Seroprevalence of anti-SARS-CoV-2 IgG at the first epidemic peak in French Guiana, July 2020
Claude Flamand, Christelle Alves Sarmento, Antoine Enfissi, Sarah Bailly, Emmanuel Beillard, Mélanie Gaillet, Céline Michaud, Véronique Servas, Nathalie Clement, Anaïs Perilhou, et al.

To cite this version:
Claude Flamand, Christelle Alves Sarmento, Antoine Enfissi, Sarah Bailly, Emmanuel Beillard, et al.. Seroprevalence of anti-SARS-CoV-2 IgG at the first epidemic peak in French Guiana, July 2020. PLoS Neglected Tropical Diseases, 2021, 15 (11), pp.e0009945. 10.1371/journal.pntd.0009945. pasteur-03512716

HAL Id: pasteur-03512716
https://pasteur.hal.science/pasteur-03512716
Submitted on 5 Jan 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution 4.0 International License
RESEARCH ARTICLE

Seroprevalence of anti-SARS-CoV-2 IgG at the first epidemic peak in French Guiana, July 2020

Claude Flamand1,2*, Christelle Alves Sarmento1, Antoine Enfissi3, Sarah Bailly1, Emmanuel Beillard4, Mélanie Gaillet5, Céline Michaud5, Véronique Servas6, Nathalie Clement6, Anaïs Perilhou6, Thierry Carage7, Didier Musso8,9, Jean-françois Carod10, Stéphanie Eustache3, Céline Tourbillon1, Elodie Boizón1, Samantha James1, Félix Djossou11, Henrik Salje2,12,13, Simon Cauchemez2*, Dominique Rouset3

Abstract

Background

While Latin America has been heavily affected by the pandemic, only a few seroprevalence studies have been conducted there during the first epidemic wave in the first half of 2020.

Methodology/Principal findings

A cross-sectional survey was performed between 15 July 2020 and 23 July 2020 among individuals who visited 4 medical laboratories or 5 health centers for routine screening or clinical management, with the exception of symptomatic suggestive cases of covid-19.

Samples were screened for the presence of anti-SARS-CoV-2 IgG directed against domain S1 of the SARS-CoV-2 spike protein using the anti-SARS-CoV-2 enzyme-linked immunosorbent assay (ELISA) from Euroimmun.

Conclusions/Significance

The overall seroprevalence was 15.4% [9.3%-24.4%] among 480 participants, ranging from 4.0% to 25.5% across the different municipalities. The seroprevalence did not differ according to gender (p = 0.19) or age (p = 0.51). Among SARS-CoV-2 positive individuals, we...
found that 24.6% [11.5%-45.2%] reported symptoms consistent with COVID-19. Our findings revealed high levels of infection across the territory but a low number of resulting deaths, which can be explained by French Guiana’s young population structure.

Author summary
While Latin America has been heavily affected by the pandemic, only a few seroprevalence studies have been conducted there during the first epidemic wave in the first half of 2020.

A cross-sectional survey was performed between 15 July 2020 and 23 July 2020 among individuals who visited 4 medical laboratories or 5 health centers for routine screening or clinical management, with the exception of symptomatic suggestive cases of covid-19.

Samples were screened for the presence of anti-SARS-CoV-2 IgG using the anti-SARS-CoV-2 enzyme-linked immunosorbent assay (ELISA) from Euroimmun.

The overall seroprevalence was 15.4% [9.3%-24.4%] among 480 participants, ranging from 4.0% to 25.5% across the different municipalities. The seroprevalence did not differ according to gender (p = 0.19) or age (p = 0.51). Among SARS-CoV-2 positive individuals, we found that 24.6% [11.5%-45.2%] reported symptoms consistent with COVID-19.

Our findings revealed high levels of infection across the territory but a low number of resulting deaths, which can be explained by French Guiana’s young population structure.

Introduction
The world’s attention remains focused on the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), that causes coronavirus disease 2019 (COVID-19), and the implementation of drastic control measures to limit its expansion. By the end of July 2020, more than 17 million confirmed cases and approximately 650,000 deaths have been reported worldwide [1]. With more than 4,500,000 cases and 190,000 deaths, Latin America has been particularly affected by the crisis [1].

