# COVID 19 SERO SURVEILLANCE REPORT

## August - September 2021

**Department of Health & Family Welfare**

**Government of Kerala**

# KERALA COVID-19 (SARS CoV2 IgG) SEROPREVALENCE STUDY SEPTEMBER 2021

## CHAPTER-1 OVERVIEW

### 1. INTRODUCITON AND BRIEF METHODOLOGY

It is essential to undertake relevant investigations during the course of the COVID-19 pandemic to understand the burden of infection, transmission patterns and risk factors of infection. One such investigation is population based sero-epidemiological investigations. The inference arrived at can be used to inform and guide decision makers to formulate and refine the prevention and control activities. The World Health Organization (WHO) also recommends the use of the sero-epidemiological surveys to understand the dynamics of the pandemic and suggests that total or IgG antibodies should be preferred.

In this background the Government of Kerala has so far conducted three such sero-epidemiological surveys. This survey is perhaps the first of its kind in India which also focuses on specific vulnerable populations like the Antenatal women, Tribal, coastal, and urban slum populations.

The first survey was conducted measuring IgG and IgM antibodies using ELISA method during May-June 2020 and was focused on specific risk groups considering that there was not much community transmission. The second one was conducted measuring SARS CoV-2 IgG Nucelocapsid antibody (CLIA method) during February 2021 and had focused on the general community aged ≥18 yrs, front line workers and on the residual samples from blood banks and taluk level laboratories. The residual samples form blood banks and taluk level laboratories were used to correlate the results among the other categories.

The results of the previous serosurveys conducted in Kerala state has provided valuable insights into the epidemiology of COVID-19 pandemic.

The overall seroprevalence in the community in Kerala in February 2021 was found to be 10.76% as per 2$^{nd}$ serosurvey. Kerala faced the second wave of COVID-19 in the state during the months of May and June 2021. The population behaviour, mobility and other factors were changing with the various stages of easing the restrictions. ICMR report of the 4th serosurvey (May 2021) has reported the seroprevalence estimates of Kerala state as 44.4% one of the least among similar Indian sates, when the national seroprevalence was 67.6%.

The present survey, the third one has focused on six categories of the population in the state namely Community ≥18 yrs, Antenatal women, Children aged 5-17 yrs, Tribal population ≥18yrs, coastal population ≥18 yrs and the urban slum population aged ≥18 yrs. Basic demographic, epidemiological factors, vaccination status along with a small amount of blood was collected in the survey. Designated laboratories were identified to perform the test. The

antibodies measured were SARS CoV-2 IgG Nucelocapsid antibody (anti nucleocapsid antibody) and SARS CoV-2 IgG Spike -S1 RBD antibody (anti spike antibody) in the same samples. Seroprevalence was estimated based on an individual's positivity if any of the 2 types of antibody was positive similar to the study done by the Indian Council of Medical Research (ICMR) in the 4th round of their survey.

The data was captured using an online platform developed for the purpose. The detailed protocol is available in the Government Order G.O.(Rt)No.1803/2021/H&FWD Dated-25/08/2021, Thiruvananthapuram[1]. An analytical team was constituted and performed the analysis and the results are presented as chapters 2-7 below.

A population based cross-sectional survey was used in the survey. The objectives are listed below.

**Primary**

1. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among ≥18 year old population of Kerala.

2. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among the Antenatal women attending Antenatal care clinics in Kerala.

3. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among the children aged 5 to 17 yrs in Kerala.

4. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among the tribal population aged ≥18 yrs in rural parts of districts in Kerala.

5. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among people ≥18yrs in coastal areas of Kerala.

6. To estimate the seroprevalence of SARS CoV-2 IgG antibodies among people ≥18yrs in slums areas in corporations of Kerala.

**Secondary**

1. To study the determinants of seropositivity among the various study populations

2. To study the seropositivity among the categories for vaccination status in the study populations
3. To estimate the case to infection ratio and infection fatality ratio in the general population.

The study design and setting adopted for estimating the seroprevalence of IgG antibodies to SARS CoV-2 among the various populations for the objectives are summarised in table 1.

Table.1. Summary of the study design across the study objectives.

| Objective | Description of population | Design and setting |
|---|---|---|
| 1 | Estimation of seroprevalence among adults ≥18yrs | Community based cross-sectional survey |
| 2 | Estimation of seroprevalence among antenatal women | Hospital based cross-sectional survey |
| 3 | Estimation of seroprevalence among children 5 to 17 yrs | Community based cross-sectional survey |
| 4 | Estimation of seroprevalence among tribal population ≥18yrs | Community based cross-sectional survey |
| 5 | Estimation of seroprevalence among people ≥18yrs in coastal area | Community based cross-sectional survey |
| 6 | Estimation of seroprevalence among people ≥18 yrs in urban slum areas | Community based cross-sectional survey |

Those individuals not willing to consent for the study , presently active COVID cases in home treatment, persons on quarantine, travellers who have arrived in Kerala within the last 4 weeks, and those with contraindication to venepuncture were excluded from the survey.

The effective sample size estimated for each of the six categories is given the table 2.

Table.2. Estimated sample size for each of the six categories.

| Category | Expected prevalence taken for sample size calculation | Precision % | Calculated Sample size | Design effect | Wastage % | Effective Sample Size |
|---|---|---|---|---|---|---|
| Community | 33 | 2 | 2123 | 2 | 5 | 4458 |
| ANC | 33 | 2 | 2123 | 1 | 5 | 2229 |
| Children | 20 | 3 | 683 | 2 | 5 | 1434 |
| Trial | 33 | 4 | 530 | 3 | 5 | 1670 |
| Coastal | 33 | 4 | 530 | 3 | 5 | 1670 |
| Urban Slum | 33 | 4 | 530 | 3 | 5 | 1670 |

Appropriate sampling techniques were used for the selection of study subjects as per the protocol.
The administration and management of the serosurvey was executed through the Department of Health and Family Welfare Government of Kerala; Department of Health Services (DHS), Department of Medical Education (DME), Kerala Medical Services Corporation (KMSCL),

State Public Health Lab (SPHL), National Informatics Centre (NIC), Kerala Health Research and Welfare Society(KHRWS), Govt. of Kerala through their respective functionaries. State level coordination was performed by the Additional Director of Health Services (ADHS) and Director SPHL and the district level coordination was done by the District Medical Officers, COVID District Surveillance Officers (COVID DSO), District Nodal Officer for Serosurvey and the District laboratory Officer.

The field level activities were performed by the sample collection team constituted for the survey consisting of Medical Officer, Nurse (staff or JPHN) /counsellor, Laboratory technicians of respective teams / District sample collection team. Basic socio-demographic and epidemiological data was collected online after obtaining informed consent and blood samples were collected. Blood samples collected were centrifuged in the local laboratory, serum separated and packed in cold chain and transported to the designated laboratories. The tests were performed using Chemiluminescent immunoassay (CLIA) technology; SARS CoV-2 IgG S1 RBD antibody test (Siemens assay) and SARS CoV-2 IgG Nucleocapsid antibody (Abbott assay) kits. The kits used has high sensitivity and specificity[2]. The data was collected using an online portal developed by NIC Thiruvananthapuram centre and the test results were also uploaded in the online portal.

## 2. OVERALL RESULTS OF THE PRIAMRY OBJECTIVES

The overall seroprevalence across the six categories are presented in the table below. Seroprevalence was estimated based on an individual's positivity to any of the 2 types of antibody tests as mentioned earlier.

Table.3. Seroprevalence across the six categories

| Category | Total Samples (a) | Number Positive (b) | Seroprevalence (%) (c= (b/a) x 100) | 95 % Confidence Interval |
|---|---|---|---|---|
| Community ≥18 yrs | 4429 | 3659 | **82.6** | 81.5- 83.7 |
| Antenatal women (ANC 18-49 yrs) | 2274 | 1487 | **65.4** | 63.4 - 67.4 |
| Children 5-17 yrs | 1459 | 586 | **40.2** | 40.11- 40.39 |
| Tribal ≥18 yrs | 1521 | 1189 | **78.2** | 76.1- 80.2 |
| Coastal ≥18 yrs | 1476 | 1294 | **87.7** | 85.9-89.3 |
| Urban Slum ≥18 yrs | 1706 | 1455 | **85.3** | 83.63 - 86.97 |

The primary analysis and results of each category are presented chapter wise. Detailed analysis is provided for the antenatal and children categories considering the priority for interventions.

REFERENCE:

1. Health And Family Welfare (F) Department. Government Order
   G.O.(Rt)No.1803/2021/H&FWD Dated- 25/08/2021, Thiruvananthapuram.
   Health C for D and R. EUA Authorized Serology Test Performance. FDA [Internet].
   2021 Aug 18 [cited 2021 Aug 19]; Available from:
   https://www.fda.gov/medicaldevices/coronavirus-disease-2019-covid-19-emergency-
   use-authorizations-medicaldevices/eua-authorized-serology-test-performance.

