

# Household survey to estimate the seroprevalence of SARS-CoV-2 infection in the city of São Paulo, Brazil

Pilot study conducted in the São Paulo neighborhoods of Pari, Belém, Água Rasa, Morumbi, Bela Vista, and Jardim Paulista between May 4 and 12, 2020

## Preliminary Results

Authors: SARS-CoV-2 Mapping Group (authors and affiliations on the last page)



# Executive Summary

- 1,152 households were randomly selected in the São Paulo neighborhoods of Pari, Belém, Água Rasa, Morumbi, Bela Vista, and Jardim Paulista.
- Venous blood samples were collected from randomly selected residents of each of the 296 households that participated in the study.
- Venous blood samples were also collected from 224 cohabitants.
- In total, 520 samples were collected and analyzed.
- Antibodies against the SARS-CoV-2 virus was detected in 27 individuals:
  - 16 individuals among 296 residents drawn (5.41%)
  - 11 individuals among 224 cohabitants (4.91%)
- 5.19% is the preliminary estimate of the inhabitants of these six neighborhoods who have already had contact with the virus.
- Of the 352,428 inhabitants of these neighborhoods, 18,299 have already been infected with SARS-CoV-2, which corresponds to 5,192 infected people per 100,000 inhabitants.
- The number of people already infected in the general population of these neighborhoods is 11.9 times greater than the number of cases confirmed by the epidemiological monitoring of the city of São Paulo.
- Up until May 11, 175 deaths were recorded as caused by COVID-19 in these six neighborhoods. The apparent lethality of the infection is 0.95%.

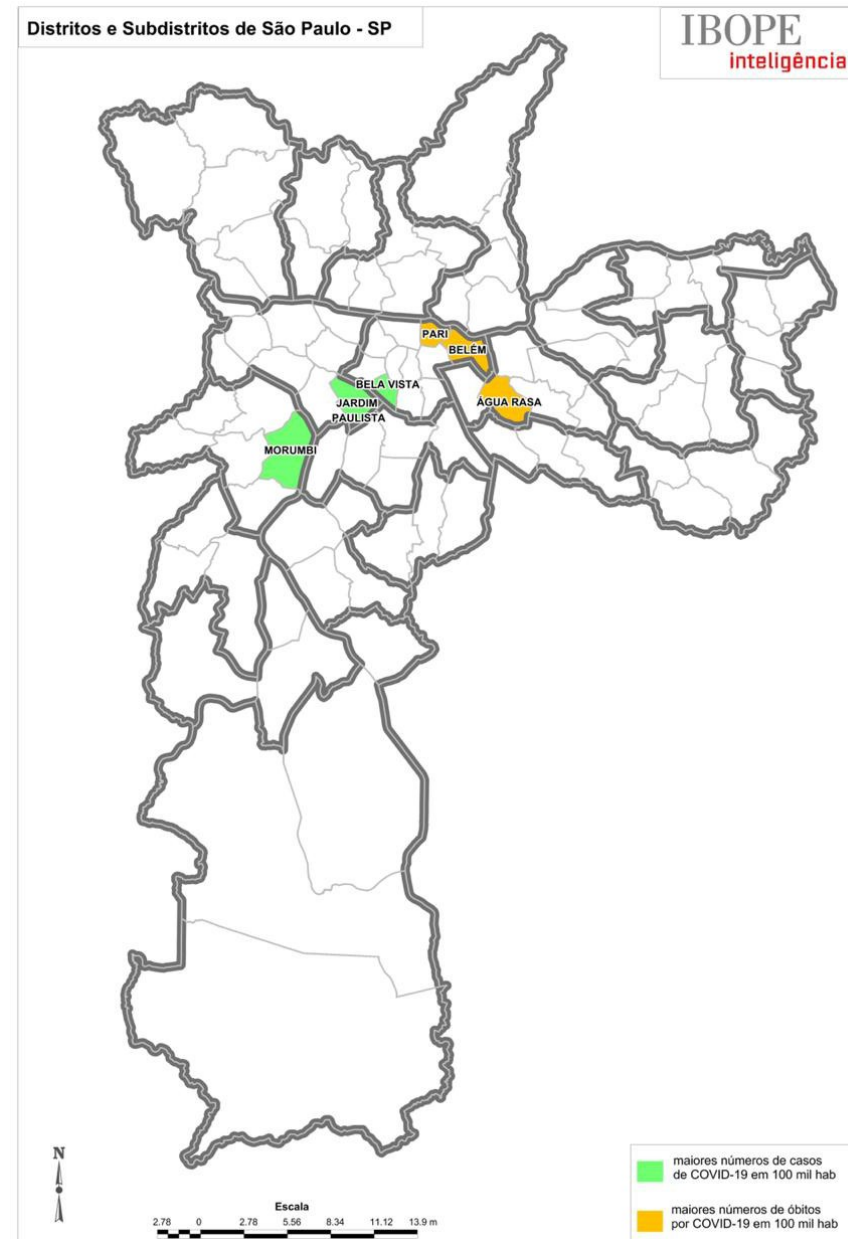
# Methods: District selection

The 3 neighborhoods with the highest number of confirmed COVID-19 cases per 100,000 inhabitants and the 3 neighborhoods with the highest number of deaths per 100,000 inhabitants in the municipality of São Paulo according to data from the municipality's epidemiological monitoring released on April 23, 2020\*