A thorough evaluation of the proportion that has already been infected by SARS-CoV-2 and is likely immunized is important to estimate the level of herd immunity of the population [2] and to inform public health decision making. Data on laboratory molecular -confirmed cases do not capture the full extent of viral circulation because a majority of infected individuals have asymptomatic or mild infections and may therefore not seek care [3,4]. In contrast, population immunity is typically estimated through cross-sectional surveys of representative samples using serological tests. Numerous serological surveys were conducted in affected countries during or at the end of the first COVID-19 epidemic wave [5]. Most of the serological studies already available in July 2020 have been carried out in continental Europe [6–12] and in the United States [13–16]. Although Latin America has been heavily affected by the pandemic, only a few seroprevalence studies have been conducted across the continent, meaning the underlying level of infection remains largely unknown [5,17,18]. French Guiana, a French overseas department with 290,000 inhabitants [19], located in Latin America in the Amazonian forest complex experienced a large SARS-CoV-2 epidemic wave. A territory-wide lockdown was set up from March 17th 2020 concomitantly with the rest of French territories, at a time when five imported cases and one secondary case were being confirmed on the territory [20]. The lockdown resulted in limited viral transmission until it was ended on May 11th 2020. In the middle of June there was a rapid intensification of viral circulation over a large
part of the territory with 917 confirmed cases of COVID-19 detected from March 4th, 2020 to June 11th, 2020 [21]. This was followed by the implementation of strict mitigation measures such as curfews and local lockdowns in the course of June and July. The epidemic peaked at the beginning of July with 4,440 cumulative confirmed cases [22], followed by a gradual slowing down throughout the territory. Between March 4 and September 17, 9,623 cases (3,310 per 100,000 inhabitants) of COVID-19 and 65 hospital deaths (22.3 per 100,000 inhabitants) of COVID-19 were detected in French Guiana [23]. As the disease severity is reduced in younger individuals [24], we can suspect that many infections are likely to have been missed in this territory which has a much younger population (mean age of 25.1 versus 32.1 for Latin America and 42.3 for mainland France) [19]. In order to understand the underlying level of infection, we conducted a cross-sectional study within the general population, estimated the seroprevalence of SARS-CoV-2 and assessed its distribution in age groups and geographical areas.

Methods

Ethics statement

The study was recorded on Clinicaltrials.gov (ID: NCT04490850) and approved by the “Comité de Protection des Personnes EST-III” Ethical Research Committee (No.CPP 20.07.04–8827; N°ID-RCB 2020-A01826-33). Personal data processing for this study complied with the requirements of the “reference methodology MR-001” established by the French Data Protection Authority (CNIL) regarding data processing in health research. Fieldworker investigators were trained to explain the project, and, when allowed, collect participants’ signatures in a free and informed consent form and carry out the interviews. For participants under 18 years old, age-appropriate information was given and the written informed consent of legally responsible person was collected. A specific educational-style comic poster was designed to explain, in an understandable way, the nature and objectives of the survey and inform them about the voluntary nature of the participation of the study.

Study area

French Guiana is composed of two main inhabited geographical regions: a central, urbanized area including a coastal strip along the Atlantic Ocean, where 90% of the population lives, and a more remote area along the Surinamese and Brazilian borders (Fig 1). This territory has the highest crude birth rate in the Americas (25.6 per 1,000 people) and 32% of the population is under the age of 15 [19]. The healthcare system includes 8 medical biology laboratories and 3 hospital centers located in the main municipalities of the coastal area, as well as 17 healthcare centers representing the only health care offer in more isolated areas in the Amazonian rainforest.

Study design and participants

A cross-sectional survey was performed between 15 July 2020 and 23 July 2020 (Fig 2) in medical biology laboratories located in the coastal urban area of French Guiana and health centers located in isolated areas along the Surinamese and Brazilian borders (Fig 1). All laboratories and health centers were invited to participate in the study. A total of 4 laboratories and 5 health centers had sufficient human and technical resources to implement the study protocol and agreed to participate in the study.

The geographical areas of the different laboratories and health centers involved in the study cover 87% of the population of French Guiana.

Publicity and information about the survey was provided at the reception desk of recruitment centers. All individuals who visited medical laboratories or health centers during the
study period for routine screening or clinical management were invited to participate in the study, with the exception of those who came for SARS-CoV-2 viral screening in the context of symptomatic infections potentially suggestive of covid-19.

Demographic data, including age, gender, residential region and occupation of each participant, were collected during a preliminary face-to-face interview through a standardized questionnaire. Participants were asked to report history of symptoms compatible with COVID-19 and to specify if they had consulted a doctor or obtained a biological confirmation of their infection. Thereafter, a venous blood sample of 3.5mL was collected from each participant, in accordance with current biosafety standards.

**Laboratory methods**

**Blood sample collection.** Blood samples were collected into 3.5 ml gold BD Vacutainer SST II advance tubes with gel for serum separation (Becton-Dickinson, USA). Immediately after puncture, samples were stored at 4°C-8°C until centrifugation within 12 hours. Sera were then frozen and stored at -20°C until used at the National Reference Center for respiratory viruses in Institut Pasteur in French Guiana.

