Age and socio-economic status affect dengue and COVID-19 incidence: Spatio-temporal analysis of the 2020 syndemic in Buenos Aires City

Aníbal E Carbajo [Equal first author, 1, 2], **María V Cardo** [Equal first author, 1, 2], **Martina Pesce** [3], **Luciana E Iummato** [3], **Pilar Bárcena Barbeira** [3], **María Soledad Santini** [2, 4], **María Eugenia Utgés** [Corresp. 5]

1 Instituto de Investigación e Ingeniería Ambiental (IIIA), Escuela de Hábitat y Sostenibilidad, Universidad Nacional de San Martín (UNSAM), San Martín, Buenos Aires, Argentina

2 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina

3 Dirección Nacional de Epidemiología e Información Estratégica, Ministerio de Salud de la Nación, Buenos Aires, Argentina

4 Instituto Nacional de Parasitología (INP), ANLIS "Dr. C. G. Malbrán", Ministerio de Salud de la Nación, Buenos Aires, Argentina

5 Centro Nacional de Diagnóstico e Investigación en Endemo-epidemias (CeNDIE), ANLIS "Dr. C.G. Malbrán", Ministerio de Salud de la Nación, Buenos Aires, Argentina

Corresponding Author: María Eugenia Utgés
Email address: mariaeugeniau@gmail.com

In early 2020, Argentina experienced the worst dengue outbreak in its history, concomitant with first-to-date increasing COVID-19 cases. Dengue epidemics in temperate Argentina have already been described as spatially heterogeneous; in the previous 2016 outbreak, transmission occurred 7.3 times more frequently in slums compared to the rest of Buenos Aires City (CABA). These informal settlements have deficient sanitary conditions, precarious housing and high incidence of social vulnerabilities. The purpose of this work was to study the spatio-temporal patterns of the 2020 dengue epidemic in CABA in relation to socio-economic living conditions of its inhabitants and its interaction with the onset of COVID-19. The study considered the period between Jan 1st and May 30th 2020. Dengue and COVID-19 databases were obtained from the National Health Surveillance System; each record was anonymized and geo-localized. The city was divided according to census tracts and grouped in four socio-economic strata: slums, high, mid and low residential. Aligned-Rank Transform ANOVA was performed to test for differences in the incidence of dengue and COVID-19, and age at death due to COVID-19, among socio-economic strata, four age categories and their interaction. The incidence by cluster was calculated with a distance matrix up to 600 m from the centroid. Spatial joint dengue and COVID-19 risk was estimated by multiplying the nominal risk for each disease, defined from 1 (low) to 5 (high) according to their quantiles. During the study period, 7,175 dengue cases were registered in CABA (incidence rate 23.3 cases per 10,000 inh), 29.2% of which occurred in slums. During the same period, 8,809 cases of COVID-19 were registered (28.6 cases per 10,000 inh); over half (51.4%) occurred in slums, where the median age of cases (29 yo) was

lower than in residential areas (42 yo). The mean age of the deceased was 58 yo in slums compared to 79 yo outside. The percentage of deaths in patients under 60 yo was 56% in slums compared to 8% in the rest of the city. The incidence of both diseases was higher in slums than in residential areas for most age categories. Spatial patterns were heterogeneous: dengue presented higher incidence values in the southern sector of the city and the west, and low values in highly urbanized quarters, whereas COVID-19 presented higher values in the east, south, high populated areas and slums. The lowest joint risk clusters were located mainly in high residential areas, whereas high joint risk was observed mainly in the south, some western clusters, the historical part of the city and center north. The social epidemiological perspective of dengue and COVID-19 differed, given that socio environmental heterogeneity influenced the burden of both viruses in a different manner. Despite the overwhelming effect of the COVID-19 pandemic, health care towards other diseases, especially in territories with pre-existing vulnerabilities, should not be unattended.

1 **Title**

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5 **Authors**

6   Aníbal E. Carbajo [1,2] +

7   María V. Cardo [1,2] +

8   Martina Pesce [3]

9   Luciana E. Iummato [3]

10   Pilar Barcena Barbeira [3]

11   M. Soledad Santini [2,4]

12   M. Eugenia Utgés [5]

13   + Equal contribution

15   [1] Instituto de Investigación e Ingeniería Ambiental (IIIA), Escuela de Hábitat y

16 Sostenibilidad, Universidad Nacional de San Martín (UNSAM), Provincia de Buenos Aires,

17 Argentina.

18   [2] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires,

19 Argentina.

20   [3] Dirección Nacional de Epidemiología e Información Estratégica, Ministerio de Salud de

21 la Nación, Argentina.

22   [4] Instituto Nacional de Parasitología, ANLIS "Dr. C. G. Malbrán", Ministerio de Salud de la

23 Nación, Argentina.

24   [5] Centro Nacional de Diagnóstico e Investigación en Endemo-epidemias, ANLIS "Dr. C.G.

25 Malbrán", Ministerio de Salud de la Nación, Argentina.

27 Corresponding Author:

28 M. Eugenia Utgés [5]

29 Av. Paseo Colón 568 1er piso, CP1063, Ciudad Autónoma de Buenos Aires, Argentina.

30 mariaeugeniau@gmail.com

35 **Abstract**

36   In early 2020, Argentina experienced the worst dengue outbreak in its history,
37 concomitant with first-to-date increasing COVID-19 cases. Dengue epidemics in temperate
38 Argentina have already been described as spatially heterogeneous; in the previous 2016
39 outbreak, transmission occurred 7.3 times more frequently in slums compared to the rest of
40 Buenos Aires City (CABA). These informal settlements have deficient sanitary conditions,
41 precarious housing and high incidence of social vulnerabilities. The purpose of this work was to
42 study the spatio-temporal patterns of the 2020 dengue epidemic in CABA in relation to socio-
43 economic living conditions of its inhabitants and its interaction with the onset of COVID-19.

44   The study considered the period between Jan 1st and May 30th 2020. Dengue and
45 COVID-19 databases were obtained from the National Health Surveillance System; each record
46 was anonymized and geo-localized. The city was divided according to census tracts and
47 grouped in four socio-economic strata: slums, high, mid and low residential. Aligned-Rank
48 Transform ANOVA was performed to test for differences in the incidence of dengue and
49 COVID-19, and age at death due to COVID-19, among socio-economic strata, four age
50 categories and their interaction. The incidence by cluster was calculated with a distance matrix
51 up to 600 m from the centroid. Spatial joint dengue and COVID-19 risk was estimated by
52 multiplying the nominal risk for each disease, defined from 1 (low) to 5 (high) according to their
53 quantiles.

54   During the study period, 7,175 dengue cases were registered in CABA (incidence rate
55 23.3 cases per 10,000 inh), 29.2% of which occurred in slums. During the same period, 8,809
56 cases of COVID-19 were registered (28.6 cases per 10,000 inh); over half (51.4%) occurred in
57 slums, where the median age of cases (29 yo) was lower than in residential areas (42 yo). The
58 mean age of the deceased was 58 yo in slums compared to 79 yo outside. The percentage of
59 deaths in patients under 60 yo was 56% in slums compared to 8% in the rest of the city. The
60 incidence of both diseases was higher in slums than in residential areas for most age
61 categories. Spatial patterns were heterogeneous: dengue presented higher incidence values in
62 the southern sector of the city and the west, and low values in highly urbanized quarters,
63 whereas COVID-19 presented higher values in the east, south, high populated areas and
64 slums. The lowest joint risk clusters were located mainly in high residential areas, whereas high
65 joint risk was observed mainly in the south, some western clusters, the historical part of the city
66 and center north.

67   The social epidemiological perspective of dengue and COVID-19 differed, given that
68 socio environmental heterogeneity influenced the burden of both viruses in a different manner.
69 Despite the overwhelming effect of the COVID-19 pandemic, health care towards other

70   diseases, especially in territories with pre-existing vulnerabilities, should not be unattended.

71

72

73   **Keywords**

74   syndemic, SARS-CoV2, arbovirus, compulsory social isolation, pandemia, temperate Argentina,

75   precarious settlement, slum, socio-economic stratum

76

77   **INTRODUCTION**

78

79   SARS-CoV2 was detected and notified on December 31st, 2019, generating a new

80   infection named COVID-19. This virus belongs to the Coronavirus family known for causing

81   upper-respiratory tract illnesses (NIH 2021). First cases were detected at Wuhan, China, the

82   epicenter of the outbreak, and then extended to other countries in a quick propagation at

83   community, regional and international scale causing an exponential increase in cases and

84   deaths (OPS 2020a).

