan with group A and then had different itineraries in
209 Europe (Figure 2). On board, the cases in group B had a seat proximity of >3 rows to
210 the family in group A. At this point, the zero case did not have any symptoms. The
211 onset of disease in the first case (case 12) in group B occurred on January 29, which
212 was 7 days later than the zero case in group A. Thus, we could not completely
213 exclude the connection to group A.

214

215 ***Inbound flight Paris – Shanghai***

216 On AF116, there were approximately 200 Chinese passengers (group C; they shared
217 the same flight but not belonged to a same tour group), in which two were
218 diagnosed as suspected case in quarantine after arrival in Shanghai (Figure 2; Table
219 1). Case 15 was an independent traveler and case 16 was a guide of a tour group of
220 19 members (the rest of the tour group have not developed symptoms). Their seats
221 were <3 rows away from the cases in group A. Neither of them reported travel or
222 living history in Hubei province / communities with confirmed case of COVID-19;
223 contact with confirmed case of COVID-19; or contact with patients with fever and/or
224 respiratory symptoms from Hubei province / communities with confirmed case of
225 COVID-19, within 14 days before the onset. They might have a connection to group
226 A.

227

228 ***During the tour***

229 We identified another group of 41 tourists (group D), which had been visiting
230 Interlaken, Switzerland, in the afternoon of January 22, sharing the same shopping
231 venue with the group A. The group D was not placed under quarantine after they
232 arrived in Shanghai. Later, two confirmed cases and one suspected case were
233 successively diagnosed, which composed a cluster (Figure 2; Table 1). The dates of
234 onset of symptoms were January 30 for confirmed case 17 and February 4 for
235 suspected case 19; date of onset of symptoms was unavailable for confirmed case
236 18. Unfortunately, we could not identify all the Chinese tour groups that visited
237 Interlaken on January 22 or check the Chinese COVID-19 cases who had visited

238 Interlaken on January 22. So far, we have recognized only the cases in group A and D,
239 which suggests they might have an epidemiological linkage, though we had
240 contacted and investigated another two Chinese tour groups which had no
241 confirmed or suspected cases (not listed in the study).

242

243 **Discussion**

244 A large concern is if SARS-CoV-2 is able to efficiently spread in settings beyond the
245 family or other sustained close contact. We reported three clusters of COVID-19
246 confirmed cases in three tour groups travelling in European countries and one
247 cluster of suspected cases on one flight in late January 2020. The outbreak in total
248 involved 11 confirmed cases, 10 suspected cases, and more than two hundred
249 persons placed in quarantine. In group A, the cluster was initiated by a familial
250 transmission, followed by spread of disease to 13 out of 34 members in the 12-day
251 tour. Group A was characterized by lower pathogenicity in the following group
252 transmission, compared to the familial transmission which might be attributable to
253 exposure to the Huanan Seafood Wholesale Market.

254

255 In our study, the first case in group D might have been infected through a casual
256 meeting with the zero case in group A at a shopping venue. A similar finding had
257 been reported in a previous study that reports that Chinese tourists wearing facial
258 masks may have infected a Thai taxi driver (Pongpirul et al., 2020). Thus, there may
259 be two conditions facilitating efficient transmission, 1) confined space, and 2)
260 consistent close contact. However, we found five tour group members who
261 remained healthy even after sustained contact with the cases, such as sharing same
262 hotel rooms, taking dinner together, and having neighboring seats. One explanation
263 is that children are less susceptible to the virus (del Rio & Malani, 2020). Further
264 studies on how the virus transmits across different age groups is urgently warranted.
265 This is especially important considering the possible role of pre-symptomatic
266 transmission (Kong et al., 2020).