**SEROPREVALENCE OF SARS CoV-2 IgG ANTIBODY AMONG INDIVIDUALS IN THE COMMUNITY ≥18 YEARS**

## 1. INTRODUCTION

The objective of the survey was to estimate the seroprevalence of SARS CoV-2 IgG antibodies among the community ≥18 years at the state level. Anti-spike antibodies are produced in an individual following natural infection due to COVID-19 virus (SARS CoV-2) or through any of the COVID vaccinations available. Anti-nucleocapsid antibodies are produced in an individual following natural infection or after vaccination with COVAXIN. Seroprevalence was estimated based on either anti-spike or anti-nucleocapsid IgG seropositivity, similar to the methodology adopted by Indian Council of Medical Research (ICMR) in the 4th round of their survey.

The expected seropositivity for the adult segments of populations in this survey was hypothesized to be at least 33% with a precision of 2%, design effect of 2 and a significance level of 95%. (As per ICMR 4th serosurvey estimates for Kerala). The sample size estimated was 4458 and a multistage cluster sampling was used for the calculation. The clusters were randomly selected and individuals were selected using the KISH grid method to ensure the representation of the general population[1]. The district wise urban and rural samples were distributed according to the population proportionate to size and given in table A below.

Table A. district wise distribution of urban and rural samples

| DISTRICT | NUMBER OF PANCHA YATHS TO BE SAMPLED (a) | NUMBER OF WARDS IN EACH PANCHAYATH TO BE SAMPLED (b) | TOTAL RURAL SAMPLES (c= 10xbxa) | NUMBER OF URBAN BODIES TO BE SAMPLED (d) | NO OF WARDS/DIVISION IN EACH URBAN BODY TO BE SAMPLED (e) | TOTAL URBAN SAMPLES (f=10xexd) | TOTAL SAMPLES (c+f) |
|---|---|---|---|---|---|---|---|
| Thiruvananthapuram | 11 | 2 | 220 | 3 | 9 | 270 | 490 |
| Kollam | 10 | 2 | 200 | 3 | 5 | 150 | 350 |
| Pathanamthitta | 7 | 2 | 140 | 2 | 1 | 20 | 160 |
| Alappuzha | 7 | 2 | 140 | 3 | 5 | 150 | 290 |
| Kottayam | 9 | 2 | 180 | 3 | 3 | 90 | 270 |
| Idukki | 7 | 2 | 140 | 1 | 1 | 10 | 150 |
| Ernakulam | 7 | 2 | 140 | 7 | 4 | 280 | 420 |
| Thrissur | 7 | 2 | 140 | 4 | 7 | 280 | 420 |
| Palakkad | 14 | 2 | 280 | 4 | 2 | 80 | 360 |
| Malappuram | 15 | 2 | 300 | 6 | 4 | 240 | 540 |
| Kozhikode | 7 | 2 | 140 | 4 | 7 | 280 | 420 |
| Wayanad | 5 | 2 | 100 | 2 | 1 | 20 | 120 |
| Kannur | 6 | 2 | 120 | 5 | 4 | 200 | 320 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Kasaragod | 5 | 2 | 100 | 2 | 3 | 60 | 160 |
| STATE TOTAL | - | - | 2320 | - | - | 2100 | 4470 |

## 2. RESULTS

Individuals in the community aged ≥18 years were sampled based on the methodology described in the study protocol[1]. The seroprevalence based on various types of tests is described in table 1. For detailed analysis a positive test result on any of the two types of tests was considered. (i.e. either positive for Anti-spike IgG antibody or anti-nucleocapsid IgG antibody)

Table.1 Overall seroprevalence based on the type of test and whether either one of the tests is positive.

| Type of test / either test positive | Total Samples (a) | Number Positive (b) | Rejected (c) | Total for analysis (d= a-c) | Percentage Seroprevalence | 95% Confidence Interval |
|---|---|---|---|---|---|---|
| Anti -spike IgG antibody | 4543 | 3727 | 6 | 4537 | 82.14% | 80.92 – 83.15 |
| Anti-nucleocapsid IgG antibody | 4522 | 868 | 11 | 4511 | 19.26% | 18.04 -20.34 |
| Anti -spike IgG antibody or anti-nucleocapsid IgG antibody | 4429 | 3659 | 0 | 4429 | 82.61% | 81.50 -83.73 |
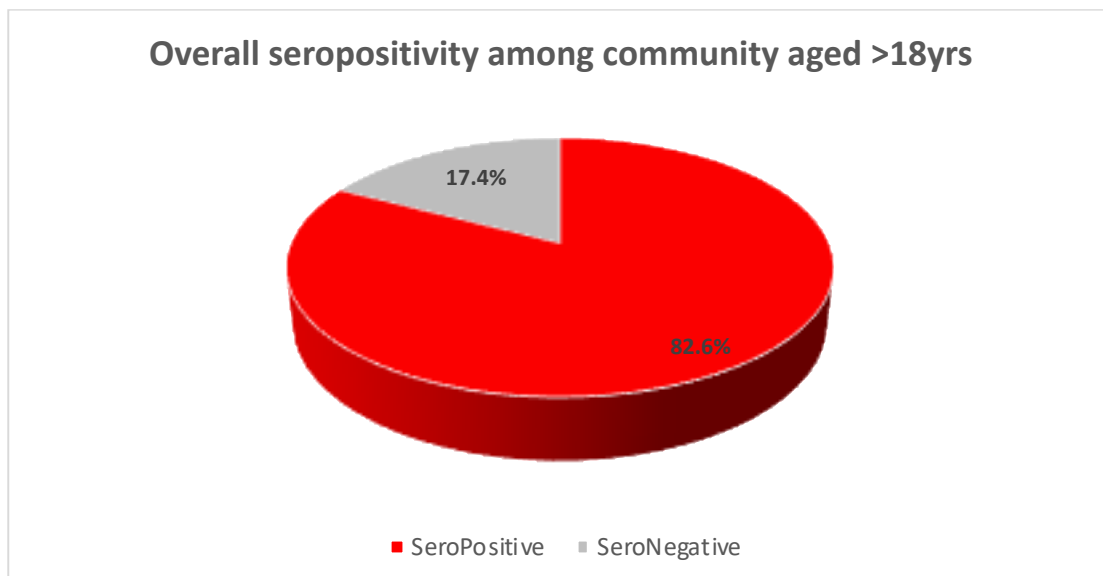


Overall seropositivity among community aged >18yrs

17.4%

82.6%

■ SeroPositive   ■ SeroNegative

Table 2. District wise distribution of seropositivity

| District | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Alappuzha | 208 | 177 | 85.09 |
| Ernakulam | 427 | 347 | 81.26 |
| Idukki | 169 | 139 | 82.24 |
| Kannur | 334 | 283 | 84.73 |
| Kasaragod | 215 | 194 | 90.23 |
| Kollam | 379 | 303 | 79.94 |
| Kottayam | 265 | 233 | 87.92 |
| Kozhikode | 300 | 232 | 77.33 |
| Malappuram | 515 | 436 | 84.66 |
| Palakkad | 357 | 283 | 79.27 |
| Pathanamthitta | 157 | 145 | 92.35 |
| Thiruvananthapuram | 469 | 398 | 84.86 |
| Thrissur | 504 | 397 | 78.76 |
| Wayanad | 130 | 92 | 70.76 |
| **Total** | **4429** | **3659** | **82.61** |