85   The first case in Argentina was reported on March 3rd, 2020 at Buenos Aires

86   Autonomous City (CABA, for its acronym in Spanish) (MSN 2020a). At the beginning, cases

87   were notified in people returning to the country from areas with viral circulation and their close

88   contacts but, by the end of the month, community circulation was registered both in the

89   metropolitan area of Buenos Aires and in the north-east of the country. Schools were shut down

90   on March 16th together with international airports and land border closure for foreigners. On

91   March 20th, the entire country population with the exception of essential workers was isolated at

92   home, and border closure extended to all Argentinian residents (this group of measures was

93   locally denominated ASPO). The majority of the population adhered to these measures, so that

94   public transport journeys within CABA decreased 65% for buses and trains, and 94% for

95   subways; the entry/exit of private vehicles to the city fell 85% and internal circulation was

96   reduced by 68% (GCBA 2020a). During early April, first cases in CABA slums were reported to

97   the National System of Health Surveillance. In May, the National Health Ministry in collaboration

98   with the City Health Ministry established a testing strategy in slums to contain the situation,

99   denominated DETeCTAr. It consisted in a home-by-home active search for close contacts of

100   confirmed cases and all citizens with COVID-19 compatible symptoms, followed by the

101   redirection to a nearby testing site for PCR diagnostic (MSN 2020b). ASPO was maintained

102   until the beginning of June, after which isolating measures were progressively relaxed allowing

103   certain types of commercial and recreational activities (MNS 2020c).

104   Taking into consideration the regional epidemiology of arboviral diseases, multiple
105   implications arose concomitant with COVID-19. In 2020 Argentina experienced the worst
106   dengue outbreak in its history, which largely exceeded previous epidemics of 2009 and 2016.
107   The epidemic took place between January and May, similar to the two mentioned outbreaks,
108   with co-circulation of three serotypes (72% DEN-1, 26% DEN-4 y 2% DEN-2) (MSN 2020d). In
109   non-endemic territories like Argentina, dengue transmission dynamics is influenced mainly by
110   the density of its vector, *Aedes aegypti*, by climatic factors that condition its ecophysiology, and
111   by people's movements from endemic to non-endemic areas. Typically, outbreaks start in towns
112   bordering endemic neighboring countries (Bolivia, Paraguay and Brazil) and then extend to
113   temperate regions (Carbajo et al. 2012, 2018a). In the Buenos Aires Metropolitan Area,
114   imported cases have been positively correlated with a higher proportion of foreign population
115   and larger working-age class, confirming virus pressure from neighboring countries related to
116   travelers who usually live in low-income neighborhoods (Carbajo et al. 2018b). In the 2016
117   outbreak, transmission occurred 7.3 times more frequently in slums compared to the rest of
118   CABA, and most foci were more persistent within slums than outside them (Gurevitz et al.
119   2021). This may be explained by the fact that in slums, irregular water supply, precarious toilets
120   in the houses and lack of regular garbage collection foster the proliferation of potential larval
121   habitats for *Ae. aegypti*, mainly reusable buckets, tanks for water reservoirs and disposable
122   containers which accumulate rain water (Gubler 2011).

123   As dengue and COVID-19 share clinical symptoms (e.g. fever, myalgia, fatigue,
124   headache, rash), the differential diagnosis in a situation of syndemic is not straightforward
125   (Harapan et al. 2021, but see Thein et al. 2021). Co-infections have been reported in individual
126   patients -both in Argentina (Radisic et al. 2020, Salvo et al. 2020) and abroad (e.g. Epelboin et
127   al. 2020, Verduyn et al. 2020, Villamil-Gómez et al. 2021)- and in small cohorts (e.g. Carosella
128   et al. 2021, Mejía-Parra et al. 2021). As both diseases may potentially lead to fatal outcomes
129   especially in patients with chronic comorbidities, overlapping infections may increase the
130   number of patients requiring intensive care and mechanical ventilation, further stressing the
131   health attention system (Cardona-Ospina et al. 2020).

132   Three million people live in CABA, which together with the neighboring contiguous
133   urbanization adds up 13 million inhabitants, making it the largest urban area in the country and
134   the second in South America. The socio-spatial dynamics of its historic conformation has
135   generated boundaries that define contrasting living conditions for its inhabitants, showing a
136   wide gap between the population living in precarious settlements and the one from the rest of
137   the city. Dadamia (2019) estimated that 170,000 people live in 30 slums occupying an
138   approximate area of 5 km^2. These territories are generally poorly integrated to the urban plot

139   and basic service networks, resulting in deficient sanitary conditions and precarious housing
140   which, added to poor nutrition quality, low health coverage and limited economic possibilities to
141   face contingencies, reinforce the social vulnerability of its inhabitants. A greater exposure to
142   threats combined with higher levels of vulnerability therefore results in a greater environmental
143   risk in slums than the one encountered in a formal neighborhood (DPNA 2018, Morandeira et
144   al. 2019). Slums therefore deserve special attention due to unequal conditions to face diseases,
145   favoring both infections and severe illness, e.g. structural poverty, high prevalence of
146   comorbidities, and impossibility of maintaining social distancing and recommended hygiene
147   measures. The need for a singular approach to the COVID-19 pandemia in these contexts has
148   been globally alerted (Corburn et al. 2020, Austrian et al. 2020, Naciones Unidas-Argentina
149   2020).

150   The purpose of this work was to study the spatio-temporal patterns of the 2020 dengue
151   epidemic in CABA in relation to socio-economic living conditions of its inhabitants and its
152   interaction with the onset of COVID-19. The specific objectives were (1) to compare the spatial
153   pattern of COVID-19 and dengue outbreaks, considering possible differences in the
154   epidemiological profiles in and outside slums; and (2) to evaluate the impact of preventive and
155   compulsory social isolation implemented for COVID-19 on the temporal patterns of dengue
156   cases by socio-economic stratum. The associated hypotheses were that (1) the total and per
157   class age incidence of COVID-19 and dengue differ by socio-economic stratum; and (2) the
158   establishment of ASPO to contain COVID-19 decreased the incidence of dengue cases. The
159   unprecedented national isolation and border closure due to COVID-19 spread in the midst of
160   the dengue epidemic can provide relevant information regarding dengue transmission dynamics
161   and possible keys to its control and mitigation.

162

163   **MATERIALS AND METHODS**

164

165   ***Study area and timespan***

166   Buenos Aires Autonomous City (CABA) is the capital city of Argentina, located in the
167   center-east of the country with an area of 203 km^2. The urban plot resembles a hand fan of 60
168   km of perimeter that limits to the south, west and north with urbanized areas of Buenos Aires
169   Province and to the east with the Río de la Plata river (Fig. 1). It is formed by 48 neighborhoods
170   and 15 administrative communes. For operational purposes, it is divided in 3554 census tracts
171   (defined as the minimal sampling unit for the last national census performed in 2010, hereafter

172   CT), each consisting of a polygon of variable size comprising in average 400 dwellings (min. 6,

173   max. 1405).

174   The last national census recorded 2,890,151 inhabitants with 6.3% of residents in slums.

175   Mean population per CT was 814 inh (min. 25, max. 3945) (INDEC, 2010). Projections for 2020

176   (total population 3,075,646 inh) estimate that CABA has 11% more women than men, and that

177   the population over 60 years old (hereafter, yo) represents over 21% of the total, while those

178   under 15 yo comprise almost 20% (GCBA 2020b). The population living in slums has a younger

179   profile (43% <15 yo, and 8% >60 yo; Bonfiglio and Márquez 2017). The global average age of

180   the population is 42 and 37 yo, while life expectancy is 82 and 75 yo for women and men,

181   respectively. In slums, the average age is lower (e.g. in 2009 the average age in the slum

182   known as "Villa 31" was 23.3 yo) (DGEyC 2009).

183   Slum inhabitants are unevenly distributed within CABA, 88% of them are located in the

184   southern part of the city, and surrounded by low-income neighborhoods that do not fit the slum

185   definition. The wealthier population is located mainly in a fringe from east to north, some areas

186   of the north-west and the geographic center of the city (Fig. 1). The spatial distribution of socio-

187   economic strata has been previously studied in detail (e.g. Marcos et al. 2015).

188   The current study considered the period between January 1st and May 30th 2020, that is,

189   between epidemiological weeks (EW) 1 and 22. Thus, the entire dengue epidemic was analyzed

190   from the beginning to the drop in the number of cases simultaneously with the onset of the

191   COVID-19 epidemic. During the study period, DETeCTAr was established in slums s3, s1 and

192   s2 (as numbered in Figure 1A, base map data © 2022 Google) on May 5th, 11th and 18th

193   respectively.