**Serologic diagnosis.** Collected samples were screened for the presence of anti-SARS-CoV-2 IgG directed against domain S1 of the SARS-CoV-2 spike protein using the anti-SARS-CoV-2 enzyme-linked immunosorbent assay (ELISA) from Euroimmun (Lübeck, Germany). Semiquantitative results were calculated as the ratio of the extinction of samples over the extinction of a calibrator. According to the distributor, the specificity of the test was 99.6%. We internally validated the specificity of the serological assay with serum samples collected.
Statistical analysis

In order to obtain population representative estimates of overall seropositivity in the territory we weight each sample by the population size within each municipality, age and sex group. We employ the following notation to describe the study design (Table 1):

- \( i \): one of the 16 strata (municipalities);
- \( M_i \): number of individuals living within the \( i \)th stratum, \( i = 1, \ldots, 16 \) (Census data);
- \( m_i \): number of individuals enrolled from the \( i \)th stratum, \( i = 1, \ldots, 16 \);

We considered that, in each municipality \( i \), the probability of selecting a particular subject is equal to \( \left(1/m_i/M_i\right) = (M_i/m_i) \). This statistical weight indicates the number of people in the population represented by each subject in the sample.

We applied a post-stratification adjustment to each of these weights to arrive at the final statistical weight for each subject. This adjustment helped us to weight the age-sex groups within each municipality to match the distribution in the French Guiana total population. Nine age-groups ([0–15 years[, [15–20[, [20–25[, [20–25[, [25–35[, [35–45[, [45–55[, [55–65[, >65 years) were used within males and females groups and for each age-sex subgroups, we applied an adjustment factor \( c_{ijk} \), to have a final statistical weight

\[
w_{ijk} = (M_i/m_i)^{c_{ijk}},
\]

where \( i \) indexes municipalities, \( j \) indexes sex groups and \( k \) indexes age groups. The outcome of interest was the weighted SARS-CoV-2 seroprevalence estimate.

Table 1. Weighted SARS-CoV-2 seroprevalence estimated by municipality, July 2020, French Guiana.

| Municipality (i) | Pop. size | Number of enrolled individuals | Number of SARS-CoV-2-positive individuals | Weighted seroprevalence %[95% CI] |
|------------------|-----------|---------------------------------|------------------------------------------|----------------------------------|
| Cayenne          | 57,614    | 95                              | 15                                       | 25.5% [10.9–48.8]                |
| Matoury          | 32,427    | 34                              | 4                                        | 11.5% [3.5–32.2]                 |
| Saint-Laurent    | 43,600    | 20                              | 2                                        | 4.3% [1.0–16.8]                  |
| Kourou           | 26,221    | 95                              | 18                                       | 19.8% [8.6–39.1]                 |
| Remire-Montjoly | 23,976    | 98                              | 8                                        | 4.0% [1.7–9.2]                   |
| Macouria         | 11,719    | 10                              | 2                                        | 20.7% [3.9–62.4]                 |
| Mana             | 10,241    | 1                               | 0                                        | -                                |
| Maripasoula      | 11,856    | 13                              | 2                                        | 15.2% [2.9–51.7]                 |
| Apatou           | 8,431     | 22                              | 2                                        | 12.1% [2.9–38.5]                 |
| Grand-Santi      | 6,969     | 40                              | 6                                        | 20.5% [8.7–41.1]                 |
| Saint-Georges    | 4,020     | 29                              | 3                                        | 16.1% [4.9–47.3]                 |
| Papaichon        | 7,266     | 10                              | 1                                        | 7.8% [1.0–50.0]                  |
| Sinnamary        | 2,957     | 2                               | 0                                        | -                                |
| Roua             | 3,713     | 8                               | 0                                        | -                                |
| Montsinny-Tonnegrave | 2,473 | 2                              | 0                                        | -                                |
| Ircoubo          | 1,878     | 1                               | 0                                        | -                                |
| Total            | 259,865   | 480                             | 63                                       | 15.4% [9.3–24.4]                 |
Analyses were carried out using survey capabilities of Stata version 15 statistical software [28]. French Guiana’s layers were drawn using geodata from the BD Ortho database available from https://www.data.gouv.fr/ under the terms of the CC-BY 2.0 license. Spatial distribution of seroprevalence was mapped using QGIS 2.18 software [29].

**Results**

We enrolled 480 participants between July 15 and July 23, 2020, in 16 municipalities (Table 1). The mean age of participants was 38.3 ranging from 0.2 to 87 years old. Comparison of the socio-demographic characteristics of the study sample to the census data demonstrated an over-representation of women (68.1% vs 50% in the general population of French Guiana) and adults over 25 years (79% vs 53% in French Guiana). These differences, mostly related to the structure of the population visiting the laboratories and health centers in French Guiana, were corrected in the analyses of seroprevalence and risk factors by allocating a post-stratification weight to each participant.