267

268 Furthermore, we supposed that group C had a connection to group A and could not
269 exclude a connection between groups B and A. These connections suggest potential
270 transmission on the plane. Recent studies have documented conflicting findings,
271 including possible transmission on planes (Liu et al., 2020) or in cars (Pongpirul et al.,
272 2020), but also no observed transmission in vehicles (Phan et al., 2020). Previous
273 studies have shown that planes have high-efficiency particulate air filters that may
274 avoid airborne transmission of pathogens, whereas buses have about 70%
275 recirculated inside air (Han et al., 2009). We did not precisely examine the seats in
276 tour bus. The confirmed and suspected cases had an obvious cluster of seats on the
277 inbound flight, suggesting the infection was very likely to occur on plane, which may
278 be associated with high affinity of SARS-CoV-2 spike glycoprotein binding ACE2
279 (Wrapp et al., 2020). However, we also identified healthy members after taking seats
280 close to the family cases on board. Thus, we hypothesized that disabling the efficient
281 transmission of SARS-CoV-2 may depend on social distance and personal protection,
282 in addition to air conditioning system and air filters.

283
284 The tour groups included in our study had visited France, Italy, Switzerland, Spain,
285 Portugal, Germany, and Morocco, which has raised a public health concern of
286 spreading the virus internationally. Currently, China is the number 3 sender of
287 tourists globally and is estimated to be 1 by 2030 (Arcibal, 2018). However, the
288 entry-exit quarantine in airports has limited capability in detecting cases whose
289 course of infection is in the incubation period. This problem of detection has been
290 documented in the influenza A/H1N1 (Priest et al., 2011) and current COVID-19
291 pandemic (Gostic et al., 2020). The spread of SARS-CoV-2 into South Korea, Italy, and
292 Iran has increased attention toward those tourists (Gostic et al., 2020; Pongpirul et
293 al., 2020; Tuite et al., 2020). However, it is possible that the typical activities
294 undertaken by tourists make them less likely to infect compared to other members
295 of the tour group. The zero case in group A was diagnosed in France. However, we
296 did not identify any local cases epidemiologically linked to the tour group members
297 in the above-mentioned countries. This lack of transmission may be attributed to the

298 absence of sustained contact in a confined space between local people and Chinese
299 tourists. There of course could be existing cases with mild or no obvious symptoms.
300 Since February 22, COVID-19 cases have increased dramatically in Italy, Iran, and
301 South Korea, which have been retrospectively traced to some locals who reported no
302 known exposure history (World Health Organization, 2020b, 2020c). They might
303 have been exposed to asymptomatic carriers of SARS-CoV-2. Thus, improvement in
304 the continuous surveillance on international tourists remains crucial.

305
306 The study has several limitations. The sensitivity of the PCR assays could be low and
307 result in a large number of false-negative results in the diagnosis of COVID-19
308 (Sheridan, 2020; Wang et al., 2020). All of the suspected cases reported in this study
309 were finally excluded from the diagnosis of COVID-19 due to a negative RT-PCR test,
310 though some of them had pulmonary inflammation according to chest CT
311 examination. Because our diagnostic methods may have underestimated the
312 incidence of disease in the study population, we combined suspected cases with
313 confirmed cases to explore potential transmission dynamics. Another limitation was
314 recall bias and concealment in the investigation. We checked the activities with each
315 case, cross-checked activities between cases, illustrated the transmission chains, and
316 then determined the potential connections between cases and groups. We also may
317 have missed asymptomatic carriers on the passenger flights.

318
319 In conclusion, we reported a cluster of thirteen COVID-19 cases, which was initiated
320 by within-family transmission followed by propagative transmission into tour groups
321 traveling in European countries. The study findings show that clustered cases in tour
322 groups may be more propagative than simple familial transmission. Currently, the
323 COVID-19 pandemic is spreading to increased numbers of countries and regions
324 worldwide. If we consider each country as a group, such as China, South Korea, Iran,
325 and Italy, we could understand the pandemic of the COVID-19 as a propagative
326 transmission within a “group” and then between “groups”. Thus, the government
327 should improve screening at airports and consider increased surveillance of tour

328 groups – particularly those with older tour members.

329

330 **Declaration of interests**

331 All authors declare no competing interests.

332

333 **Acknowledgement**

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339

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346

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Figure legends.

Figure 1. Map of travel for four groups of Chinese tourists in January - February 2020.