### District wise distribution of Seropositivity

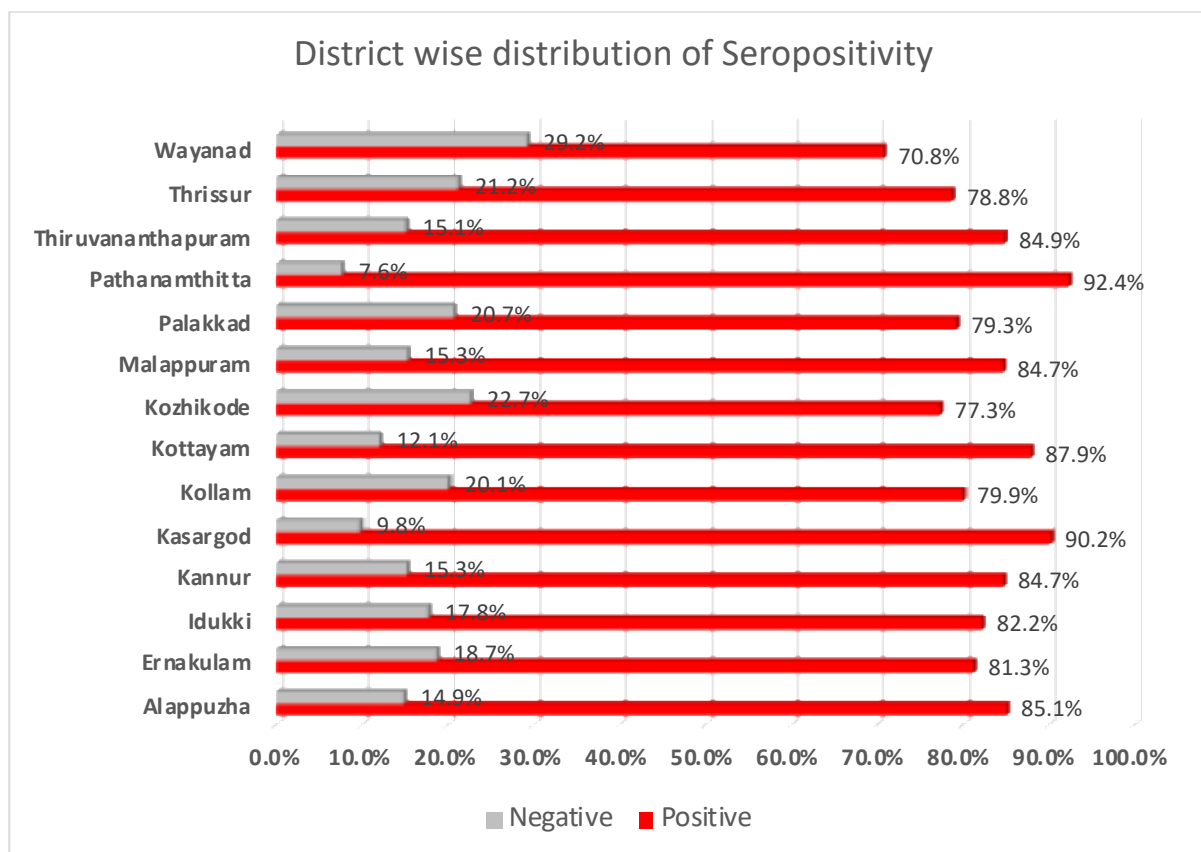| District | Negative | Positive |
|---|---|---|
| Wayanad | 29.2% | 70.8% |
| Thrissur | 21.2% | 78.8% |
| Thiruvananthapuram | 15.1% | 84.9% |
| Pathanamthitta | 7.6% | 92.4% |
| Palakkad | 20.7% | 79.3% |
| Malappuram | 15.3% | 84.7% |
| Kozhikode | 22.7% | 77.3% |
| Kottayam | 12.1% | 87.9% |
| Kollam | 20.1% | 79.9% |
| Kasargod | 9.8% | 90.2% |
| Kannur | 15.3% | 84.7% |
| Idukki | 17.8% | 82.2% |
| Ernakulam | 18.7% | 81.3% |
| Alappuzha | 14.9% | 85.1% |

Table 3. Distribution of Seropositivity among the age categories

| Age category | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| 18-29 | 698 | 554 | 79.37 |
| 30-44 | 1348 | 1072 | 79.53 |
| 45-59 | 1435 | 1231 | 85.78 |
| 60-74 | 825 | 707 | 85.70 |
| ≥75 | 123 | 95 | 77.24 |
| **Total** | **4429** | **3659** | **82.61** |

## Age group wise seropositivity
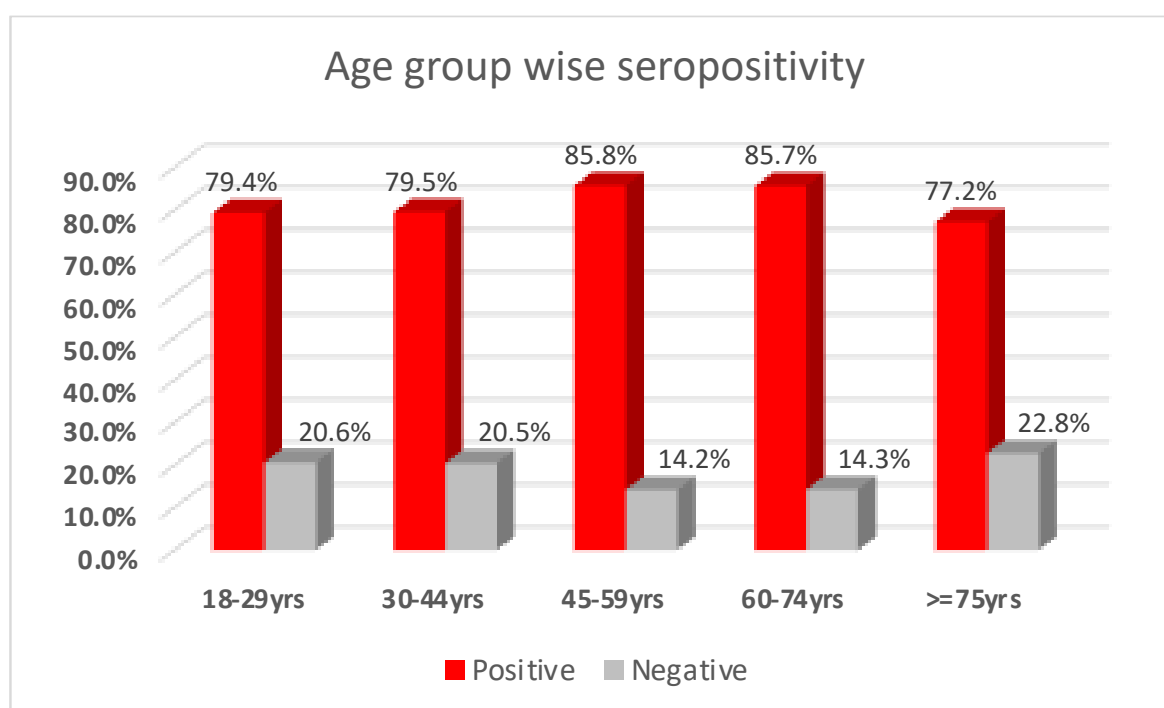


Table 4. Gender wise distribution of seropositivity

| Gender | Total | Numberpositive | Percentage Seropositivity (%) |
|---|---|---|---|
| Male | 2153 | 1782 | 82.77 |
| Female | 2276 | 1877 | 82.47 |
| **Total** | **4429** | **3659** | **82.61** |

**Gender wise distribution of seropositivity**
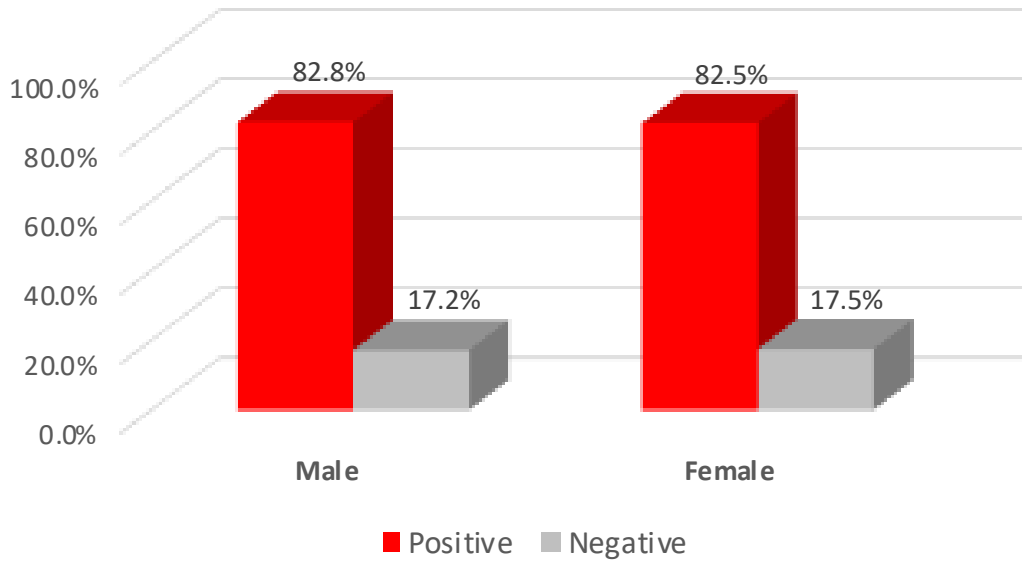
Table 5. Seropositivity according to APL/ BPL status

| APL/ BPL | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| APL | 2433 | 2032 | 83.52 |
| BPL | 1996 | 1627 | 81.51 |
| **Total** | **4429** | **3659** | **82.61** |