Between 15 July 2020 and 23 July 2020, the crude proportion seropositive was 13.1% and the overall weighted seroprevalence of SARS-CoV-2 antibodies in French Guiana was 15.4% [95% Confidence Interval CI, 9.3%-24.4%] (Table 1). This corresponds to 44,660 [95% CI, 26,970–70,760] seropositive individuals out of a population of 290,000.

Since the study was implemented two weeks after the epidemic peak and the sensitivity of the test is limited in the three weeks that follow infection, this likely represents a lower bound for the proportion of individuals infected by the time the epidemic peaked.

The seroprevalence was higher among men than women (19.6% vs 10.4%) but the difference was not significant. There were also no significant differences according to age (p = 0.51) (Table 2).

### Table 2. Distribution of SARS-CoV-2 seropositivity according to sociodemographic factors, July, French Guiana.

| Characteristic                      | Total tested individuals | Weighted prevalence (%) [95% CI] | Pearson p-value |
|-------------------------------------|--------------------------|----------------------------------|-----------------|
| **Gender**                          |                          |                                  |                 |
| Male                                | 153                      | 19.6 [9.7–35.6]                  | 0.19            |
| Female                              | 327                      | 10.4 [6.7–15.9]                  |                 |
| **Age, years**                      |                          |                                  |                 |
| [0–9]                               | 16                       | 24.0 [4.7–66.9]                  | 0.51            |
| [10–19]                             | 34                       | 18.7 [4.2–54.4]                  |                 |
| [20–29]                             | 105                      | 9.6 [3.7–22.6]                   |                 |
| [30–39]                             | 125                      | 16.6 [7.6–32.5]                  |                 |
| [40–49]                             | 78                       | 18.4 [9.1–33.5]                  |                 |
| [50–59]                             | 77                       | 9.4 [4.4–19.3]                   |                 |
| [60–69]                             | 34                       | 11.2 [2.5–38.4]                  |                 |
| ≥ 70                                | 11                       | 15.2 [4.0–43.6]                  |                 |
| **Geographical area**               |                          |                                  |                 |
| Coastal area                        | 366                      | 15.5 [8.8–25.9]                  | 0.94            |
| Western area                        | 85                       | 14.2 [6.6–27.9]                  |                 |
| Eastern area                        | 29                       | 16.1 [3.9–47.3]                  |                 |
| **Occupational category (over 18)** |                          |                                  |                 |
| Employed individuals                | 267                      | 11.8 [7.0–19.1]                  | 0.48            |
| Pensioners                          | 17                       | 4.1 [0.6–25.2]                   |                 |
| Unemployed individuals              | 156                      | 13.8 [7.7–23.6]                  |                 |

https://doi.org/10.1371/journal.pntd.0009945.t002
Serological results in the different geographical areas (Fig 3) showed that SARS-CoV-2 circulated in most of French Guiana (Table 1). Highest infection risks were observed in the main population center in Cayenne municipality (25.5% [10.9% - 48.8%]) in the coastal and urban area. Two other municipalities located in the coastal area were also strongly impacted (Kourou: 19.8% [8.6% - 39.1%] and Macouria: 20.7% [4.0% - 62.4%]). However, even outside the main population centers, some areas appeared to have been heavily affected. For example, among the river areas, Grand-Santi (20.5% [8.7% - 41.1%]), a small municipality located in the western part of the territory and Saint-Georges (16.1% [4.0–47.3]), a municipality located in the eastern part, at the Brazilian border had seroprevalence levels similar to that observed in Cayenne (Table 2).

The proportion of individuals who thought they had COVID-19 was higher among seropositive participants than among seronegative participants (29.9% [14.3%-52.3%] vs 19.9% [14.4%-26.8%]). Among those who reported a presumptive infection, 12.6% [4.9%-28.7%] declared that diagnosis was confirmed by a clinician and 17.1% [6.9%-36.5%] that the diagnostic was confirmed by a SARS-CoV-2 RT-PCR. Nine seronegative participants reported having a RT-PCR confirmation representing 2.1% [0.8%-4.9%] of seronegative participants. Among them, five reported infections less than 3 weeks old and three reported infections older than 3 months.

The presence of compatible COVID-19 symptoms was reported in 24.6% [11.5%-45.2%] of seropositive participants vs 19.5% [14.0%-26.5%] of seronegative participants. Fever (50.7%), anosmia (48.8%), asthenia (48.8%) and cough (34.7%) were the most frequently reported symptoms in SARS-CoV-2 seropositive participants. However, only anosmia was significantly more prevalent in SARS-CoV-2 seropositive versus seronegative individuals (p = 0.01) (Table 3).