Figure 2. Timeline of novel coronavirus disease (COVID-19) diagnosis in four groups of Chinese tourists in January - February 2020.

Figure 3. Seat map of three flights containing cases of novel coronavirus disease (COVID-19).

Table 1 Clinical examinations and virological testing results

Case by sex and age	Case no.	Case type	Clinical examination				Virological testing			
			Body	White blood cell	Lymphocyte	Chest CT	Nasal swab		Throat swab	
			temperature (°C)	(10 ⁹ /L)	%		ORF1 a/b	N	ORF1 a/b	N
Group A										
M, 81	Zerot	confirmed	NA	NA	NA	NA	NA	NA	NA	NA
F, 77	1	confirmed	36.5	5.8	41.5	bilateral pneumonia	+	+	+	+
M, 69	Index	confirmed	36.5	5.3	31.0	bilateral pneumonia	—	—	+	+
F, 46	2†	confirmed	NA	NA	NA	NA	NA	NA	NA	NA

M, 36	3	confirmed	36.7	4.7	38.4	bilateral pneumonia	+	+	+	+
F, 43	4	confirmed	37.5	4.1	43.9	unilateral pneumonia, left	+	+	+	+
F, 49	5	confirmed	36.7	7.1	30.6	no obvious abnormality	—	—	+	+
M, 9	6	suspected	36.5	10.8	31.9	NA	—	—	—	—
F, 40	7	suspected	36.0	8.7	36.3	no obvious abnormality	—	—	—	—
M, 13	8	suspected	36.0	5.2	42.0	bilateral pneumonia	—	—	—	—
F, 28	9	suspected	37.5	3.1	43.3	unilateral pneumonia, left	—	—	—	—
F, 29	10	suspected	36.8	5.5	37.1	no obvious abnormality	—	—	—	—
F, 29	11	suspected	36.5	4.1	36.3	unilateral pneumonia, left	—	—	—	—
Group B										
M, 65	12	confirmed	37.9	6.5	32.1	bilateral pneumonia	+	+	+	+
M, 33	13	confirmed	36.1	5.1	46.6	bilateral pneumonia	—	—	+	+
F, 56	14	suspected	37.1	5.4	19.4	unilateral pneumonia, right	—	—	—	—
Group C										
M, 29	15	suspected	36.5	5.3	34.0	no obvious abnormality	—	—	—	—
M, 34	16	suspected	37.0	5.6	24.6	bilateral pneumonia	—	—	—	—
Group D										

M, 65	17	confirmed	37.5	5.0	20.6	bilateral pneumonia	+	+	+	+
F, 38	18 †	confirmed	NA	NA	NA	NA	+	+	+	+
F, 63	19	suspected	38.0	7.6	30.0	unilateral pneumonia, right	—	—	—	—

† The zero case and case 2 were hospitalized in Paris; thus, we did not obtain detailed clinical examination and virological testing results.

‡ Case 18 was kept in quarantine for 10 days after her arrival in China and then diagnosed another 9 days later, due to a stay-home notice sent by Shanghai Municipal Center for Disease Control and Prevention; thus, we did not obtain detailed clinical examination and virological testing results.