194

195   ***Databases***

196   Databases were obtained from the National Health Surveillance System, which is the

197   legitimate source of epidemiological information at the national level as it collects all obligatory

198   notification health events reported by enabled users from the public and private sectors and the

199   social security system (MSN 2022). Each record (a health event or case) was anonymized with

200   a numerical identifier and geo-localized as described ahead. The variables studied for each

201   case were: age (continuous for general descriptions and in four categories for further analyses:

202   0-19, 20-39, 40-59, and over 59 yo), sex (male / female), and death (yes/no).

203

204   **a. Dengue database**

205   All cases with a symptom onset date between January 1st and May 30th, 2020 were

206   considered. If not recorded, the earliest date among consultation, sample collection for

207   diagnosis and case notification date was used. A suspicious case is considered as a person

208   with fever, lasting less than 7 days without upper airway involvement or other defined etiology,

209   accompanied by two or more of the following signs: headache and/or retroocular pain, general

210   malaise, myoarthralgia, diarrhea, vomiting, anorexia and nausea, skin rash, petechiae or a

211   positive tourniquet test, leukopenia, thrombocytopenia. A probable case is any person with a

212   positive NS1 antigen detection test or a positive IgM detection test, whereas a confirmed case is

213   any suspicious case with a confirmatory laboratory diagnosis (viral isolation/genome

214   detection/neutralization test) or an epidemiological link, depending on the situation of the

215   jurisdiction (MSN 2015).

216   Regarding the origin, an imported case is any confirmed or probable case with address in

217   an area without viral circulation and that has visited areas with proven viral circulation in the last

218   15 days, whereas an autochthonous case is such whose possible site of infection corresponds

219   to the jurisdiction of habitual residence of the patient.

220   All probable and confirmed cases as defined above were included in the study, both

221   autochthonous and imported, and pooled for further analyses.

222

223   **b. COVID-19 database**

224   Cases with a symptom onset date between March 1st and May 30th 2020 were selected.

225   If not recorded, the earliest date of sampling for diagnosis was considered or, failing that, the

226   date of notification of the case.

227   A suspicious case is defined as any person with fever of at least 37.5 °C together with

228   one or more of the following symptoms: cough, sore throat, respiratory distress or alteration of

229   taste or smell. For closed institutions, close contact in slums and health personnel, only 1 of the

230   specified symptoms is required (MSN 2020e). A confirmed case is any suspicious case

231   confirmed by PCR laboratory test (MSN 2020e). These case definitions correspond to the study

232   period and have been modified since then.

233

234   **c. Case geo-reference**

235   A slum was operationally defined as a neighborhood in which at least eight grouped or

236   contiguous families live, where more than half of the population does not have land title and/or

237   lack regular access to at least two of the three basic public services (running water network,

238   electricity network with household meter, and sewer network) (Decreto 2670/2015). Combining

239   the slums shapefile and the map of vulnerable neighborhoods of CABA (GCBA 2015), all CTs

240   were assigned to 2 categories, slums and non-slums. Taking a conservative criterion, if any CT

241   contained a portion of slum it was classified as such. Next, contiguous slum CTs were put

242   together into a single cluster, giving a total of 17 slums.

243   In the National Health Surveillance System databases, the address is a free field. In

244   slums, this field generally specified the slum's name, the block's number and the house's

245   number. This allowed us to identify that a case occurred in a slum, but not to geolocate it

246   accurately. A list of words and fragments of words indicating slums was created to identify them.

247   A macro was developed in *Visual Basic* to scan the address field for the presence of any of the

248   terms in the list and thus assign the cases to slums. As a result, all cases were classified into: 1-

249   located in one of the 17 identified slums, 2- located in unspecified slums (without the slum's

250   name) or 3- outside slums, when no term on the list was found in the address field. The cases in

251   2- were manually inspected and, if possible, assigned to their corresponding slum based on

252   knowledge of the study area. All cases in 3- were georeferenced in *R* version 4.1.0 (R Core

253   Team 2021) using the *RUMBA* package (v0.1.0, Vazquez Brust 2019), converting addresses in

254   lat/lon variables. Finally, a union of the cases was made with the map of CTs with the slums

255   information. In this way, the CT was assigned to the records and, if they were within slum CTs,

256   they were included within that classification.

257

258   ***Classification of non-slums CTs in three socio-economic strata***

259   Non-slums CTs were classified in 3 socio-economic strata using available cartography

260   for the study area based on 4 variables, as follows: proportion of households with water from the

261   public network inside the home; proportion of households that use the gas network, bulk gas, or

262   gas tube primarily as cooking fuel; proportion of households with a computer; and population

263   from 25 to 64 yo with complete university education (Marcos et al. 2015). The original

264   categories High Residential (HighR)*,* Mid Residential (MidR) and Low Residential (LowR) were

265   kept as defined in the cited work as three levels in the socio-economic gradient. To reclassify

266   the CTs that originally belonged to categories as Central City, Colonial City and Housing

267   Complexes, a decision tree classifier was used with the 4 explanatory variables mentioned

268   above and the response variable as one of HighR, MidR, LowR, or slum + informal settlement +

269   transitory housing complex (as in Marcos et al. 2015). The cutoff criteria obtained for that subset

270   were applied to the above to reclassify them. Not urbanized areas (parks and water bodies)

271   were excluded from the classification.

272   Most (67/83) of the CTs from Central City (located at the north-east edge of the study

273 area) were assigned to MidR, while two-thirds (57 out of 86) of the CTs from Colonial City (also

274 located east, south of Central City) were classified as HighR. The housing complexes (located

275 mostly in the southern part of the city but also on the west bank) were distributed equally

276 between LowR and MidR (Table 1). The total number of CTs for each residential category was

277 401, 1559 and 1439 for LowR, MidR and HighR respectively, resulting in the final classification

278 of four socio-economic strata observed in Figure 1B (census tracts geospatial data from

279 INDEC).

280

281 ***Non spatial analysis***

282 **a. Socio-economic strata x age.** Aligned-Rank Transform ANOVA was performed using

283 packages *ARTool* (Kay et al. 2021) and *rcompanion* (Mangiafico 2016) in R to test for

284 differences in the incidence of dengue and COVID-19, and age at death due to COVID-19

285 among socio-economic strata, age categories and their interaction. Post-hoc comparisons for

286 pairwise interactions were conducted, with Bonferroni adjustment for multiple pairs.

287 **b. Temporal dengue pattern.** The proportion of dengue cases in each EW were plotted

288 together with weekly mean temperature to compare the occurrence of dengue cases by

289 socioeconomic strata. The incidence of dengue cases per EW by 10,000 inhabitants was also

290 plotted to help visualize any effect due to the ASPO and COVID-19 disturbances.

291

292 ***Spatial analysis***

293 **a. Variogram.** We calculated the sample variogram of the number of dengue cases per 10,000

294 inh during the study period in order to have a picture of the spatial dependence of dengue cases

295 per CT as a function of distance. We used an isotropic Cressie's robust variogram estimate

296 included in the R *gstat* package (Pebesma 2004). Three parameters are important in the

297 interpretation of these graphs: the nugget, the sill and the range. The nugget is the height of the

298 jump of the variogram at the origin, which represents basal variability at very close separation

299 distances. The sill is the variability due to spatial correlation, and is the difference between total

300 variation and the nugget. The range represents the distance limit beyond which the data are no

301 longer spatially correlated and is calculated as the distance where the variance first reaches its

302 maximum (Cressie 1993).

303 **b. Incidence by cluster.** A distance matrix was run in *QGIS 3.16* from the centroid of each CT
304 to all its neighboring CTs up to 600 m. The selection of this distance was to make clusters
305 similar in extension to CT agglomerates that make up the largest slums, and also following the
306 report that this was approximately the correlation distance for dengue cases in CABA during the
307 2016 epidemic (Gurevitz et al. 2021). This was also intended to make population totals in and
308 outside slums within the same magnitude order and therefore be able to compare incidence
309 values in the different socio-economic strata.