**Discussion**

We report the first serosurvey for the detection of SARS-CoV-2 antibodies in French Guiana. We found that 15.4% [9.3%-24.4%] of the population was seropositive two weeks after the peak of the first epidemic wave. Assuming a two or three-week delay for seroconversion, our estimation reflects the level of infection of the population at the end of June or beginning of July, which roughly corresponds to the epidemic peak. Our results indicate that by that time, at least 44,660 [26,970–70,760] of French Guiana’s 290,000 population had been affected by the virus, more than 10 times the official count of 4,440 confirmed cases reported by public health surveillance system by the first week of July [22]. Various investigators have shown that seroprevalence levels in South American populations during the first epidemic wave were much higher than those reported in European cities and countries [30]. It appeared in countries such as Peru, Colombia, Argentina and Brazil, that the highest values came from low-income populations. The relationship with poverty has already been demonstrated in different studies [30]. In Brazil, one of the bordering countries in French Guiana, seroprevalence estimates varied markedly across the country’s cities and regions, from below 1.0% in most cities in the south and center-west regions to up to 25.0% in the city of Breves in the Amazon (North) region [17]. Nevertheless, overall seroprevalence was estimated at 1.4% (95% CI 1.3–1.6). In contrast, our findings highlighted high but also relatively homogeneous levels of infection in most municipalities, ranging from 10% to 20%.

The case fatality rate of COVID-19 was low during the outbreak as there were 65 COVID-19 related deaths from the beginning of the outbreak up to September 17 [23] across the territory while about 45,000 people have been infected at the beginning of July. This was probably due in part to the young age of the population of French Guiana.
Fig 3. Spatial distribution of SARS-CoV-2 seroprevalence, July, French Guiana; Geodata source: BD ortho, publicly available at https://www.data.gouv.fr/; QGIS 2.18 software.

https://doi.org/10.1371/journal.pntd.0009945.g003
Younger populations are likely to have more social ties than older populations, and therefore physical distancing may be more difficult to implement than in countries with ageing populations. Furthermore, since young people are less susceptible to disease severity, they may be less likely to adopt physical distancing measures when they are infected and potentially contagious in a context of high level of transmission [31].

Seroprevalence was higher in men than in women (19.6% versus 10.4%), which could reflect a different exposure potentially related to a greater number of contacts and exposure situations in men than in women but this difference was not significant in our study. Although several population-based studies have demonstrated differences in seroprevalence rates between male and female subjects, most of them indicate that seroprevalence does not differ significantly between men and women [32].

Our study has several limitations inherent in the study design. Our approach made it possible to obtain rapid estimates of the impact of the epidemic. However, convenience sampling may result in a lack of population representation if part of the general population has lower access to the laboratories and health centers participating in the study. In the study, we observed a significant under-representation of men and children under 15 years of age, related to the structure of the population typically visiting laboratories and health centers, and therefore performed a post-stratification adjustment. However, this may have led to large confidence intervals for some of parameter estimates. In addition, sample size calculation was determined to obtain a sufficient point estimate of territory-wide prevalence estimates but not to study risk factors of infection. A few municipalities with no laboratory or health centers were not represented. However, the municipalities represented by the laboratories and health centers involved in the study are home to 90% of the population, so that our estimates are likely a good reflection of the situation across the territory.

We may underestimate infection levels if precarious populations are at higher risk of infection and have limited access to health facilities. Furthermore, it is also possible that sampled individuals who were routinely monitored for pregnancy or chronic health problems took more precautions and reduced their exposure to the virus.

Although it is difficult to assess the representativeness of the sample, the relatively easy access to health care and diagnostic facilities in Guyana, particularly in the larger population centers represented in our study, may have limited coverage bias.

Additionally, it is possible that infected people did not develop specific SARS-CoV-2 antibodies or that these antibodies were not detected by our assay. Since the study was performed shortly