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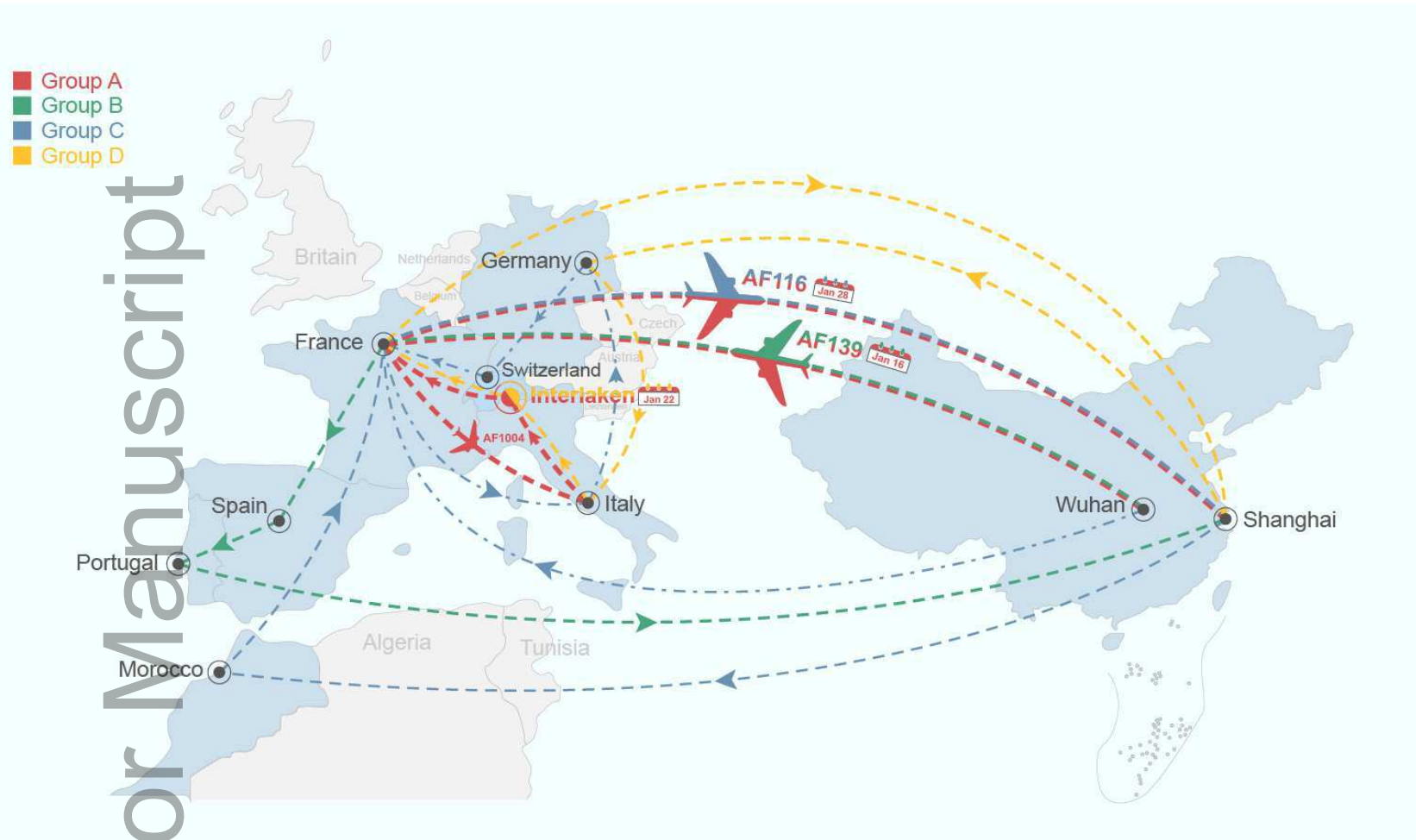


Figure 1. Map of travel for four groups of Chinese tourists in January - February 2020.