**APL/BPL status wise seropositivity**
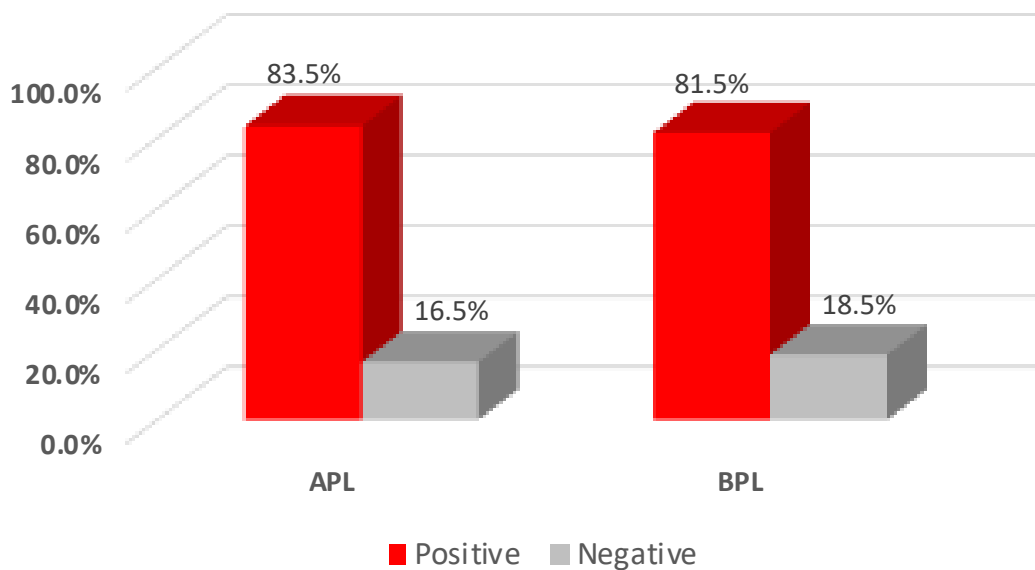
Table 6. Seropositivity according to LSG Type

| Type of LSG | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Corporation | 371 | 307 | 82.75 |
| Municipality | 1431 | 1194 | 83.44 |
| Grama Panchayath | 2627 | 2158 | 82.15 |
| **Total** | **4429** | **3659** | **82.61** |

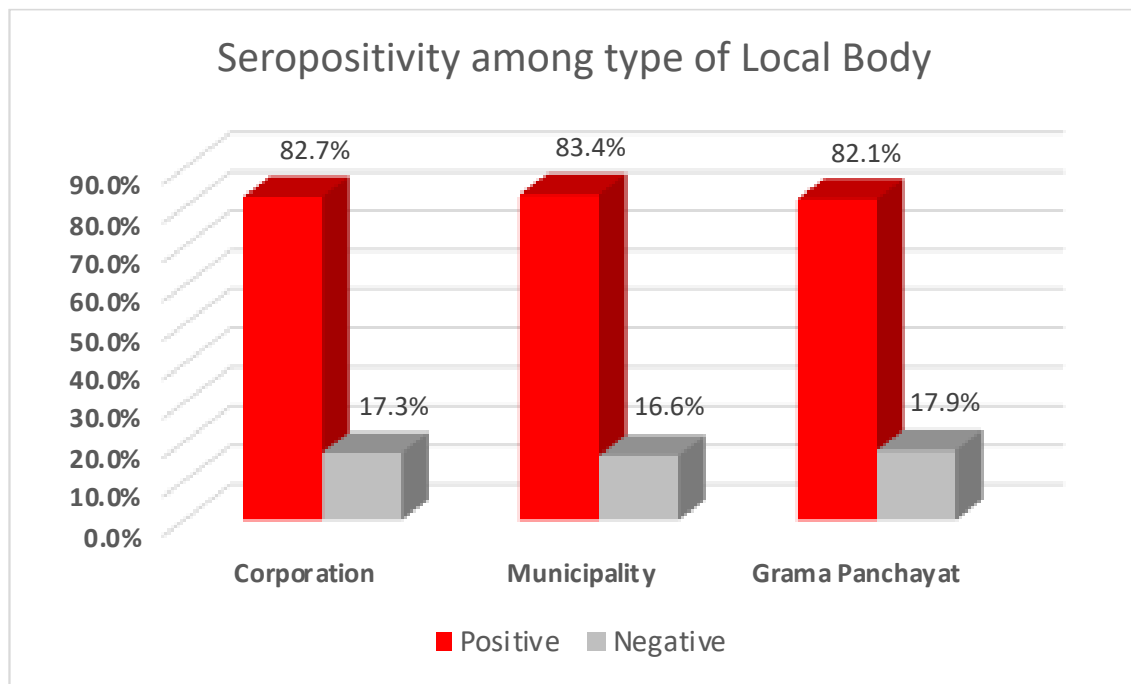## Seropositivity among type of Local Body



Table 7. Seropositivity according to previous history of having been confirmed as COVID positive

| Previous history of having been confirmed as COVID positive | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 292 | 279 | 95.55 |
| No | 4137 | 3380 | 81.70 |
| **Total** | **4429** | **3659** | **82.61** |

Seropositivity according to previous history of having been confirmed as COVID positive
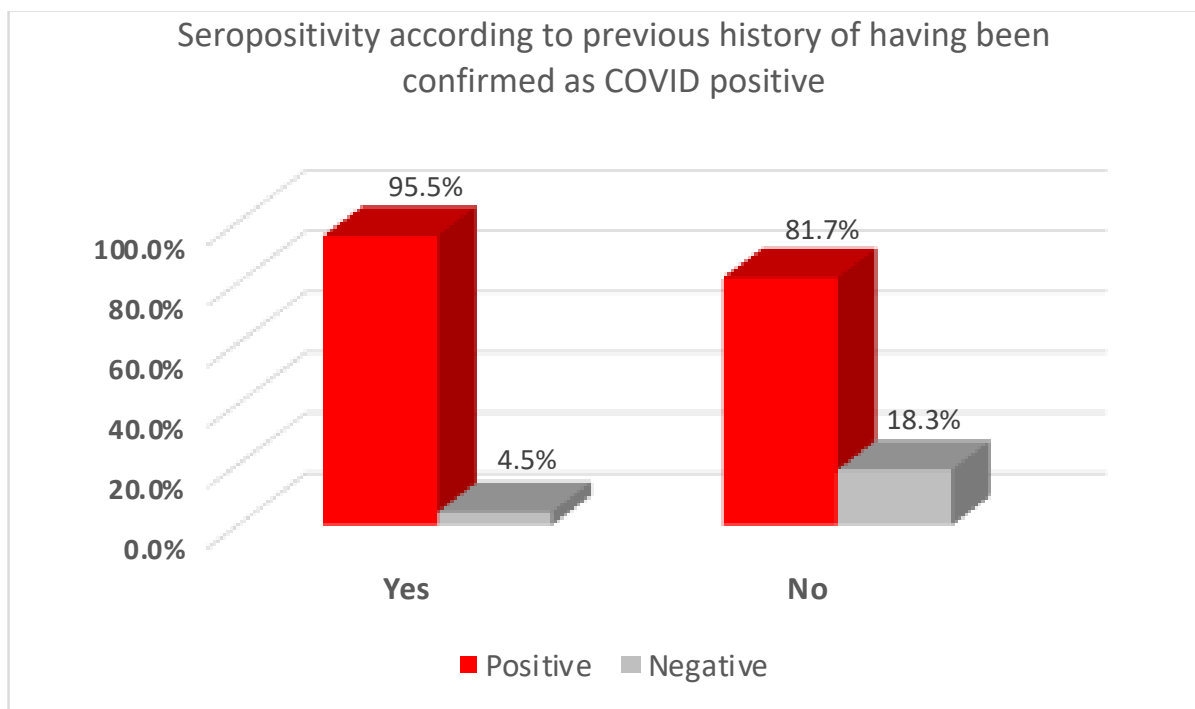
Table 8. Seropositivity according to previous history of contact with a confirmed COVID positive case

| History of contact with a confirmed COVID positive case | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 334 | 294 | 88.02 |
| No | 4095 | 3365 | 82.17 |
| **Total** | **4429** | **3659** | **82.61** |

Table 9. Seropositivity according to type of contact with the confirmed COVID positivecase

| Type of Contact with confirmed COVID positive case | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Hospital contact | 10 | 8 | 80.00 |
| Community Contact | 130 | 113 | 86.92 |
| Household | 194 | 173 | 89.18 |
| No contact | 4095 | 3365 | 82.17 |
| **Total** | **4429** | **3659** | **82.61** |

Table 10. Seropositivity according to COVID vaccination status

| COVID vaccination status* | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Unvaccinated | 847 | 593 | 70.01 |
| Partially Vaccinated | 1885 | 1540 | 81.70 |
| Fully Vaccinated | 1697 | 1526 | 89.92 |
| **Total** | **4429** | **3659** | **82.61** |