| Presence of clinical symptoms | Total (N = 102) | Weighted proportion % (CI 95%) | SARS-CoV-2-positive individuals % (CI 95%) | SARS-CoV-2-negative individuals % (CI 95%) | Pearson P value |
|-------------------------------|----------------|---------------------------------|---------------------------------------------|---------------------------------------------|----------------|
| Fever                         | 56             | 62.0% [47.0–75.1]               | 50.7% [23.0–78.0]                           | 64.6% [48.1–78.3]                           | 0.42           |
| Cough                         | 36             | 28.8% [18.2–42.4]               | 34.7% [12.1–67.3]                           | 27.4% [16.4–42.2]                           | 0.65           |
| Throat pain                   | 25             | 17.7% [9.7–30.2]                | 10.2% [2.7–31.8]                            | 19.5% [10.1–34.3]                           | 0.34           |
| Dyspnea                       | 16             | 9.6% [4.9–17.8]                 | 7.0% [1.6–25.5]                             | 10.2% [4.8–20.1]                            | 0.63           |
| Arthralgia                    | 36             | 28.9% [18.2–42.7]               | 9.8% [2.4–32.4]                             | 33.3% [20.3–49.3]                           | 0.04           |
| Headache                      | 42             | 26.5% [16.9–38.9]               | 18.1% [7.1–39.1]                            | 28.4% [17.1–43.1]                           | 0.35           |
| Asthenia                      | 51             | 45.6% [31.2–60.7]               | 48.8% [21.8–76.5]                           | 44.8% [28.7–62.1]                           | 0.82           |
| Ageusia                       | 19             | 26.4% [14.6–42.8]               | 25.4% [9.7–51.6]                            | 26.6% [13.3–46.2]                           | 0.92           |
| Anosmia                       | 16             | 15.1% [7.6–27.7]                | 48.8% [21.8–76.5]                           | 7.3% [2.4–20.4]                             | 0.01           |
| Diarrhea                      | 23             | 21.4% [11.4–36.7]               | 31.6% [10.1–65.6]                           | 19.1% [8.9–36.5]                            | 0.42           |
| Vomiting                      | 4              | 1.0% [0.3–3.1]                  | 2.9% [0.7–11.5]                             | 0.5% [0.1–3.8]                              | 0.13           |

https://doi.org/10.1371/journal.pntd.0009945.t003
after the peak of the epidemic, a proportion of individuals infected at the peak may not have seroconverted by the time of sample collection. With the exception of anosmia, which is already known as a common and distinctive feature of SARS-CoV-2 infection [33,34], symptoms were not significantly more frequently reported by seropositive than seronegative individuals.

In conclusion, we found that at least 15.4% of the population in French Guiana was infected by SARS-CoV-2 by the time the epidemic peaked in July. Our estimates are close to the infection attack rate of SARS-COV-2 of 17.6% [17.2%, 18.0%] estimated in a recent modeling study conducted to characterize the epidemic dynamics and to evaluate the impact of control measures that were implemented to contain the epidemic in French Guiana [35].

This corresponds to an elevated infection burden given the relatively limited mortality, which can be explained by French Guiana’s young population structure.

Acknowledgments

We are grateful to all field workers, collaborators, technical and medical staff from Health Centers Department of Cayenne Hospital Center and biological laboratories and health centers involved in the EPI-COVID-19 project. We thank Bhety LABEAU, David MOUA, Laetitia BREMAND, Sylvie ALOEPOE, Elisabeth CHAN from Institut Pasteur in French Guiana, Nathalie JOLLY from Clinical Core of the Center for Translational Research of Institut Pasteur. We also thank Sophie GAULIN, Lysiane ROMAIN, Véronique TOGNERI and Tadens MPWENE from La Liberté.

Author Contributions

Conceptualization: Claude Flamand, Henrik Salje, Simon Cauchemez.

Data curation: Claude Flamand, Christelle Alves Sarmento, Antoine Enfissi, Sarah Bailly, Stéphanie Eustache, Céline Tourbillon, Samantha James, Dominique Rousset.

Formal analysis: Claude Flamand, Sarah Bailly.

Funding acquisition: Claude Flamand.

Investigation: Claude Flamand, Christelle Alves Sarmento, Antoine Enfissi, Emmanuel Beillard, Mélanie Gaillet, Céline Michaud, Véronique Servas, Thierry Carage, Didier Musso, Jean-françois Carod, Stéphanie Eustache, Céline Tourbillon, Elodie Boizon.

Methodology: Claude Flamand.

Project administration: Claude Flamand, Nathalie Clement, Anaïs Perilhou, Félix Djossou.

Supervision: Claude Flamand.

Validation: Antoine Enfissi, Dominique Rousset.

Writing – original draft: Claude Flamand, Simon Cauchemez.

Writing – review & editing: Claude Flamand, Christelle Alves Sarmento, Antoine Enfissi, Sarah Bailly, Emmanuel Beillard, Mélanie Gaillet, Céline Michaud, Véronique Servas, Nathalie Clement, Anaïs Perilhou, Thierry Carage, Didier Musso, Jean-françois Carod, Stéphanie Eustache, Céline Tourbillon, Samantha James, Félix Djossou, Henrik Salje, Simon Cauchemez, Dominique Rousset.