310   Due to the exclusion of non-inhabited areas, there are 5 CT (3 classified as slum and 2
311 as LowR) that have no neighbors within 600 m, for which the value of the CT itself was applied.
312 For all others, the cumulative population and cumulative cases of dengue and COVID-19 were
313 calculated for each cluster. With this information the incidence was calculated as:

314

315 $\text{Incidence\_cluster}_i = \text{accumulated cases\_cluster}_i * 10{,}000 \ / \ \text{accumulated population\_cluster}_i$

316

317   For both diseases, each cluster was assigned to one of 5 categories according to the
318 quantiles of its incidence throughout the whole study period (EW 1-22). Categories were ranked
319 nominally from 1 (lowest) to 5 (highest) incidences of each disease. To study the combined
320 behavior of both diseases in space, nominal categories for each disease were multiplied
321 (COVID-19 category * dengue category) obtaining values from 1 (lowest) to 25 (highest)
322 combined risk. We considered values 1 and 2 indicative of low joint risk and values 20 and 25 of
323 high risk.

324   The incidence by residential type (HighR, MidR, LowR) was compared with the one
325 registered in slums, evaluating whether the values in slums were higher than the 97.5% quartile
326 of the distribution of values obtained in the residential clusters. First, the analysis was performed
327 without taking into account the composition of CTs of each cluster, then considering whether the
328 neighbors included in each cluster were of the same residential type as the centroid CT.

329

330

331 **RESULTS**

332

333   Between January 1st and May 30th 2020, 7,175 dengue cases were registered in CABA,
334 the incidence rate being 23.3 cases per 10,000 inhabitants. No deaths were recorded and only

335   172 cases showed signs of alarm. The database was fairly complete, allowing the georeference

336   of 93% of the cases, and lacking information of gender and age only for 3 and 9 cases,

337   respectively. Regarding gender, 50.2% of the cases were men and 49.8% were women, and

338   the median age of all cases was 33 yo (32 yo men; 34 yo women). Of the total geo-referenced

339   cases (6670), 29.2% occurred in slums. For the former, the median age was 29 yo and the

340   percentage of women was 52.5% while in the rest of the city values were 35 yo and 48.2%. The

341   largest number of cases in slums occurred in s1, s2 and s5 (Fig. 1), accumulating among them

342   67% of the slum cases.

343   During the same period, 8,809 cases of COVID-19 were registered, with an incidence rate

344   of 28.6 cases per 10,000 inhabitants. There were 251 deceased persons, with a mortality rate

345   of 0.82 per 10,000 inhabitants and a fatality rate of 2.8%. Georeference was achieved for 87%

346   of the cases, all records reported age information and 38 lacked gender information. Cases

347   were distributed almost equally between men and women (49.6% and 50.4%), the median age

348   of the cases was 34 yo (34 yo women; 35 yo men). As for the deceased, 55.1% were males

349   (median age 70 yo) and 44.9% were females (83 yo). Of the total georeferenced cases (7653),

350   slightly over half (51.4%) occurred in slums. There were almost no variations in and outside

351   slums regarding sex distribution, but the median age of cases was lower in slums (29 yo) than

352   outside (42 yo). Greater differences were observed among the deceased, the proportion of

353   deaths among women in slums was 32% (14/44) compared to 49% outside slums (83/171).

354

355   ***Age groups, cases and mortality***

356   **Dengue.** In the analysis of dengue incidence, there was a significant interaction between

357   the socio-economic stratum and the age group (F=37.28, p<0.001). In general, the incidence

358   was higher in slums for all age categories, in LowR for all categories below 60 yo, and in MidR

359   for 20-59 yo. In MidR and HighR, intermediate age categories presented higher incidences than

360   the age extremes. In HighR, the youngest and the eldest had remarkably low incidence,

361   whereas incidence for intermediate age categories was comparable to >59 yo in LowR and

362   MidR (Table 2).

363   **COVID-19.** There was also a significant interaction between the socio-economic stratum

364   and the age group (F=53.68, p<0.001). Incidence was remarkably higher in slums than in

365   residential CTs for all age groups, however large intra-class variability prevailed in the >59 yo

366   group (Table 2). Within each residential type, incidence for the 0-19 yo group was remarkably

367   lower than for the 20+ yo groups, whereas incidence for mid-age groups in LowR was higher

368   than for all MidR and HighR (with the exception of MidR 20-39 yo, Table 2). Comparing age

369   groups among socio-economic strata, incidence in the group 0-19 yo was maximum for slums

370   and LowR, while in MidR and HighR showed the lowest values. The elder population (>59 yo)

371   incidence was lowest in slums, intermediate in LowR and MidR and highest in HighR. Of the

372   251 diseased, 48 were reported in slums, 17 in LowR, 92 in MidR and 68 in HighR, and 26

373   could not be assigned to a location (and were further excluded). The mean age of the diseased

374   differed significantly among socio-economic strata (F=37.19, p<0.001), being higher in HighR

375   and MidR than in LowR and slums. This is also reflected in the proportion of diseased below 60

376   yo, which was over 56% in slums and less than 2% in HighR (Table 2).

377

378   ***Temporal patterns***

379   **Dengue.** The general pattern of dengue occurrence showed two main peaks in EWs 11

380   and 14, and a third in EW 18 for MidR and LowR, and a valley in EWs 12 and 13 which

381   coincided with the establishment of ASPO. The fall in incidence from EW 11 to EWs 12 and 13

382   was higher in slums as compared to the other strata. All four categories reached the highest

383   peak in EW 14, after which cases in slums decayed until the end of the study, but in all

384   residential categories a rebound in EW 18 was observed (Fig. 2 a, b). Peaks in EWs 11, 14 and

385   18 were lagged one week with relative rises in mean temperature. The fall in temperature in

386   EWs 11,12 and 14 may have been related to the fall in cases the following weeks. But LowR

387   and MidR showed a rise in the proportion of cases in EW12. Also, although the fall in mean

388   temperature to 23 °C in EW 11 was followed by a fall in cases, the fall in EW 7 was followed by

389   a rise. Furthermore, the rise in temperature of EW 13 was 23 °C too (Fig. 2 a, b).

390   **COVID-19.** First cases appeared earlier (EW 10) in residential areas than in slums (EW

391   13). Then on until the end of the study, cases in slums increased steadily, whereas an

392   oscillation pattern with a rising tendency was observed in residentials (Fig. 2 c). The incidence

393   temporal pattern showed the preponderance of cases within slums, with a sharp rise as from

394   EW 17 (Fig. 2 d). Note that weekly incidence values for COVID-19 were nearly 4 times higher

395   than for dengue (Fig. 2 b, d).

396

397   ***Variograms***

398   The range of the variogram for the number of dengue cases per 10,000 inhabitants

399   during the study period was 0.00497°, indicating spatial correlation up to ≈ 550m (Fig. 3). The

400   nugget was 119.0, and the sill 75.6. The former value suggests a variation of dengue cases

401   between closest CTs around 58%, and the latter that similarity due to proximity accounts for

402   37% of the variation in dengue cases between CTs (76/(119+76)), which in turn only happens

403   up to 550m.

404

405   ***Incidence per cluster***

406   The mean accumulated population per cluster was 10,773 inh (min 105; max 48,427) for

407   residential central CTs and 18,955 (min 4284; max 41354) for slums. Regarding the

408   composition of neighboring CTs within each cluster, only 47% (187/399) of the LowR stratum

409   clusters (as defined by their central CT) had over 50% of their neighboring CTs of the same

410   category. Contrastingly, the same stratum neighbors were 82% for MidR and 86% for HighR

411   clusters (1278/1559 and 1239/1439 respectively). Therefore, for LowR analyses were

412   discriminated regarding neighbor composition, whereas for MidR and HighR it was performed

413   all together.

414   **Dengue.** Cluster incidence presented a heterogeneous pattern, with higher values in the

415   southern sector of the city, followed by the west, and low values in highly urbanized

416   neighborhoods (Fig. 4a). Median values were 24.2 for slums, 14.1 for LowR (8.2, 14.2 and 26.2

417   if discriminated by neighbor composition, less than 0.4, 0.4-0.6 and over 0.6 respectively), 11.6

418   for MidR and 4.3 for HighR. Slums with higher incidence were s1 (158.1), s5 (137.8), s2 (111.4)

419   and s4 (59.1). Quantiles 2.5-97.5% for each socio-economic stratum were 2.1-118.8 for LowR,

420   2.2-112.1 for MidR, and 8.8-49.2 for HighR. Only 2 of the 17 slums (s1 and s5) presented

421   values above the 97.5% quantile for LowR and MidR, whereas 4 of them did so for HighR.