*Partially vaccinated are those who have taken 1 dose of COVID-19 vaccination. Fully vaccinated are those that have received 2 doses of COVID-19 vaccine. Unvaccinated are those that have not received any doses of COVID-19 vaccine till the time of survey.
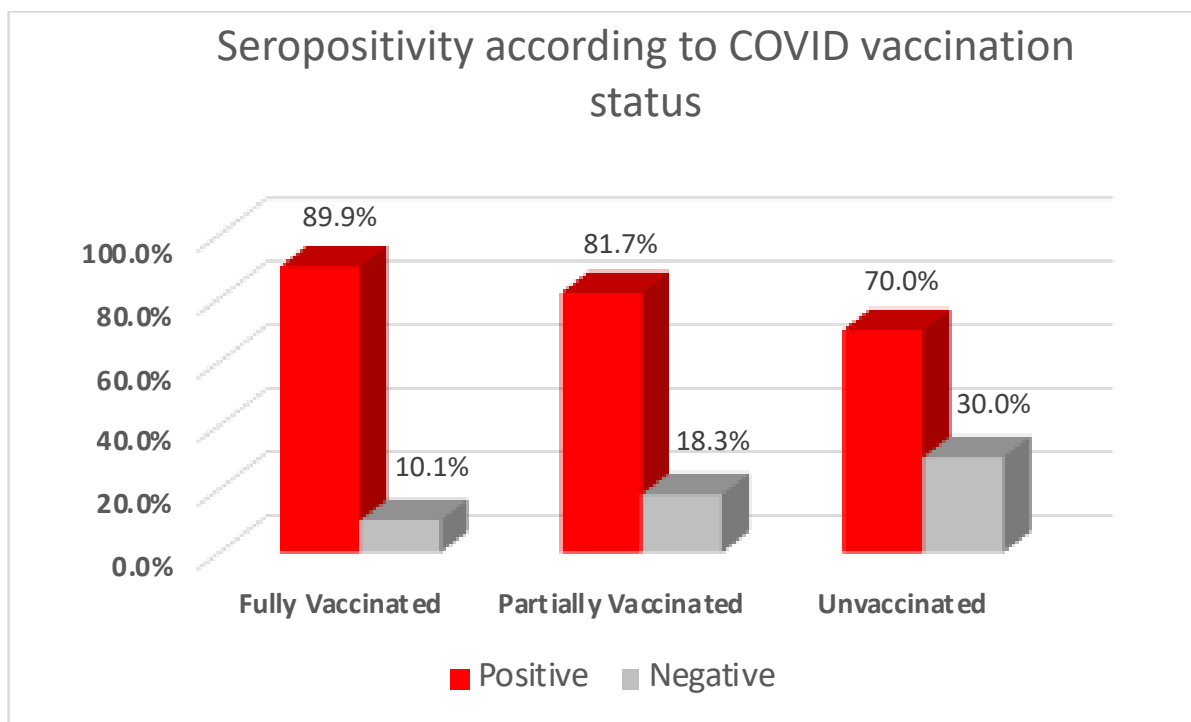
Table 11. The following exposure variables were found to be statistically significant in bivariable analysis with outcome as a positive test results in any of the tests done.

| Factor | Chi Square | df | p Value | Odds Ratio |
|---|---|---|---|---|
| District | 58.27 | 13 | <0.001 | - |
| Age group | 32.04 | 4 | <0.001 | - |
| History of contact with a Confirmed COVID positive cases (yes/no) | 7.36 | 1 | 0.005 | 1.59 (1.13-2.24) |
| History of a being a COVID positive case (yes/no) | 36.40 | 1 | <0.001 | 4.80 (2.74- 8.43) |
| COVID vaccination status (vaccinated vs unvaccinated) | 115.81 | 1 | <0.001 | 2.54    2.13- 3.02) |

Table 12. Results of Multivariable binary logistic regression.

| Exposure variable | Adjusted Odds ratio | 95% Confidence Interval of Adjusted Odds ratio | p value |
|---|---|---|---|
| COVID vaccination status (vaccinated vs unvaccinated) | 2.75 | 2.3- 3.3 | <0.001 |
| History of a being a COVID positive case (yes/no) | 5.6 | 3.2- 9.9 | <0.001 |
| History of contact with a Confirmed COVID positive cases (yes/no) | 1.26 | 0.89- 1.79 | 0.201 |

## 3. DISCUSSION

The overall seropositivity of 82.61% in the community samples (≥18 yrs), for either Anti -spike IgG antibody or Anti-nucleocapsid IgG antibody denotes that there is high level of seropositivity among adults in the general population. This could have been achieved either through natural infection or through COVID vaccination. It is a good indicator of the level of protection in the population. The seropositivity of 70% observed among the unvaccinated population may be an indicator of the background infection rate in the population.

The seroprevalence reported by the various rounds of ICMR surveys in Kerala were as follows[2]; May 2020 - 0.33%, August 2020 - 0.88%, December 2020 - 11.6% and May 2021 - 44.4% (42.7 % for S1RBD antibodies). Kerala state always had a lower seroprevalence as compared to the seroprevalence estimates for the country which were as follows; May 2020-

0.73%, August 2020 - 6.6%, December 2020 - 21%, May 2021 - 67.6%* (S1 RBD antibody). These low seropositivity compared to that in the country during ICMR serosurvey timeframes reflect the effective prevention and control activities implemented in the state against the pandemic at these times of the survey. The meticulous control activities included robust surveillance, contact tracing, quarantine measures, testing, isolation along with other measures adopted by the state. The last seroprevalence estimate for Kerala done by ICMR- May 2021 (44.4%) implied that more than 55% of the population remained susceptible to the infection. The current seropositivity from this survey indicates that around 17% of the population are still susceptible to COVID 19 infection. This may be explained by two major factors. Firstly, Kerala faced a major surge of covid cases during the months of May- June 2021 but the pandemic plateaued[3] out in a short time due to the intense control activities like rapidly increasing the testing, contact tracing, isolation, quarantine measures and by strict enforcement of COVID appropriate behaviour. Though the hospital beds were filling up rapidly at one point of time the health system was never overwhelmed. Secondly the COVID vaccinations were intensified through outreach camp and fixed site approaches along with wide IEC campaigns. Multiple innovative approaches like drive in vaccination sites, bed side vaccinations for bedridden and those in palliative care, "Mathrukavacham" program for antenatal vaccination etc were adopted to cater to maximum number from eligible population within shortest time period possible based on vaccine availability. The high seroprevalence observed in the survey and the higher seropositivity in those who were vaccinated compared to unvaccinated, reflects the impact of the State's vaccination drive and the effective way in which delta wave was handled without overwhelming the health system at any point during the second wave. Both these factors may have contributed to the high level of seroprevalence in the general population in Kerala observed in this serosurvey.

The seropositivity among the districts in Kerala was highest in Pathanamthitta district (92.4%) and lowest in Wayanad (70.8%). There was no statistically significant difference between seropositivity among the gender groups, APL/ BPL categories, or residence of the individual based on the local body type. Statistically significant differences were observed among the different age groups, districts, among those with history of COVID positivity and among those with history of contact with a COVID positive case. Among the significant factors, the area where one can modify for improving the population immunity is by enhancing vaccination. Continued surveillance and vaccinations coverage evaluations needs to be performed to finetune the prevention and control strategies in the state.

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3. https://dashboard.kerala.gov.in/covid/index.php

# CHAPTER 3

## KERALA SARS CoV-2 IgG SEROSURVEY AMONG ANTENATAL WOMEN- SEPTEMBER 2021

**Highlights**

- 2274 antenatal women were studied from the government and private antenatal clinics of 14 districts of Kerala for estimating seroprevalence
- Antibodies against COVID 19 spike and nucleocapsid protein were assessed
- The seroprevalence of COVID 19 among antenatal women in Kerala was **65.4 % (95% CI; 63.4-67.4)**
- The highest seropositivity among antenatal women was recorded in Thrissur district, followed by Idukki and Kottayam districts
- Seropositivity among women from urban areas was higher than that of rural areas
- 15.3 % of antenatal women gave a history of COVID positivity. Those women who gave a history of COVID positivity higher seropositivity compared to those with no such history
- 58.8% of antenatal women were unimmunized against COVID. 41.2% of the antenatal women have taken at least one dose of vaccine. 8.8% of the antenatal women have taken two doses of COVID vaccine.
- The seropositivity among unvaccinated antenatal was 49.8%. Among those who took at least one dose it was 87.6 %.
- The independent determinants of COVID seropositivity were being positive with COVID (Adjusted OR 6.25 ; 95%CI -4.41-8.84) and first dose of vaccine  (adjusted OR -8.6 ; 6.7 to 11.03)

## 1. Introduction

### 1.1. Background

Antenatal women with COVID 19 are at higher risk of developing severe COVID, requiring admission to an ICU or invasive ventilation. Pregnant women with COVID-19 are also at an increased risk of receiving cesarean sections, delivering preterm and their babies being admitted to a NICU. Higher age, higher body mass index, and pre-existing comorbidities might be associated with severe disease. Testing for SARS-CoV-2 in non-pregnant women is usually based on symptoms or contact history while testing in pregnant women is generally done for reasons that might not be related to COVID-19. [1]. Review of several studies of COVID 19 in pregnancy show that pregnant women with COVID-19 may be at increased risk of adverse pregnancy and birth outcomes and low risk of congenital transmission. [2] Hence COVID 19 among antenatal women needs special attention. However, there are very few studies of COVID 19 among antenatal women.