Timeline

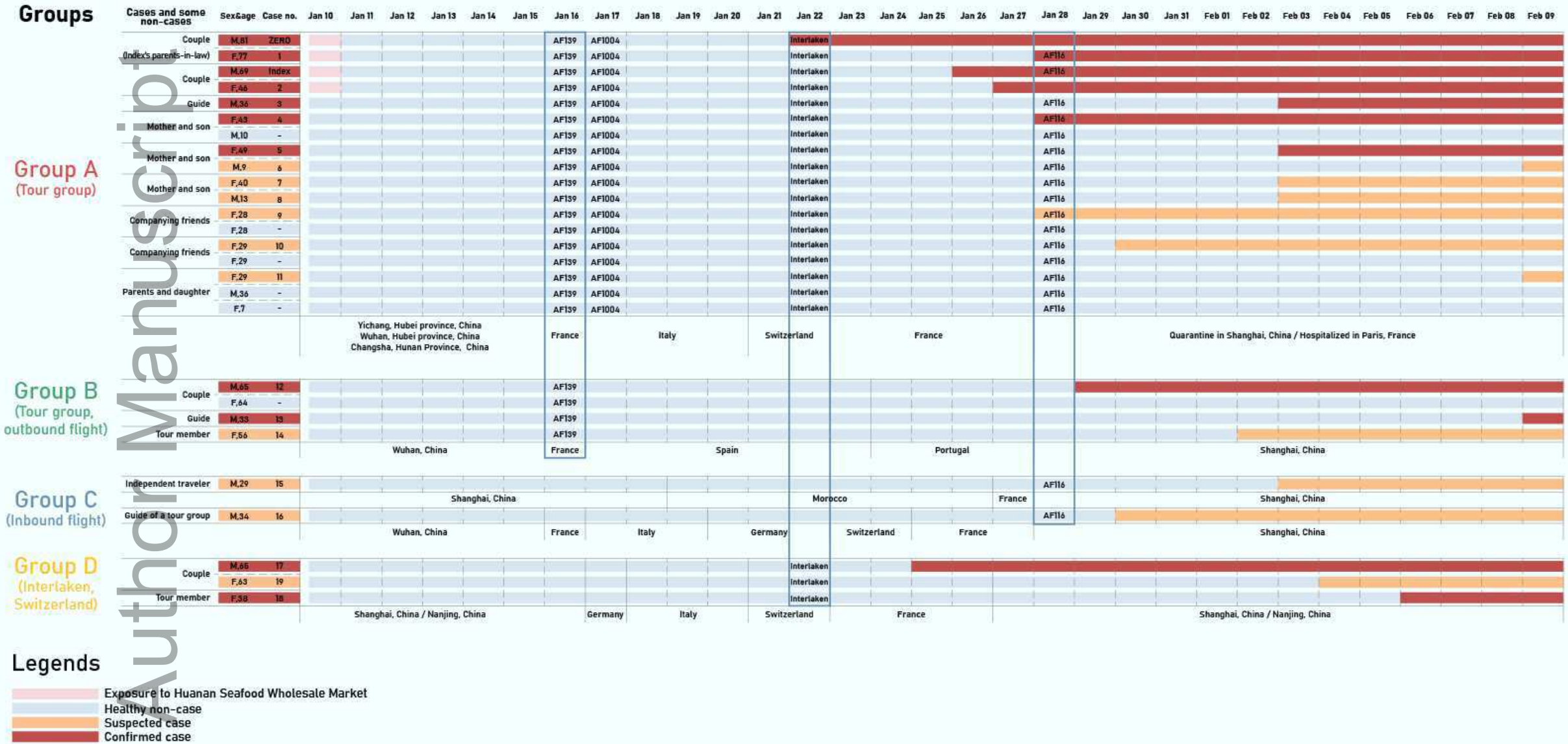


Figure 2. Timeline of novel coronavirus disease (COVID-19) diagnosis in four groups of Chinese tourists in January - February 2020.