422   **COVID-19.** Cluster incidence presented a marked geographical pattern, with higher

423   values in the east, south, high populated areas and slums (Fig. 4b). Median values were 21.8

424   for slums, 19.8 for LowR (19.2 for less than 0.4 LowR neighboring CTs, and 21.2 for 0.4-0.6 and

425   over 0.6), 12.0 for MidR and 10.7 for HighR. Slums with higher incidence values were s3 (685),

426   s1 (332), s2 (98.4) and s5 (42.7). Also, 1 CT from LowR and 1 from MidR which are located

427   next to s1 included the slum as a neighbor and therefore presented incidence values close to

428   300. Quantiles 2.5-97.5% for each socio-economic stratum were 3.1-51.2 for LowR, 2.0-36.4 for

429   MidR, and 4.5-27.1 for HighR.

430   **Joint risk for dengue and COVID-19.** The lowest joint risk clusters were located mainly

431   in HighR areas, whereas high joint risk was observed mainly in the south, the historical/oldest

432   part of the city and center north (Fig. 5). As shown in Fig. 6, the proportion of CTs of each joint

433   risk category by type of neighborhood evidenced a clear pattern of higher risk in LowR and

434   slums, and of lower risk in HighR. The two lowest risk categories (1 and 2) represented less

435   than 7% of slums, LowR and MidR tracts and 19% of HighR tracts. More than 51% of HighR

436   CTs did not reach risk level 4 of either illness (joint risk values of 1, 2, 3, 6 and 9). On the other

437   extreme, the 20 and 25 risk categories represented 65% of slums, 38% of LowR, 12% of MidR

438   and 3% of HighR, with 88% of the slums presenting values of 4 or more in one of the illnesses.

439   The three slums with lower joint risk categories were s11, s9 and s13 (all with nominal risk 1 for

440   COVID-19 and 1, 3 and 4 for dengue respectively).

441

442

443   **DISCUSSION**

444   Cities are socio-environmental mosaics of interconnected neighborhoods with varying

445   local realities, promoting particular conditions for the onset and spread of different diseases

446   (Santos et al. 2020). In CABA, both dengue and COVID-19 epidemics during early 2020 were

447   spatially heterogeneous. Differences were encountered in the incidence of both diseases

448   between slums and residential areas and also among the different slums, indicating that

449   informal settlements do not behave as a unit, rather each one presents its particularities. In fact,

450   the community-based testing strategy was established on different dates according to the cases'

451   peak in each slum.

452   The selection of the study period was intended to include the entire dengue epidemic,

453   superimposed with the onset of COVID-19. Temporal dengue patterns at temperate latitudes

454   are typically Gaussian, due mainly to climatic conditions and their effect on the population of the

455   vector *Ae. aegypti*. The temporal span of the 2020 epidemic resembled previous outbreaks

456   (MSN 2020d). Although the denominated first COVID-19 wave extended until November 2020,

457   the onset is particularly valuable to analyze a potentially heterogeneous pattern and significant

458   socio-environmental associations that were later overruled by the great number of cases and

459   high contagion rates. Also, national records were more accurate at the beginning of the

460   epidemics than when the healthcare system was saturated.

461   During the so far worst dengue outbreak in CABA, dengue incidence was higher in low

462   income areas and slums than in mid and high residential neighborhoods. Almost one out of

463   three cases were reported in slums (which occupy less than 3% of the territory), similar to the

464   2016 epidemic (Gurevitz et al. 2021). The general spatial pattern of cases was also similar to

465   the reported therein, with house prevalent neighborhoods showing favored transmission over

466   high rise buildings areas. It is noteworthy that areas of lower height edifications coincide with

467   areas where higher vector activity has been detected (Carbajo et al. 2006) and do not match the

468   most populated areas, which are closer to the east and downtown. This may be related to the

469 fact that highly impervious surfaces and tall edifications do not favor the mobility of *Ae. aegypti*
470 and do not offer adequate habitat for immatures or adults, whereas low houses with green
471 gardens or yards allow the vector to enter the inner sector of the blocks, and present better
472 conditions for mosquito proliferation (in terms of shade, humidity, artificial container abundance)
473 (Carbajo et al. 2006). The onset of cases also occurred in the lower socioeconomic strata, in
474 line with previous reports of more imported cases in low income neighborhoods with a higher
475 proportion of foreign population and people at an active age (Carbajo et al. 2018b). As *Ae.*
476 *aegypti* is a daytime biter, it is common that people acquire dengue at their work location rather
477 than at home. Although during the dengue epidemic of 2020 compulsory isolation prevented
478 most of the population from going to work, this event occurred after EW 12 when dengue had
479 already spread throughout the city. Therefore, virus transportation between work and home may
480 have occurred during early transmission.

481   On the other hand, COVID-19 cases appeared first in high-income neighborhoods, and
482 after a time lag of around 3 weeks they disseminated to slums. This may be related to the origin
483 of imported cases from the Northern Hemisphere, and that travel to those far destinations
484 occurred most probably in high and mid income strata. It is worth mentioning that during the
485 most restrictive circulation period, essential workers were excepted from mobility restriction
486 measures. Within this group were people in charge of school and community meal programs, a
487 frequent activity in city slums, along with health workers and delivery personnel. Moreover, as in
488 many other Latin American cities, in CABA there is an upper circuit of the urban economy,
489 based on high technology and information flow, and a "lower circuit" that depends on intensive,
490 informal labor (Santos et al. 2020) that did not stop functioning during the isolation measures. A
491 great proportion of workers in slums are part of the informal sector and were not reached by the
492 official release from work and economic support benefits, therefore had to continue performing
493 their activities.

494   When putting age in focus, dengue incidence did not differ by age category in slums,
495 while it was higher in middle age categories for residential neighborhoods. Similar results were
496 observed for COVID-19, with no differences in incidence per age category for slums, and higher
497 incidence in the other strata for middle age categories. The difference was that, in residentials,
498 when comparing extreme age categories, the young presented higher dengue incidences than
499 the old, and for COVID-19 the pattern was reversed. Deceased people due to COVID-19 were
500 older in HighR and MidR than in LowR and slums, probably related with a heterogeneous
501 distribution of the older population among neighborhoods and with a different probability of
502 contagion. Although older people had more risk of suffering complications, the feasibility of

503   isolation from the rest of the family given an infection might have been more frequent in

504   populations with more economic resources. Physical distancing is virtually impossible in the

505   overcrowding housing situation of slums. Also, lower income urban residents are more likely to

506   use public transportation, where exposure to the virus is higher than in private vehicles.

507   Moreover, the informal working situation mentioned above forced many low income residents to

508   expose themselves instead of staying at home. Once infected, lower age at death may be

509   related to pre-existing conditions, given that under-resourced populations frequently have less

510   access to high quality health care, they are prone to suffer from more baseline illnesses that are

511   associated with higher COVID-19 mortality, such as diabetes, heart disease, pulmonary

512   affections and cancer (Finch and Hernandez Finch, 2020). These non-communicable diseases

513   which were once considered more prevalent in wealthier populations are now major drivers of

514   poverty worldwide, related to low quality diets, precarious houses, and living in highly

515   contaminated areas (Niessen et al. 2018). The lack of access to healthcare facilities may have

516   also led to the death of young adults who could have survived if properly treated. Regarding the

517   difference in mortality by gender between slums and residential areas, a higher mortality of men

518   with respect to women has been documented (reviewed in Bienvenu et al. 2020), which could

519   add to the effect of socio-environmental vulnerabilities on mortality rates (as reported in Ribeiro

520   et al. 2021).

521   Of course, it is impossible to know what dengue incidence would have been if social

522   isolation had not been imposed, or whether it would have risen farther than the actual recorded

523   values. But what can be stated is that mobility restriction did not produce a decrease in dengue

524   incidence as hypothesized, on the contrary, values continued rising in all socio-economic

525   neighborhood types. At a first glance, the ASPO seems to have influenced transmission, this

526   might have been due to less contagion derived from low mobility or to a diminution in the

527   number of testing. But according to the rise in EW 14, it can be inferred that the decay in

528   dengue cases in EWs 12-13 due to ASPO was in the detection or report of cases but not in the

529   transmission. As already mentioned, the most vulnerable populations depend on the public

530   health system and have no possibilities of virtual assistance or medical follow-up. But this

531   pattern was observed for all socio-economic strata, indicating that the fear of contagion and the

532   compliance of the isolation national decree resulted in a lack of medical consultation and the

533   sub-diagnosis caused by symptom overlapping of both diseases.

534   At the same time, the relationship of weekly dengue cases with temperature should not

535   be overlooked, recalling that in CABA epidemic patterns are typically Gaussian. There is a fall

536   in mean temperature from EW 10 to 11 and to 12, which rises in EW 13 and falls again thereon.