It is important to assess the magnitude of burden of COVID 19 among antenatal women to understand the need of interventions in this vulnerable group. Further investment of resources for in depth understanding of maternal and neonatal outcomes related to COVID 19 in pregnancy will also be possible only after assessment of burden. Seroprevalence studies enable the understanding of burden. Since it is specific to regions and varies with time, local specific seroprevalence studies are required over different periods of time. Such an attempt has been made in the third seroprevalence study done in Kerala.

### 1.2. Primary Objective

To estimate the seroprevalence of SARS CoV-2 IgG antibodies among antenatal women in Kerala.

### 1.3. Secondary objectives

1.3.1. To study the determinants of seropositivity among the various study populations

1.3.2. To study the seropositivity among the categories of vaccination status in the study populations

17

## 2. Methodology

A hospital based cross-sectional survey was done among antenatal women attending antenatal care clinics in selected Government and private hospitals in Kerala during the months of August – September 2021. The study included pregnant women in any trimester 18-49 years attending antenatal care clinics in Kerala. Subjects with age < 18 years and age > 49 years, those individuals who are not willing to consent for the study, presence of severe comorbidity like preeclampsia or in active labour, present active COVID-19 cases in home treatment, persons on quarantine, travellers who have arrived in Kerala within the last 4 weeks, those individuals with contraindication to venepuncture (cellulitis or abscesses in the area, venous fibrosis on palpation, presence of hematoma, presence of vascular shunt or graft, presence of vascular access devices) were excluded from the study. The sample size was estimated to be 2123 based on the expected seropositivity for all adult segments of populations in this survey as 33% (As per ICMR 4th serosurvey estimates for Kerala) 95 % significance level of 95 % and an absolute precision of 2%. A sample wastage factor of 5% was added. The district wise distribution of antenatal samples and number of samples from each of the selected five institutions are given in the table 2.1 below. The selection of the various categories of health institutions for obtaining the ANC samples are given in table 2.2.

Table 2.1: District wise distribution of samples from antenatal women and samples required from each of the six selected health institutions

| District | No. of antenatal women to be sampled | No. of samples from each of the 5 Institutions |
|---|---|---|
| Thiruvananthapuram | 250 | 50 |
| Kollam | 200 | 40 |
| Pathanamthitta | 100 | 20 |
| Alappuzha | 150 | 30 |
| Kottayam | 150 | 30 |
| Idukki | 100 | 20 |
| Ernakulam | 250 | 50 |
| Thrissur | 250 | 50 |
| Palakkad | 200 | 40 |
| Malappuram | 300 | 60 |
| Kozhikode | 250 | 50 |
| Wayanad | 75 | 15 |
| Kannur | 175 | 35 |

| | | |
|---|---|---|
| Kasaragod | 125 | 25 |
| **Total** | **2575** | |

From each district a total of five institutions providing antenatal clinic services were selected

Table 2.2: Category wise selection of health institutions.

| Type of Health Institution | No of Health Institutions with ANC Clinic services to be selected |
|---|---|
| Government hospital | 2 |
| Private hospital | 3 |
| Total | 5 |

From the daily outpatient department at the ANC site of the selected health institution, every third antenatal woman starting from the first ANC OP registration of that day was selected to meet the institution specific target. If the target was not achieved on a specific day, it was continued on the next ANC OP day to achieve the target. The serum samples were tested to identify the SARS CoV-2 IgG S1 RBD antibodies and SARS CoV-2 IgG Nucleocapsid antibodies using Chemiluminescent immunoassay (CLIA) technology. The tests were performed using Siemens and Abbott assays respectively. 5 ml of venous blood was collected by venepuncture. The blood was collected in collection tubes and allowed to stand for 30 minutes. The sample was then packed to ensure that the collection tubes were not tilted or shaken due to loose packing and transported to a nearby laboratory with centrifuge facility and centrifuged. The serum was collected in a separate aliquot vial. The serum aliquot vials were tightly capped and packed in triple layer to maintain cold chain (2-8o C). The separated serum was used for the purpose of testing as per the manufacturer's instructions at the designated regional laboratory and testing laboratory. The samples should be transported along with the sample transportation sheet. The designated laboratories ensured that tests were performed accurately and the test results entered online in the portal provided. The sample IDs were autogenerated online once the participant characteristics were entered. The same ID was provided for the respective blood collection tubes and aliquots as well as for reporting the results. The sample collection team, laboratory technicians at the local lab for centrifuge and at the designated laboratories ensured that fidelity of the samples and IDs were maintained throughout the process. The online portal was developed by the National Informatics Centre (NIC), Kerala State Centre, Thiruvananthapuram.

The designated regional labs RPHL Kozhikode( Regional Public Health Laboratory) and GH (General Hospital) Lab Kottayam received the serum samples from the allocated districts and divided the serum into two equal parts (sample "A" for Abbott assay and Sample "S" for Siemens Assay) observing all the laboratory safety precautions and proper labelling of the sample ID as generated online by the district field data collection teams. The separated "sample -S" by RPHL Kozhikode and GH Kottayam were to be sent to the testing laboratories, ACR laboratory (KHRWS) at Govt. Medical college Kozhikode and ACR laboratory (KHRWS) at Govt. Medical College Kottayam respectively for undergoing the Siemens assays. State Public Health Lab (SPHL) Thiruvananthapuram performed both the assays on the samples received from the allocated districts. The results of the respective assays were entered online by the concerned laboratories.

The data entry was performed on the online portal developed by National Informatics centre (NIC), Kerala state centre, Government of Kerala. Online training on data entry was provided. The field data collection teams entered the participant details on the portal and laboratories performing the tests reported the results in the same portal.

The District Surveillance Officer-COVID, District Serosurvey Nodal Officer and District Laboratory technician provided supportive supervision to the field teams and testing laboratories. District level monitoring was also be performed. The committee constituted by the state Government to study and report the serosurvey performed the analysis and interpretation. The committee maintained the guardianship of the data. Based on the analytical plan, the committee supervised data import, variable checks, undertook descriptive and exploratory analysis and prepared appropriate graphs & tables. The seroprevalence of SARS CoV-2 IgG antibodies was expressed in proportions with 95% Confidence intervals. District wise proportions were also estimated with 95% confidence interval. Other variables such as age, urban/rural and vaccination status, strata specific seropositivity were estimated. Basic demographic and clinical details was described in means and proportions as appropriate. The determinants of positivity was found out by comparing the attributes (age, history of exposure, History of positivity, history of symptoms, comorbidities etc) of those positive with a sample of those who were negative. The determinants of positivity and subgroup analysis as appropriate were performed. Rejection rates were expressed in percentages. Estimation of infection to case ratio and infection fatality ratio was performed.

20

Participant information sheet was shared with all the study participants and informed written consent taken from the consenting participants aged ≥ 18 yrs. Participants were given opportunity to ask questions regarding the survey to be well informed. The medical officer in charge, sample collection teams, lab in charge and staff ensured all the measures required for maintaining confidentiality and privacy of data. Privacy and gender sensitivity was maintained during data and blood collection. The results were disclosed to the participant via SMS, counselling of the participant was done before recruitment (informed consent). Blood samples collected was used only for the purpose of the test mentioned in the protocol and validation of results if required. Government servers was used for online data entry and storage. Institutional Research Committee and Human Ethics committee approval was obtained.

## 3. Results

### 3.1. Seroprevalence among antenatal women in Kerala

Seroprevalence according to the type of test and positivity on either test is given in the table 3.1. below. The overall seropositivity among antenatal women in Kerala was **65.4 % (95% CI ; 63.4-67.4)**

**Table 3.1. Seroprevalence according to type of test and either test positivity**

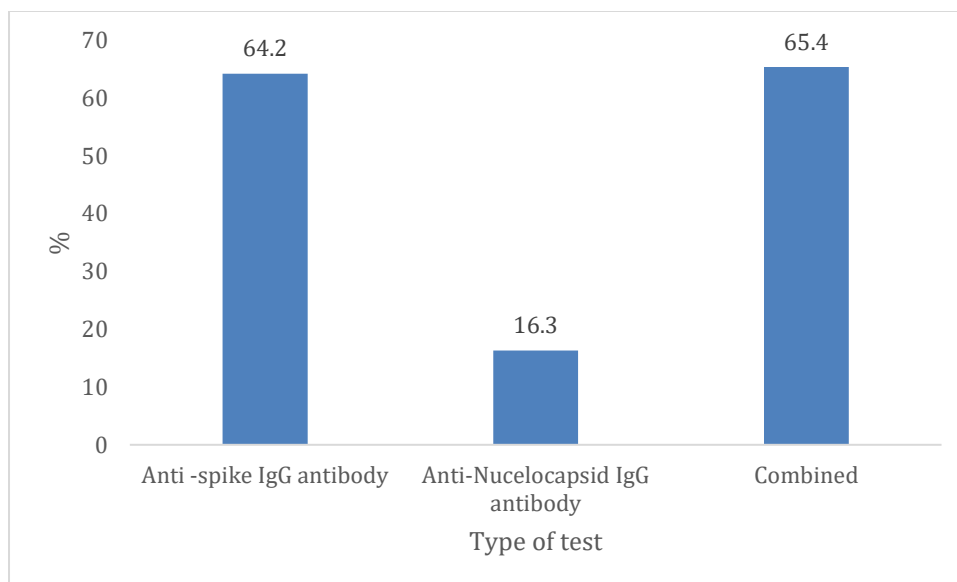| Type of test / either test positive | Total SAMPLES (a) | Positives (b) | Rejected (c) | Total for analysis (d = a-c) | EROPREVALENCE(%) (e) | 95 % Confidence Interval |
|---|---|---|---|---|---|---|
| Anti -spike IgG antibody | 2359 | 1513 | 4 | 2355 | 64.2 | 62.3 – 66.2 |
| Anti- Nucelocapsid IgG antibody | 2414 | 392 | 3 | 2411 | 16.3 | 14.8 -17.8 |
| Combined | 2274 | 1487 | 0 | 2274 | 65.4 | 63.4-67.4 |