References

1. WHO. Coronavirus Disease (COVID-19) Situation Reports—193. [cited 9 Aug 2020]. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
2. Fontanet A, Cauchemez S. COVID-19 herd immunity: where are we? Nat Rev Immunol. 2020. https://doi.org/10.1038/s41577-020-00451-5 PMID: 32908300

3. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA; 2020; 323: 1239–1242. https://doi.org/10.1001/jama.2020.2648 PMID: 32091533

4. Eckerle I, Meyer B. SARS-CoV-2 seroprevalence in COVID-19 hotspots. The Lancet; 2020; 396: 514–515. https://doi.org/10.1016/S0140-6736(20)31482-3 PMID: 32645348

5. Byambasuren O, Dobler CC, Bell K, Rojas DP, Clark J, McLawsons L-M, et al. Estimating the seroprevalence of SARS-CoV-2 infections: systematic review. medRxiv; 2020; 2020.07.13.20153163. https://doi.org/10.1101/2020.07.13.20153163

6. Stringhini S, Wisniak A, Piumatti G, Azman AS, Lauer SA, Bayssons H, et al. Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. Lancet Lond Engl; 2020; 396: 313–319. https://doi.org/10.1016/S0140-6736(20)31304-0 PMID: 32534626

7. Pollán M, Pérez-Gómez B, Pastor-Barriuso R, Oteo J, Hernán MA, Pérez-Olmeda M, et al. Prevalence of SARS-CoV-2 in Spain (ENE-COVID): a nationwide, population-based seroepidemiological study. The Lancet; 2020; 396: 535–544. https://doi.org/10.1016/S0140-6736(20)31483-5 PMID: 32645347

8. Shakiba M, Nazari SSH, Mehrabian F, Rezvani SM, Ghasempour Z, Heidarzadeh A. Seroprevalence of COVID-19 virus infection in Guilan province, Iran. medRxiv; 2020; 2020.04.26.20079244. https://doi.org/10.1101/2020.04.26.20079244

9. Snoeck CJ, Vaillant M, Abdelrahman T, Satagopam VP, Turner JD, Beaumont K, et al. Prevalence of SARS-CoV-2 infection in the Luxembourgish population: the CON-VINCE study. medRxiv; 2020; 2020.05.11.20092916. https://doi.org/10.1101/2020.05.11.20092916

10. Jerkovic I, Jubic T, Basic Z, Kruzic I, Kunac N, Bezic J, et al. SARS-CoV-2 antibody seroprevalence in industry workers in Split-Dalmatia and Sibenik-Knin County, Croatia. medRxiv; 2020; 2020.05.11.20095158. https://doi.org/10.1101/2020.05.11.20095158

11. Kraehling V, Kern M, Halwe S, Mueller H, Rohde C, Savini M, et al. Epidemiological study to detect active SARS-CoV-2 infections and seropositive persons in a selected cohort of employees in the Frankfurt am Main metropolitan area. medRxiv; 2020; 2020.05.20.20107730. https://doi.org/10.1101/2020.05.20.20107730

12. COVID-19 experience: first Italian survey on healthcare staff members from a Mother-Child Research hospital using combined molecular and rapid immunoassays test | medRxiv. [cited 22 Sep 2020]. Available: https://www.medrxiv.org/content/10.1101/2020.04.19.20071563v1

13. Ng D, Goldgof G, Shy B, Levine A, Balcerk J, Bapat SP, et al. SARS-CoV-2 seroprevalence and neutralizing activity in donor and patient blood from the San Francisco Bay Area, medRxiv; 2020; 2020.05.19.20104782. https://doi.org/10.1101/2020.05.19.20104782 PMID: 32511477

14. Sood N, Simon P, Ebner P, Eichner D, Reynolds J, Bendavid E, et al. Seroprevalence of SARS-CoV-2–Specific Antibodies Among Adults in Los Angeles County, California, on April 10–11, 2020. JAMA; 2020; 323: 2425–2427. https://doi.org/10.1001/jama.2020.8279 PMID: 32421144

15. Flannery DD, Gouma S, Dhudasia MB, Mukhopadhyay S, Pfeifer MR, Woodford EC, et al. SARS-CoV-2 Seroprevalence Among Parturient Women. medRxiv; 2020; 2020.07.08.20149179. https://doi.org/10.1101/2020.07.08.20149179 PMID: 32676623

16. Naranbhai V, Chang CC, Beltran WFG, Miller TE, Astudillo MG, Villalba JA, et al. High seroprevalence of anti-SARS-CoV-2 antibodies in Chelsea, Massachusetts. J Infect Dis. [cited 22 Sep 2020]. https://doi.org/10.1093/infdis/jiaa579 PMID: 32906151

17. Hallal P, Hartwig F, Horta B, Victora GD, Silveira M, Struchiner C, et al. Remarkable variability in SARS-CoV-2 antibodies across Brazilian regions: nationwide serological household survey in 27 states. medRxiv; 2020; 2020.05.30.20117531. https://doi.org/10.1101/2020.05.30.20117531

18. Silveira M, Barros A, Horta B, Pellanda L, Victora G, Dellagostin O, et al. Repeated population-based surveys of antibodies against SARS-CoV-2 in Southern Brazil. medRxiv; 2020; 2020.05.01.20087205. https://doi.org/10.1101/2020.05.01.20087205