Neighborhoods	Population (IBGE** 2010)	No. cases Updated 04/23***	No. cases per 100k inhab.	No. deaths Updated 04/23	No. deaths per 100k Inhab.	Social vulnerability index
Cases						
Morumbi	46.957	331	705	7	15	1.34
Bela Vista	69.460	234	337	11	16	1.49
Jardim Paulista	88.692	239	269	12	14	1.01
Deaths						
Pari	17.299	18	104	8	46	2.57
Belém	45.057	66	146	18	40	2.14
Água Rasa	84.963	89	105	37	44	1.93

\*Brazilian Institute of Geography and Statistics.

\*\*\*Confirmed and suspected cases.



\* [https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/saude/PMSP\\_SMS\\_COVID19\\_Boletim%20Semanal\\_20200417\\_atualizado.pdf](https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/saude/PMSP_SMS_COVID19_Boletim%20Semanal_20200417_atualizado.pdf)

# Methods: Sampling plan

- The target population is people aged 18 or over on the date of the interview.
- The size of the planned sample will allow a prevalence greater than 4% to be estimated with coefficients of variation below 30%, taking into account the complex delineating effects of the sampling.
- The maximum sampling error (semi-amplitude of the confidence interval), corresponding to the 5% prevalence will be 2.7, indicating a 95% confidence interval ( $CI_{95\%}$ ) of 2.3% - 7.7%. The coefficient of variation is 27.6%.

# Methods: Selection of individuals

- A probabilistic sampling was used, by clusters, in three stages: census sector, home and resident.
- In the first stage, 72 census sectors will be drawn by systematic sampling with probability proportional to size, with the number of households being used as a measure of household size, according to the 2010 IBGE Census. Sectors were ordered by district for the drawing.
- Sixteen (16) permanent private households were selected in the second stage in each census sector. A complete and updated register of every household that exists within the neighborhoods was established in this phase.
- In the third selection stage, one resident was drawn. To accomplish this, every resident eligible for the interview was listed and one of them was randomly drawn using an internal program on a tablet.
- The other residents of the household were offered the opportunity to take a blood test and give an interview.

# Methods: Home visit

- A technician from Grupo Fleury and a researcher from IBOPE Inteligência approached the households with special attire and with PPE (personal protective equipment). The selected residents were invited to voluntarily participate in the research.
- The individuals from the drawing were informed about the details of the research and received a pamphlet containing this information.
- Participants who agreed to participate, signed an Free and Informed Consent Form.
- Participants answered a questionnaire (see at the end) and had a venipuncture blood sample collected.
- The same procedure was used for other members of the household who showed interest in taking the test.
- The participants were advised on how they would receive the results (mail and internet).
- The visit was closed.

# Methods: Laboratory testing

- The quantification of antibodies against SARS-CoV-2 was performed by CLIA (chemiluminescence) methodology, using the MAGLUMI 2000 PLUS equipment, and the “MAGLUMI IgM 2019-nCoV (CLIA)”, and “MAGLUMI” 2019 IgG-nCoV (CLIA)” kits, all from Snibe Diagnostics.
- The participants’ serum samples were incubated with magnetic microspheres coated by specific monoclonal antibodies. After magnetic-field-induced precipitation, ABEI (non-enzymatic nanomolecule) labeling was performed with anti-IgM and anti-IgG human antibodies. After magnetic-field-induced precipitation, *starters 1+2* were added to initiate a chemiluminescence reaction. The light signal was then measured by a photomultiplier as relative light units (RLUs), which are proportional to the concentration of anti-SARS-CoV-2 IgM and IgG in the sample.
- The samples were analyzed in a single batch to minimize experimental variations
- The results were calculated automatically using calibration curves. IgM and IgG values greater than 1.0 and 1.1 AU/mL, respectively, were considered positive; results below 0.7 and 0.9 AU/mL, negative; and values equal to or within the mentioned values were considered indeterminate.