*Figure 1: Seroprevalence % using Anti spike IgG antibody, Anti Nucleocapsid IgG antibody and combined positivity*

For the remaining analysis, only those who had results of both **IgG S (Anti spike antibody)** and **IgG N (anti nucleocapsid antibody)** were taken. So N (total) for the results below **is 2274**

Seroprevalence according to the district is given in the table 3.2. below. The highest seropositivity among antenatal women was recorded in Thrissur district, followed by Idukki and Kottayam districts

**Table 3.2. District wise seropositivity among antenatal women**

| District | Total<br><br>N=2274 | gG S | % | IgG N | % | IgG | % |
|---|---|---|---|---|---|---|---|
| Alappuzha | **153** | 95 | 62.1 | 22 | 14.4 | **99** | **64.7** |
| Ernakulam | **218** | 141 | 64.7 | 33 | 15.1 | **146** | **67.0** |
| Idukki | **95** | 67 | 70.5 | 14 | 14.7 | **69** | **72.6** |
| Kannur | **123** | 74 | 60.2 | 22 | 17.9 | **77** | **62.6** |
| Kasargod | **33** | 22 | 66.7 | 8 | 24.2 | **22** | **66.7** |
| Kollam | **216** | 124 | 197 | 31 | 14.4 | **124** | **57.4** |

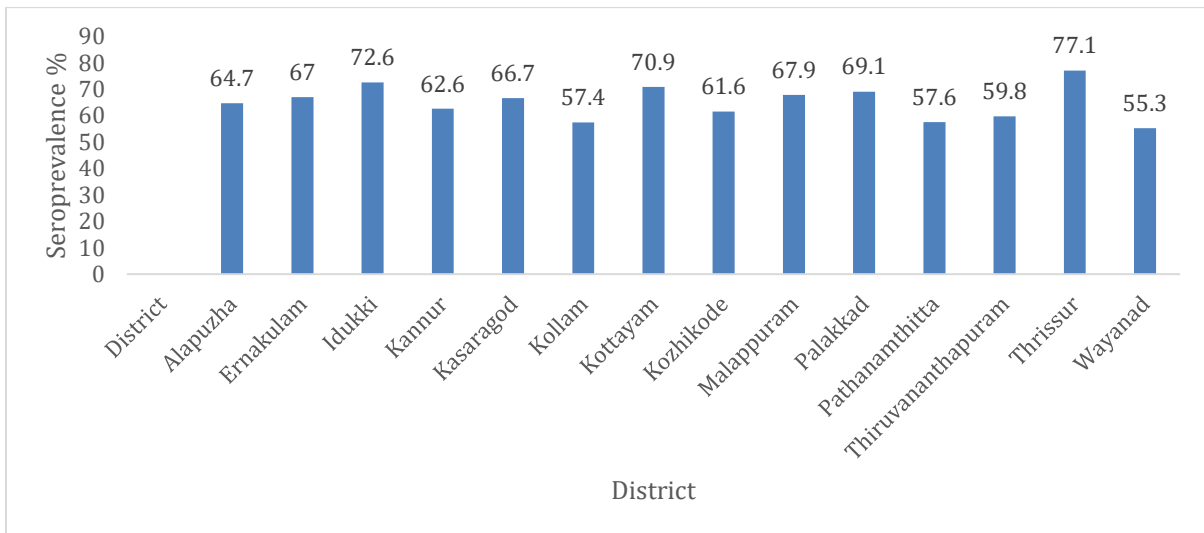| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Kottayam** | **134** | 93 | 69.4 | 23 | 17.2 | **95** | **70.9** |
| **Kozhikode** | **164** | 97 | 59.1 | 31 | 18.9 | **101** | **61.6** |
| **Malappuram** | **330** | 222 | 67.3 | 79 | 23.9 | **224** | **67.9** |
| **Palakkad** | **188** | 128 | 68.1 | 38 | 20.2 | **130** | **69.1** |
| **Pathanamthitta** | **85** | 49 | 57.6 | 10 | 11.8 | **49** | **57.6** |
| **hiruvananthapura m** | **296** | 172 | 58.1 | 33 | 11.8 | **177** | **59.8** |
| **Thrissur** | **192** | 147 | 76.6 | 28 | 14.6 | **148** | **77.1** |
| **Wayanad** | **47** | 26 | 55.3 | 4 | 8.5 | **26** | **55.3** |
| **Total** | **2274** | 1457 | 64.1 | 376 | 16.5 | **1487** | **65.4** |



*Figure 2: District wise distribution of seroprevalence among antenatal women*

There was no much difference in the seropositivity across the age groups, although in higher age group, the seropositivity was slightly higher (see table 3.3 below)

23

**Table 3.3 Age wise distribution of seropositivity**

| Age group | Total | IgG S | % | IgG N | % | IgG | % |
|-----------|-------|-------|------|-------|------|------|------|
| **18-29y** | 1660 | 1071 | 64.5 | 285 | 17.2 | **1094** | **65.9** |
| **30-44y** | 611 | 384 | 62.8 | 91 | 14.9 | **391** | **64.0** |
| **45-49y** | 3 | 2 | 66.7 | 0 | 0 | **2** | **66.7** |
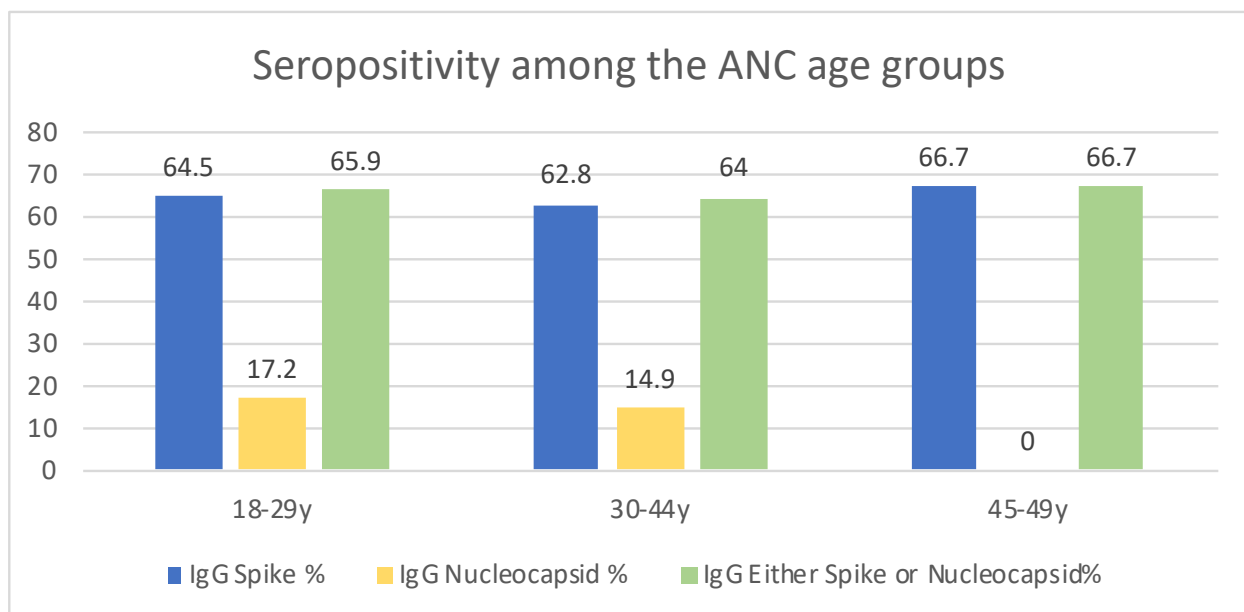


*Figure 3: Seroprevalence across the age groups*

The seropositivity among women from BPL families was higher than those from APL. However it was not a significant difference