537   The pattern in cases lags one week with temperature, especially in slums and HighR. The first
538   fall from EW10 to 11, to around 23 °C, may not be related to limiting temperature, as lower
539   temperatures were observed in previous weeks while transmission was rising (EW 7 to 9). On
540   the other hand, from EW 11 to 12, and from EW 13 to 14, temperature falls to around 21 °C.
541   Previous studies on temperature dependent R0 models have shown that low temperature
542   transmission limits may be around 17 to 21° (Mordecai et al. 2017, 2019). We believe the first
543   fall in cases after EW 11 is related to the ASPO but not due to a true decrease in transmission,
544   consequence of the factors explained above (great pressure exerted by COVID-19 epidemic on
545   the health attention and management systems, the fear of the population to attend health
546   centers during the pandemia, and the sub-diagnosis caused by symptom overlapping of both
547   diseases). Nevertheless, the following falls in case numbers may be due to the decrease in
548   temperature, particularly after EW 15, when temperatures fall to 17 °C and below.

549   When analyzing joint dengue and COVID-19 risk, the lowest risk categories were scarce
550   in slums and LowR, whereas the highest categories represented more than half of all slums and
551   almost 40% of LowR. In all, it is evident that although COVID-19 started in HighR due to
552   imported cases, when considering the entire study period both epidemics undoubtedly struck
553   harder in slums and low income neighborhoods. This is in line with the aforementioned concept
554   that greater exposure to threats combined with higher levels of vulnerability results in higher
555   environmental risks (DPNA 2018, Morandeira et al. 2019). Despite the fact that dengue mortality
556   rates in temperate Argentina are remarkably low, in general early clinical detection and
557   adequate treatment of patients can significantly reduce acute cases. Therefore, the combined
558   impact of both epidemics could harm specially the most vulnerable populations (Mascarenhas et
559   al. 2020). Still, the effect of co-infection of dengue and COVID-19 on human health is poorly
560   understood (but see Carosella et al. 2021). The first-time occurrence of a high magnitude
561   syndemic in Buenos Aires has allowed for a trustworthy record of detailed information regarding
562   dengue cases (e.g. date of onset of symptoms, exact location) that are often not available.
563   Studying the relationship between symptoms of both affections and laboratory diagnosis
564   confirmation would help to optimize future records of both dengue and COVID-19, enabling
565   proper diagnosis and treatment.

566   In the world, the effect of compulsory social isolation (lockdown) due to COVID-19
567   pandemic on dengue transmission has been variable, with some countries recording more
568   cases than usual and others the opposite (Brady and Wilder-Smith 2021). The dengue epidemic
569   of 2020 was the strongest in Argentina since the reemergence of the virus in 1998, and mobility
570   restriction measures due to COVID-19 coincidence did not contain its transmission. The crisis

571   unleashed by the pandemic once again highlights the unequal environmental, health and

572   economic conditions in which part of our society lives. As long as the lack of social protection

573   and precarious conditions in which the underprivileged sectors of society live continues, as well

574   as the fragility of the health systems to which they have access, diseases associated with

575   overcrowding, lack of infrastructure, lack of safe water, disorganized urbanization, among other

576   conditions that favor the development of infections, will continue to exist. Although 2020 will be

577   worldwide remembered for the onset of COVID-19 pandemics, health care towards other needs

578   and diseases should not be unattended, especially in territories with pre-existing vulnerabilities.

579

580

581   **Contributions**

582   AEC: Conceptualization, Methodology, Software, Formal analysis, Writing - Original Draft

583   Writing - Review & Editing, Visualization

584   MVC: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing -

585   Review & Editing.

586   MP, LEI and PBB: Conceptualization, Investigation, Data Curation, Writing - Original Draft,

587   MSS: Conceptualization, Writing - Review & Editing, Supervision

588   MEU: Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft,

589   Writing - Review & Editing, Supervision.

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591

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820 **Figure captions**

821

822 **Figure 1.** Classification of census tracts in four socioeconomic strata, (A) slums (numbered from

823 1 to 17 for identification purposes) and (B) three residentials. Parks and other vegetated areas,

824 and water bodies were excluded from the classification and shown in gray.

825 Slum numbers: s1 Villa 1-11-14/Rivadavia; s2 Villa 21-24/Zavaleta; s3 Villa 31/31bis/ San

826 Martín; s4 Fátima/Carrillo; s5 Villa 20; s6 Ciudad oculta; s7 Cildañez; s8 Barrio INTA/María

827 Auxiliadora/Barrio Obrero/Bermejo; s9 Pirelli; s10 Playón de Chacarita/Villa Fraga; s11 Barrio

828 Rodrigo Bueno; s12 Lamadrid; s13 Asentamiento Villa Ortúzar; s14 La Carbonilla; s15 Villa 26;

829 s16 NN2; s17 NN3.

830 Base map © 2022 Google, Data SIO, NOAA, U. S. Navy, NGA, GEBCO, Maxar Technologies,

831 Landsat/Copernicus, Terra Metrics.

832 **Figure 2.** Temporal dynamics of dengue and COVID-19 from epidemiological week 1 to 22,

833 2020, in Buenos Aires Autonomous City, Argentina. Lines show the weekly proportion of total

834 dengue (A) and COVID-19 (C) cases, and the weekly incidence (cases per 10,000 inhabitants)

835 for dengue (B) and COVID-19 (D) by socio-economic stratum, superimposed on bars

836 representing weekly mean temperature.

837 **Figure 3.** Semivariogram of the number of dengue cases per 10,000 inhabitants by census tract

838 (pooled from EW 1 to 22, 2020).

839 **Figure 4.** Incidence per cluster (number of cases per 10,000 inhabitants) for dengue (A) and

840 COVID-19 (B). Cluster value is represented by its central census tract.

841   **Figure 5.** Joint risk for dengue and COVID-19. Each census tract is classified from 1 to 25 as a

842   product of dengue and COVID-19 risk (each defined in 5 categories from 1 lowest risk to 5

843   highest risk, equal quantiles).

844   **Figure 6.** Proportion of census tracts classified from 1 to 25 in a joint risk category of dengue

845   and COVID-19 (each defined in 5 categories from 1 lowest risk to 5 highest risk, equal

846   quantiles), for each socio-economic stratum.

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848

Categorization of census tracts' original classes by Marcos et al. (2015) into three socio-economic residential levels (HighR, MidR, LowR) and slums

1 Table 1. Categorization of census tracts' original classes by Marcos et al. (2015) into three

2 socio-economic residential levels (HighR, MidR, LowR) and slums.

Final category	Initial classification			Total
	Colonial City	Central City	Housing Complex	
HighR	57	10	7	74
MidR	27	67	49	143
LowR	2	6	54	62
Slum			8	8
Total	86	83	118	287

5

Dengue and COVID-19 incidence per age group and socio-economic stratum, along with age statistics of diseased due to COVID-19.

yo stands for years-old. Within a column, different superscript letters indicate significant differences (p<0.05) in pairwise comparisons.

1 Table 2. Dengue and COVID-19 incidence per age group and socio-economic stratum, along
2 with age statistics of diseased due to COVID-19. *yo* stands for years-old. Within a column,
3 different superscript letters indicate significant differences (p<0.05) in pairwise comparisons.

Socio-economic stratum	Age group	Dengue Incidence (mean ± SE)	COVID-19		
			Incidence (mean ± SE)	Diseased age (mean ± SE)	Diseased % < 60 yo (total all ages)
Slums				58.1 ± 13.4[a]	56.3 (48)
	0-19 yo	37.4 ± 11.4[a,b]	66.9 ± 29.5[a,b]		
	20-39 yo	66.4 ± 18.4[a]	106.3 ± 46.7[a]		
	40-59 yo	65.6 ± 18.6[a,b]	132.2 ± 63.8[a]		
	>59 yo	73.8 ± 27.4[a,b]	151.6 ± 93.7[a,b,c,d,e]		
LowR				66.7 ± 16.8[a]	35.3 (17)
	0-19 yo	23.8 ± 2.4[b]	12.6 ± 2.0[g,h]		
	20-39 yo	40.7 ± 3.5[a]	29.4 ± 2.5[a,b]		
	40-59 yo	36.8 ± 3.2[a,b]	29.1 ± 3.3[b,e]		
	>59 yo	13.3 ± 1.8[d,e]	18.4 ± 3.4[c,g]		
MidR				80.9 ± 13.6[b]	8.7 (92)
	0-19 yo	18.6 ± 1.4[d]	6.6 ± 0.7[f,h]		
	20-39 yo	26.1 ± 1.4[b]	16.3 ± 0.9[d,e]		
	40-59 yo	27.9 ± 1.6[b]	17.3 ± 1.2[c,d]		
	>59 yo	10.7 ± 1.0[e]	15.9 ± 1.9[g]		
HighR				81.4 ± 9.7[b]	1.5 (68)
	0-19 yo	5.8 ± 0.7[c]	3.7 ± 0.7[f]		
	20-39 yo	10.4 ± 0.7[d]	11.9 ± 0.7[c,d]		
	40-59 yo	11.5 ± 0.9[d,e]	13.8 ± 0.9[c,g]		
	>59 yo	4.5 ± 0.5[c]	13.9 ± 1.5[c,g]		