19. United nations. World Population Prospects—Population Division. [cited 23 Aug 2020]. Available: https://population.un.org/wpp/

20. Préfecture de la Région Guyane, Agence Régionale de la Santé de la Guyane. Communiqué de presse: Coronavirus Guyane: 1 cas secondaire confirmé à Saint-Laurent du Maroni. 2020. Available: http://www.guyane.gouv.fr/content/download/14933/102337/file/2020_03_11_CP%20COVID-19.pdf

21. Santé Publique France. COVID-19: point épidémiologique en Guyane du 11 juin 2020. [cited 14 Sep 2020]. Available: https://www.santepubliquefrance.fr/regions/guyane/documents/bulletin-regional/2020/covid-19-point-epidemiologique-en-guyane-du-11-juin-2020
22. Santé Publique France. COVID-19: point épidémiologique en Guyane du 2 Juillet 2020. [cited 14 Sep 2020]. Available: https://www.guyane.ars.sante.fr/point-epidemio-regional-hebdomadaire-special-covid-19

23. Santé Publique France. COVID-19: point épidémiologique en Guyane du 17 septembre 2020. [cited 14 Sep 2020]. Available: https://www.guyane.ars.sante.fr/point-epidemio-regional-hebdomadaire-special-covid-19

24. Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. Acta Paediatr Oslo Nor 1992. 2020 [cited 26 Sep 2020]. https://doi.org/10.1111/apa.15270 PMID: 32202343

25. Flamand C, Bailly S, Fritzell C, Berthelot L, Vanhomwegen J, Salje H, et al. Impact of Zika virus emergence in French Guiana: A large general population seroprevalence survey. J Infect Dis. 2019. https://doi.org/10.1093/infdis/jiz396 PMID: 31418012

26. Hozé N, Salje H, Rousset D, Fritzell C, Vanhomwegen J, Bailly S, et al. Reconstructing Mayaro virus circulation in French Guiana shows frequent spillovers. Nat Commun. 2020; 11: 2842. https://doi.org/10.1038/s41467-020-16516-x PMID: 32503971

27. Krüttgen A, Cornelissen CG, Dreher M, Hornef M, Imöhl M, Kleines M. Comparison of four new commercial serologic assays for determination of SARS-CoV-2 IgG. J Clin Virol Off Publ Pan Am Soc Clin Virol. 2020; 128: 104394. https://doi.org/10.1016/j.jcv.2020.104394 PMID: 32416599

28. StataCorp. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC; 2017.

29. QGIS Development Team. QGIS Geographic Information System. Open Source Geospatial Foundation.; 2009.

30. Núñez-Zapata SF, Benites-Peralta B, Mayta-Tristan P, Rodríguez-Morales AJ. High seroprevalence for SARS-CoV-2 infection in South America, but still not enough for herd immunity! Int J Infect Dis. 2021; 109: 244–246. https://doi.org/10.1016/j.ijid.2021.07.022 PMID: 34260956

31. Levin AT, Hanage WP, Owusu-Boateng N, Cochran KB, Walsh SP, Meyerowitz-Katz G. Assessing the age specificity of infection fatality rates for COVID-19: systematic review, meta-analysis, and public policy implications. Eur J Epidemiol. 2020; 35: 1123–1138. https://doi.org/10.1007/s10654-020-00698-1 PMID: 33289900

32. Lai C-C, Wang J-H, Hsueh P-R. Population-based seroprevalence surveys of anti-SARS-CoV-2 antibody: An up-to-date review. Int J Infect Dis. 2020; 101: 314–322. https://doi.org/10.1016/j.ijid.2020.10.011 PMID: 33045429

33. Heidari F, Karimi E, Firoozifar M, Khamushian P, Ansari R, Mohammadi Ardehali M, et al. Anosmia as a prominent symptom of COVID-19 infection. Rhinology. 2020; 58: 302–303. https://doi.org/10.4193/Rhin20.140 PMID: 32319971

34. Carignan A, Valiquette L, Grenier C, Musonera JB, Nkengurutse D, Marcil-Héguy A, et al. Anosmia and dysgeusia associated with SARS-CoV-2 infection: an age-matched case-control study. CMAJ Can Med Assoc J J Assoc Medicale Can. 2020; 192: E702–E707. https://doi.org/10.1503/cmaj.200869 PMID: 32461325

35. Andronico A, Kiern CT, Paireau J, Succo T, Bosetti P, Lefrancq N, et al. Evaluating the impact of curfews and other measures on SARS-CoV-2 transmission in French Guiana. medRxiv. 2020; 2020.10.07.20208314. https://doi.org/10.1101/2020.10.07.20208314