# Methods: Laboratory test sensitivity

- The characteristics of the tests used to detect IgG and IgM have been described in the following references.
- The tests used show a sensitivity > 99.5% nineteen days after the appearance of the first symptoms of COVID-19.
- The sensitivity is 60% between the 5<sup>th</sup> and 7<sup>th</sup> day after the first symptoms and rises to 90% between days 11 and 13.
- The tests identify asymptotically infected people.
  - Jin Y, et. al. Diagnostic value and dynamic variance of serum antibody in coronavirus disease 2019, International Journal of Infectious Diseases (2020), <https://doi.org/10.1016/j.ijid.2020.03.065>
  - Quan-Xin Long et al. Antibody responses to SARS-CoV-2 in patients with COVID-19. Nature Medicine (2020) <https://doi.org/10.1038/s41591-020-0897-1>



# Results: Epidemiological data from the selected neighborhoods on the days of collection

On May 11, 2020 (the day before the end of the collection), data from the São Paulo Municipal Health Department indicated that the number of confirmed cases and the number of deaths in the selected neighborhoods increased 1.57 times and 1.88 times, respectively, as compared to the data for April 23.

## Epidemiological data of May 11, 2020

Neighborhoods	Population (IBGE 2010)	No. cases Updated 05/11*	No. cases per 100k Inhab.	No. deaths Updated 05/11	No. deaths per 100k Inhab.	Social vulnerability index
Cases						
Morumbi	46.957	594	1.265	18	38	1.34
Bela Vista	69.460	333	479	22	32	1.49
Jardim Paulista	88.692	389	439	28	32	1.01
Deaths						
Pari	17.299	19	110	16	92	2.57
Belém	45.057	79	175	37	82	2.14
Água Rasa	84.963	121	142	54	64	1.93

\* Confirmed and suspected cases

Source: São Paulo Municipal Department of Health

# Results: Difficulties encountered in the fieldwork

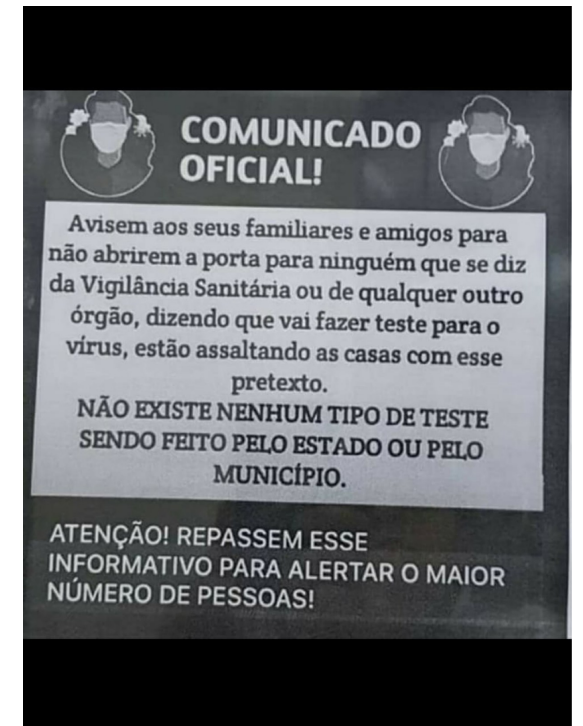
The research protocol provided for the collection of data and blood from 500 people in 4 days in the field with 30 mixed teams (a technician from Fleury and a professional from IBOPE). We had difficulties attaining that number, so we extended the fieldwork to 8 days, being 2 days using one-third of the team.

In total 520 blood samples were collected, 294 from residents and 217 from cohabitants.

## Problems:

1. Household residents refusing to receive the teams, difficulty reaching the residents the households due to the doormen or building managers denying our access.
2. Rumors and Fake News hindered the research.

The results of the 520 tests are now available for consultation by participants and cohabitants using an individual password on the Fleury group website.



# Results: Gross numbers

Population of the six neighborhoods (IBGE 2010)	Number of participating households	Number of people tested	Number of people with antibodies	% of people tested who have antibodies	Estimated number of people with antibodies in the six neighborhoods	Number of cases recorded by epidemiological monitoring	% of those infected who did not enter into official statistics
352,428	296	520	27	5.19%	18,299	1,535	91.6%

- SARS-CoV-2 antibodies were detected in 16 of the 296 parliamentary residents.
- SARS-CoV-2 antibodies were detected in 11 of the 224 cohabitants.
- Antibodies were detected in 27 of the 520 individuals tested.
- There are approximately 18,299 people in these six neighborhoods who had already had contact with the virus.
- We estimate that 91.6% of cases of infection are not covered by official statistics.