Figure 1

Classification of census tracts in four socioeconomic strata

(A) slums (numbered from 1 to 17 for identification purposes) and (B) three residentials. Parks and other vegetated areas, and water bodies were excluded from the classification and shown in gray. Slum numbers: s1 Villa 1-11-14/Rivadavia; s2 Villa 21-24/Zavaleta; s3 Villa 31/31bis/ San Martín; s4 Fátima/Carrillo; s5 Villa 20; s6 Ciudad oculta; s7 Cildañez; s8 Barrio INTA/María auxiliadora/Barrio Obrero/Bermejo; s9 Pirelli; s10 Playón de Chacarita/Villa Fraga; s11 Barrio Rodrigo Bueno; s12 Lamadrid; s13 Asentamiento Villa Ortúzar; s14 La Carbonilla; s15 Villa 26; s16 NN2; s17 NN3.

Base map © 2022 Google, Data SIO, NOAA, U. S. Navy, NGA, GEBCO, Maxar Technologies, Landsat/Copernicus, Terra Metrics.
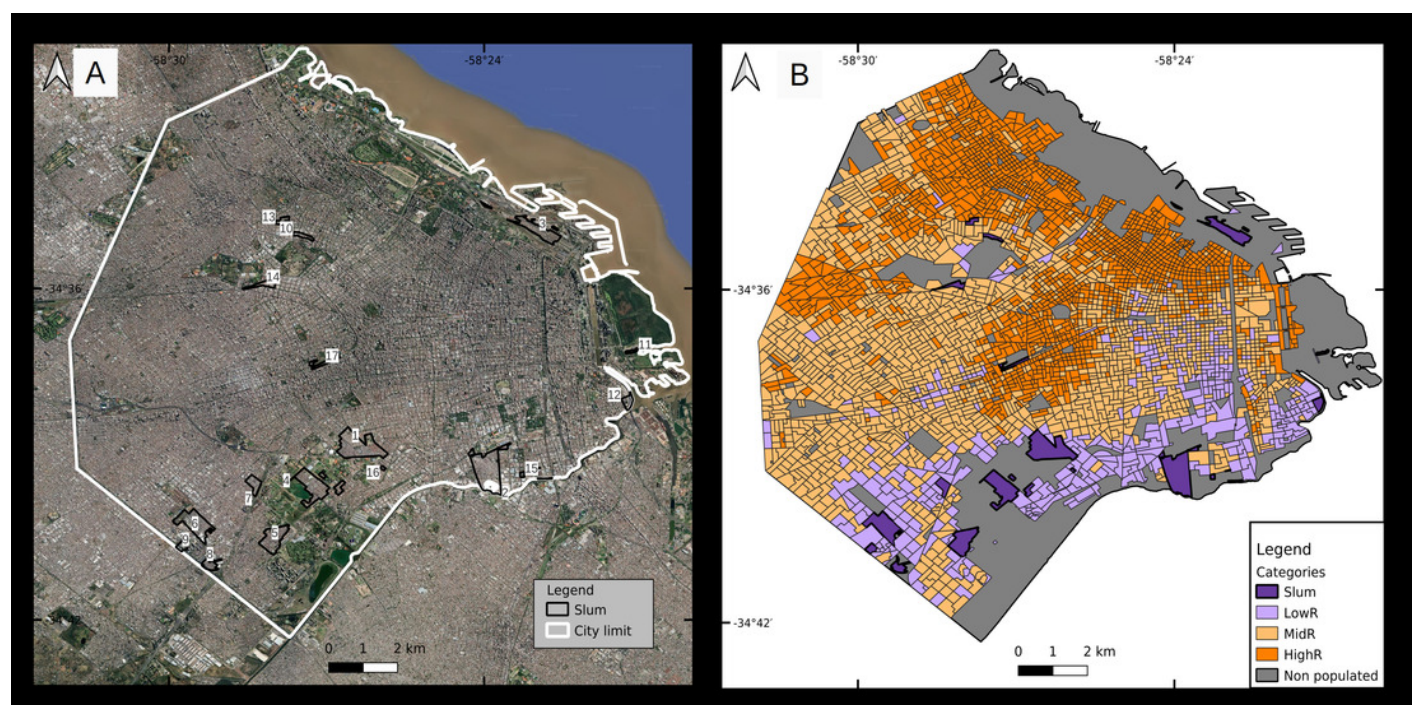
Figure 2

Temporal dynamics of dengue and COVID-19 from epidemiological week 1 to 22, 2020, in Buenos Aires Autonomous City, Argentina

Lines show the weekly proportion of total dengue (A) and COVID-19 (C) cases, and the weekly incidence (cases per 10,000 inhabitants) for dengue (B) and COVID-19 (D) by socio-economic stratum, superimposed on bars representing weekly mean temperature.
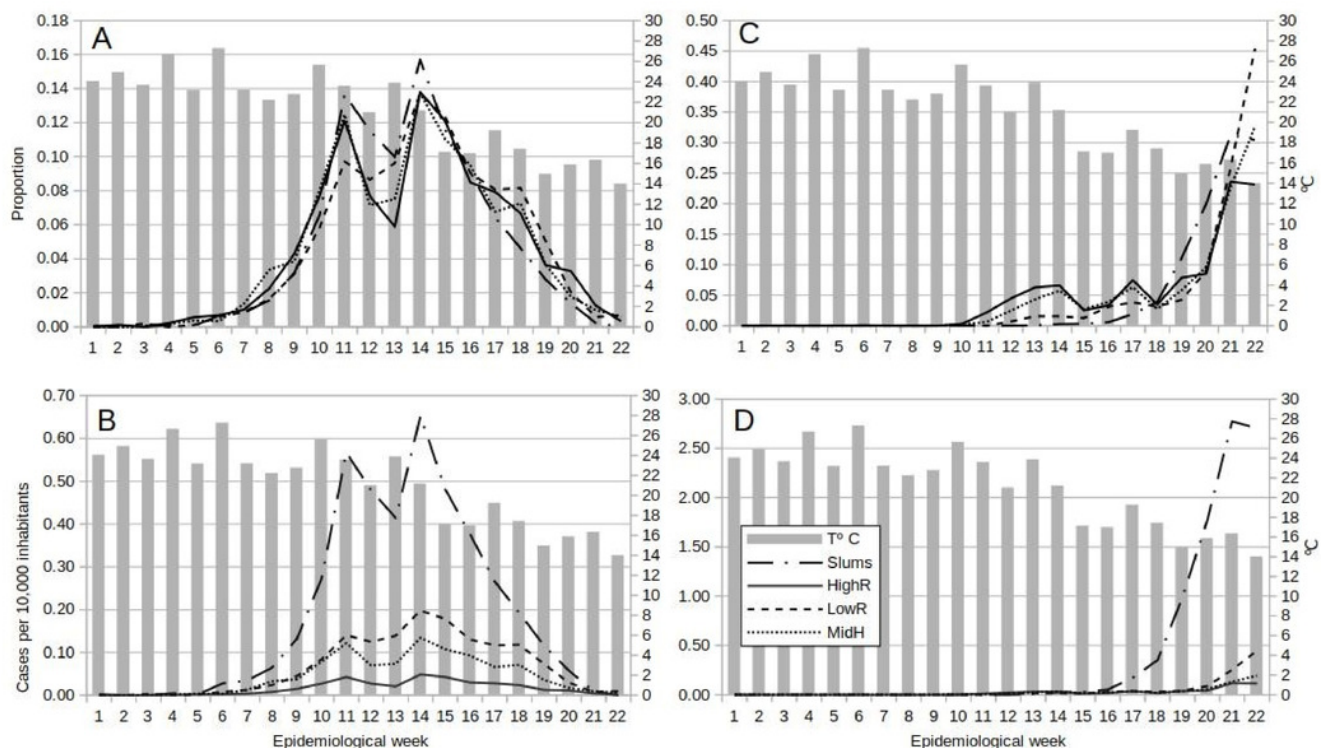
Figure 3

Semivariogram of the number of dengue cases per 10,000 inhabitants by census tract (pooled from EW 1 to 22, 2020).
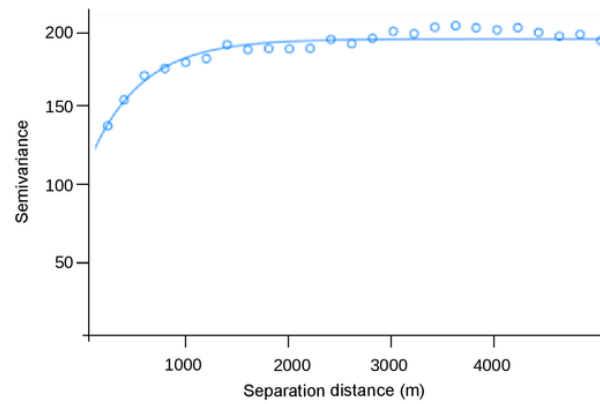
Figure 4

Incidence per cluster (number of cases per 10,000 inhabitants). for dengue (A) and COVID-19 (B).