Seats

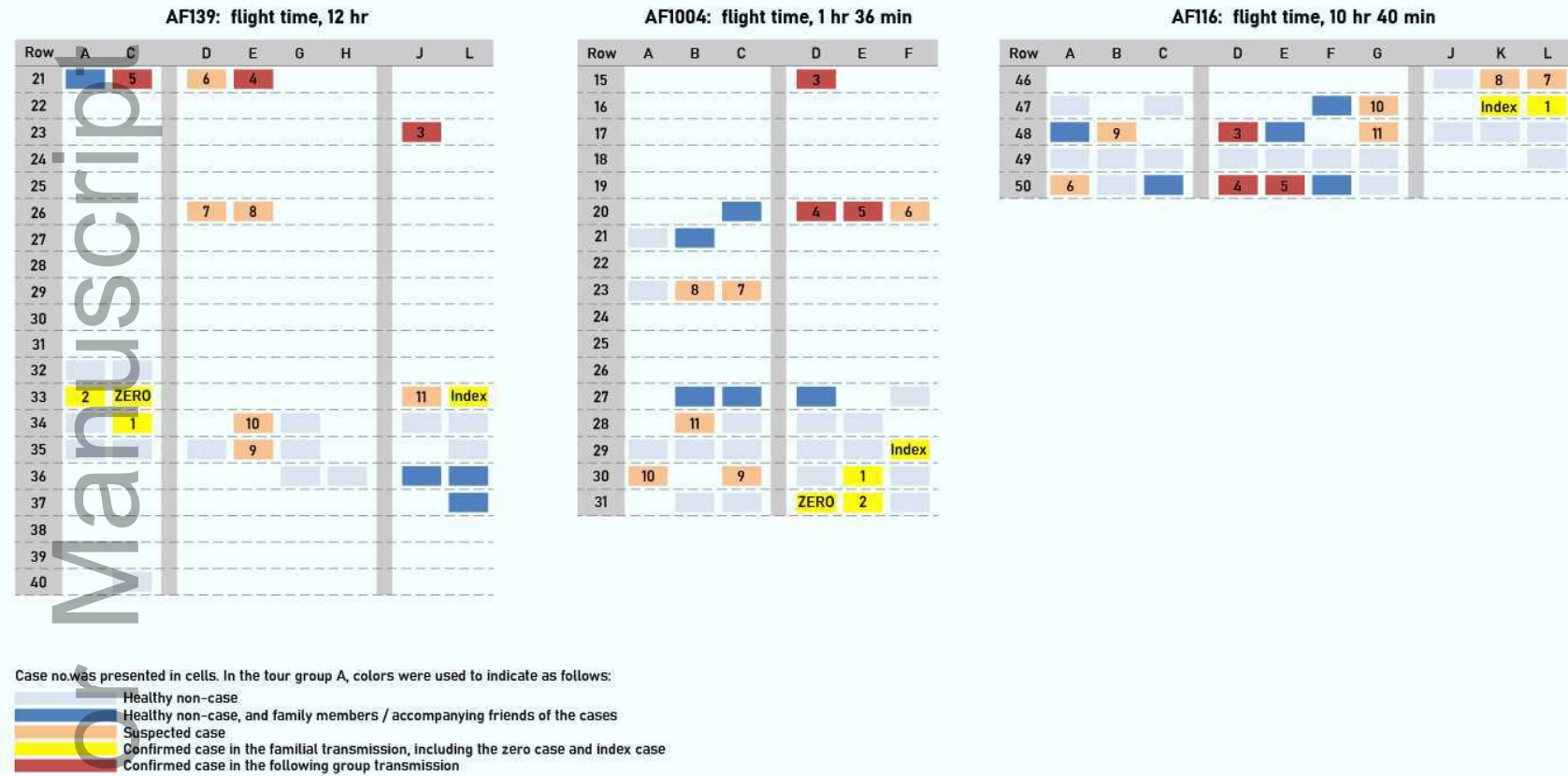


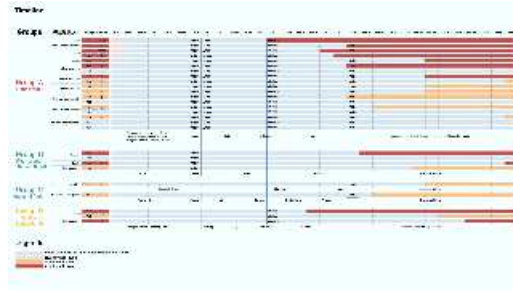
Figure 3. Seat map of three flights containing cases of novel coronavirus disease (COVID-19).

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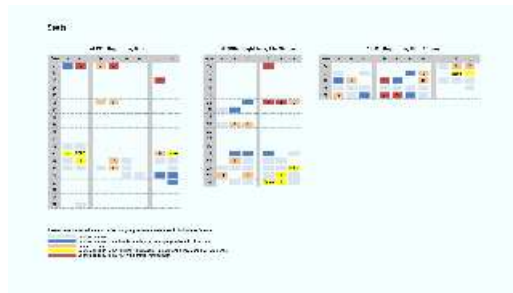


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