Note: 10 out of 520 samples (1.92%) had indeterminate results (see methods) and for the purposes of this analysis were considered negative

# Discussion: Seroprevalence of SARS-CoV-2 infection in the city of São Paulo, Brazil

- 5.19% of the inhabitants of the six neighborhoods had already had contact with the SARS-CoV-2 virus.
- It is difficult to extrapolate this estimate to the entire population of the city of São Paulo given the heterogeneity of the districts.
- The districts studied were selected because they have the highest rates of cases and deaths. Therefore, it is reasonable to expect that in the municipality of São Paulo as a whole, seroprevalence will be lower.
- 91.6% of individuals already infected with the virus are not aware of the epidemiological monitoring system due to the lack of tests.
- The apparent lethality of the infection was estimated at 0.95%. This is explained by the fact that 91.6% of infected individuals are not included in the calculation of lethality.

# References

- Kish, L. Survey Sampling. New York: Wiley, 1965.
- United Nations. Designing Household Survey Samples: Practical Guidelines. New York: United Nations, 2005.
- Silva, N.N. Amostragem probabilística: um curso introdutório (3a Ed). São Paulo: EDUSP 2015
- Cochran, W. G. Sampling techniques (3rd ed.). New York: John Wiley & Sons, 1977
- Jin Y, et. al. Diagnostic value and dynamic variance of serum antibody in coronavirus disease 2019, International Journal of Infectious Diseases (2020), doi:<https://doi.org/10.1016/j.ijid.2020.03.065>
- Quan-Xin Long et al. Antibody responses to SARS-CoV-2 in patients with COVID-19. Nature Medicine (2020) <https://doi.org/10.1038/s41591-020-0897-1>

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This study was financed by Instituto Semeia, Grupo Fleury, and IBOPE Inteligência

We would like to thank: Pedro Luiz Barreiros Passos, Guilherme Passos, Carlos Marinelli, Arthur Hernandez, Aline Resende, Diego Freitas, Fernando Pieroni, Joice Tolentino, Stefanie Silva, Vera Alves Frascino, William Malfatti, Rosi Rosendo, Helio Neves e David Uip.

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# Appendix: Applied Questionnaire

## ELECTRONIC QUESTIONNAIRE

1

JOB 200324	SÃO PAULO OVID-19 IMMUNITY	1,152 HOUSEHOLDS	4/27/2020
	AVENIDA FRANCISCO MATARAZZO 1350 – 8º ANDAR SÃO PAULO		

NEIGHBORHOOD: \_\_\_\_\_

SECTOR: \_\_\_\_\_ HOUSEHOLD: \_\_\_\_\_

Number of household residents: \_\_\_\_\_

(SEX) (1) Male (2) Female

(AGE) What is your exact age?      YEARS

(BIRTHDAY) What is your date of birth?      /      /     

(EDUCATION) What was the last year of school you completed?      grade/year. Level: ( ) K-8 ( ) high school ( ) college

P7. And what is the highest grade completed in the residence?      grade/year. Level: ( ) K-8 ( ) high school ( ) college

9. In the past two weeks to date, have you had:

a. Fever with temperature above 37.5°C?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the fever start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the fever last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

b. Have you felt intense fatigue?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the intense fatigue start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And for how many did the intense fatigue last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

c. Have you had body pain or aches?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the body pain or aches start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the body pain or aches last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

d. Have you had a sore throat?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the sore throat start?

## ELECTRONIC QUESTIONNAIRE

2

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the sore throat last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

e. Have you had a cough?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) Did the cough produce phlegm?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

How many days ago did the cough start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the cough last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

f. Have you had any difficulty breathing?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If so) Was your nose stuffy?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

For how many days have you had difficulty breathing?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And for how many did the difficulty breathing last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

g. Diarrhea?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the diarrhea start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the diarrhea last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

h. Have you experienced a loss of taste/difficulty tasting food?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the loss of taste start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And for how many days did the loss of taste last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

i. Have you experienced a loss of smell?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the loss of smell start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And for how many days did the loss of smell last?

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

j. Have you had a runny nose?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If yes) How many days ago did the runny nose start?

     days (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

And how many days did the runny nose last?

## ELECTRONIC QUESTIONNAIRE

3

     days (97) Still feverish (SPONT) (98) Don't remember (SPONT) (99) Didn't answer (SPONT)

P10. Have you ever been diagnosed with the coronavirus or COVID-19 infection?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(If so) When was the diagnosis confirmed?      /      /      2020

P11. Do you do any work in the healthcare area?

(1) Yes (2) No (8) Don't remember (SPONT) (9) Didn't answer (SPONT)

(RACE) Now, I am going to ask a question exactly as it is worded by IBGE for classification of the Brazilian population. Your color or race is: (1) White (2) Black (3) 2 or more (4) Asian (5) Indigenous (9) Did not answer (SPONT)