Dengue (A) and COVID-19 (B). Cluster value is represented by its central census tract.
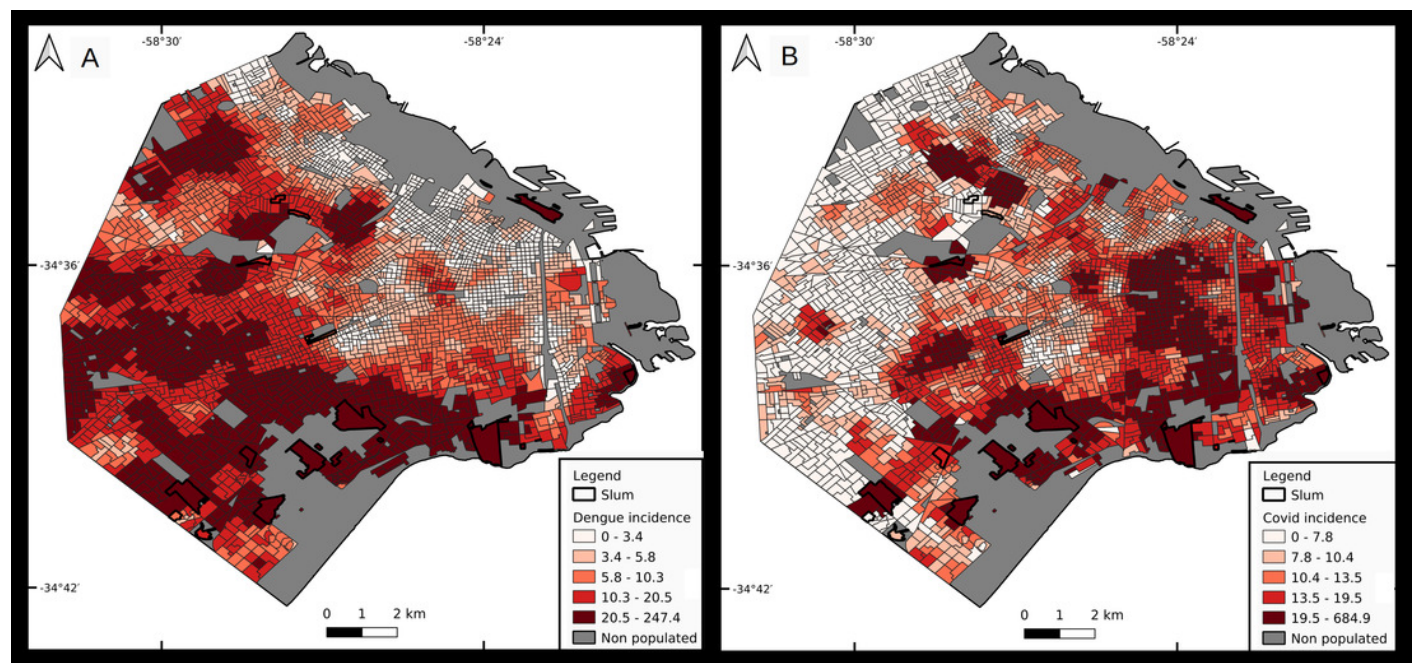
Figure 5

Joint risk for dengue and COVID-19.

Each census tract is classified from 1 to 25 as a product of dengue and COVID-19 risk (each defined in 5 categories from 1 lowest risk to 5 highest risk, equal quantiles).
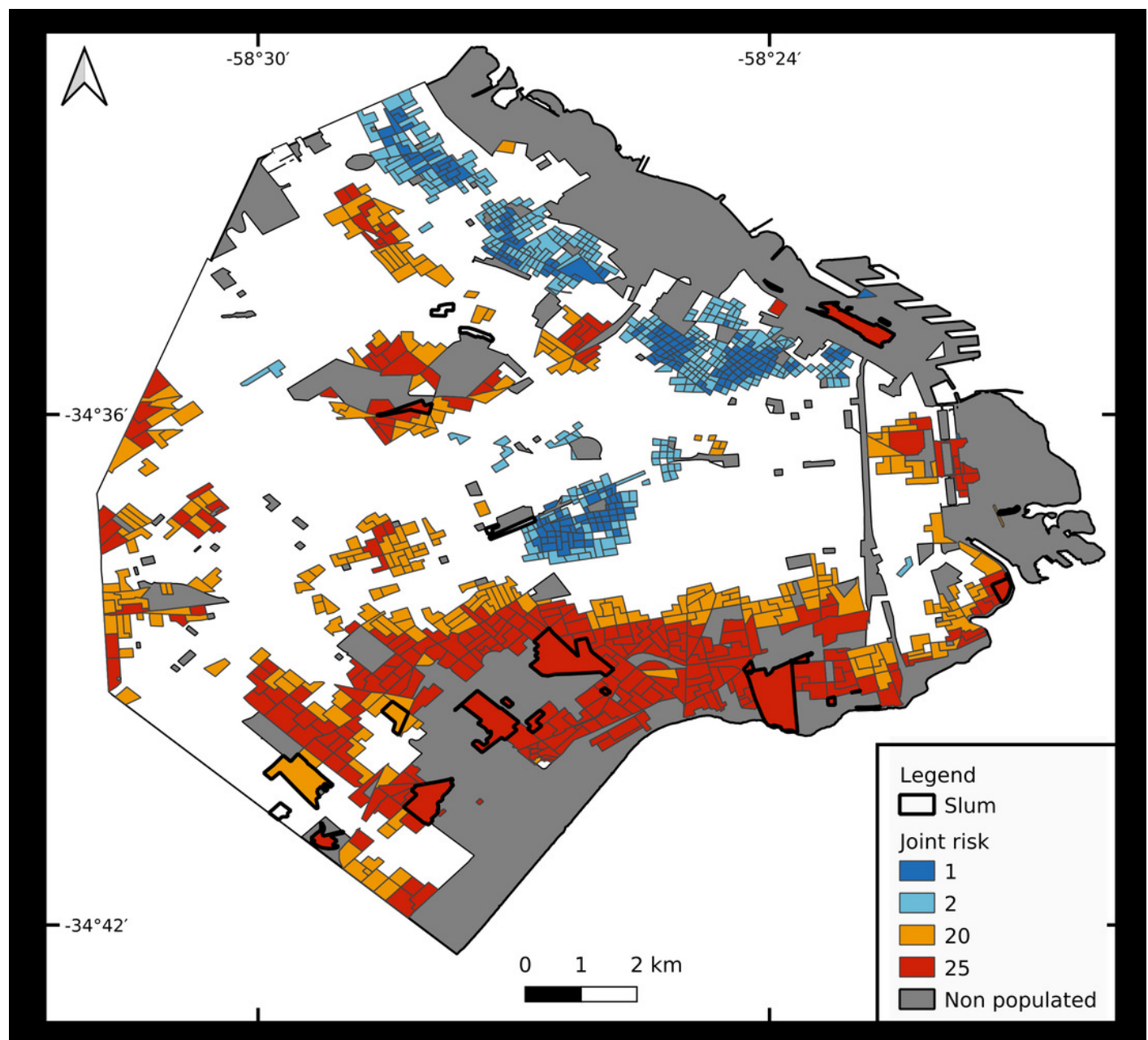
Figure 6

Joint risk category of dengue and COVID-19

Proportion of census tracts classified from 1 to 25 in a joint risk category of dengue and COVID-19 (each defined in 5 categories from 1 lowest risk to 5 highest risk, equal quantiles), for each socio-economic stratum.