Table 3.4. Seropositivity according to SES (Category APL/BPL)

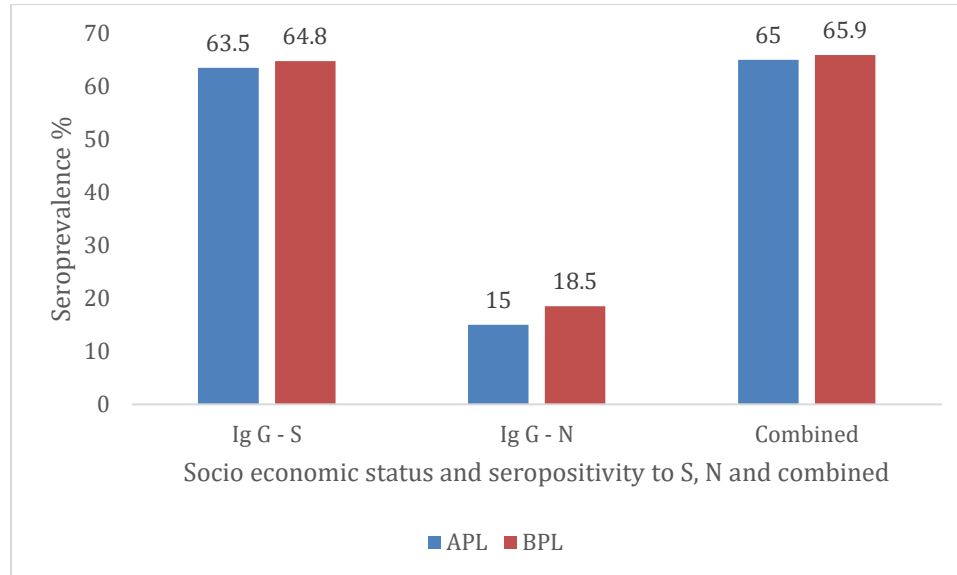| Category | Total | IgG S | % | IgG N | % | IgG | % |
|----------|-------|-------|------|-------|------|-----|------|
| **APL** | 1291 | 820 | 63.5 | 194 | 15.0 | **839** | **65.0** |
| **BPL** | 983 | 637 | 64.8 | 182 | 18.5 | **648** | **65.9** |



*Figure 4: Seropositivity according to APL/ BPL status*

Seropositivity among women from urban areas was higher than that of rural areas (see table 3.5)

Table3.5. Seropositivity according to Local body Type (Corporation, Municipality and Grama Panchayath)

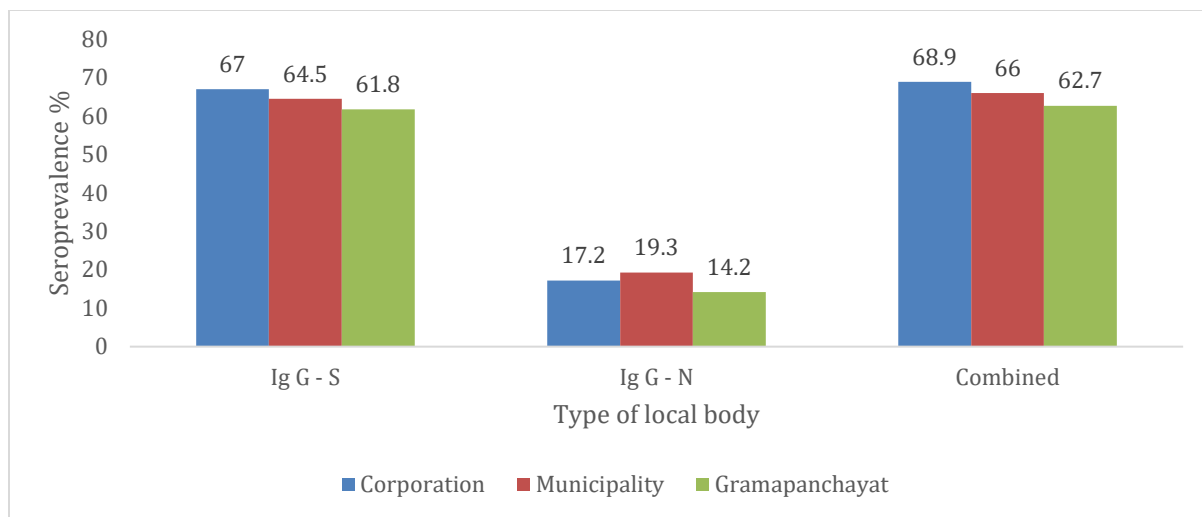| Category | Total | IgG S | % | IgG N | % | IgG | % |
|----------|-------|-------|------|-------|------|-----|------|
| **Corporation** | 645 | 432 | 67.0 | 111 | 17.2 | **444** | **68.9** |
| **Municipality** | 662 | 427 | 64.5 | 128 | 19.3 | **437** | **66.0** |
| **Grampanchayat** | 967 | 598 | 61.8 | 137 | 14.2 | **606** | **62.7** |

*Figure 5: Seropositivity according to Local body Type*

Seropositivity according to previous history of confirmed COVID positivity (COVID Positive) among the subjects is shown in table 3.6. 15.3 % of antenatal women gave a history of COVID positivity. Those women who gave a history of COVID positivity had very high seropositivity compared to those with no such history

**Table 3.6. Seropositivity according to previous history of confirmed COVID positivity (COVID Positive) among the subjects**

| COVID positive | Total | % COVID positive | IgG S | % | IgG N | % | IgG | % |
|---|---|---|---|---|---|---|---|---|
| **Yes** | 349 | **15.3** | 295 | 84.5 | 140 | 40.1 | **307** | **88.0** |
| **No** | 1925 | 84.7 | 1162 | 60.4 | 236 | 12.3 | **1180** | **61.3** |

26

## 3.2. Seroprevalence among antenatal women in Kerala, according to Vaccination status

58.8% of antenatal women were unimmunized against COVID. The seropositivity among unvaccinated antenatal was 49.8%. 41.2% of the antenatal women have taken at least one dose of vaccine. 8.8% of the antenatal women have taken two doses of COVID vaccine. The seropositivity among them is 86.4 %

**Table 3.7. Seropositivity among those who took one dose of vaccine**

| First dose vaccine taken | Total | % Vaccinated | IgG S | % | IgG N | % | IgG | % |
|---|---|---|---|---|---|---|---|---|
| Yes | 937 | **41.2** | 815 | 87.0 | 126 | 13.4 | **821** | **87.6** |
| No | 1337 | 58.8 | 542 | 48.0 | 250 | 18.7 | **666** | **49.8** |

**Table 3.8. Seropositivity among those who took two doses of vaccine**

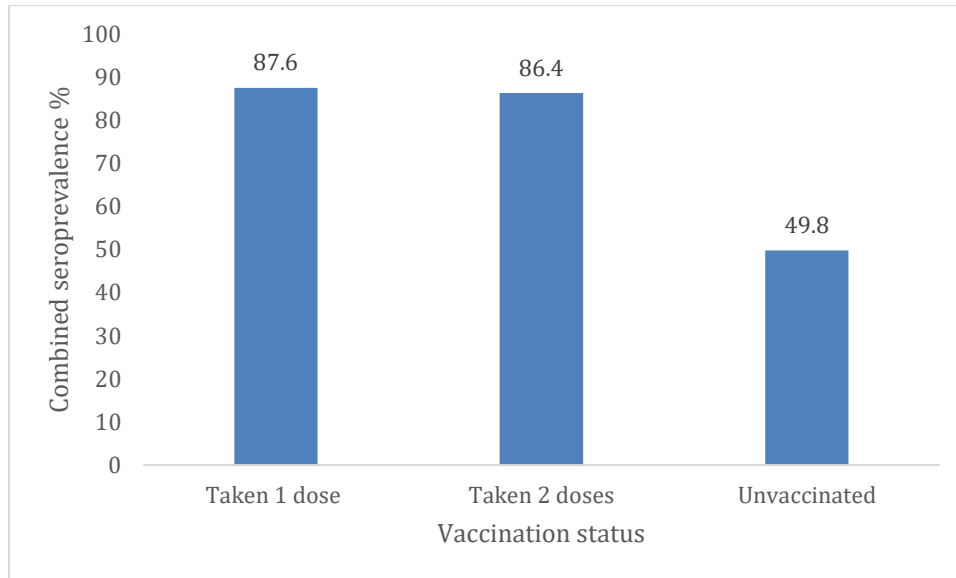| Second dose vaccine taken | Total | % Vaccinated | IgG S | % | IgG N | % | IgG | % |
|---|---|---|---|---|---|---|---|---|
| Yes | 199 | **8.8** | 169 | 84.9 | 35 | 17.6 | **172** | **86.4** |
| No | 2075 | 91.2 | 1288 | 11.6 | 341 | 16.4 | **1315** | **63.4** |

*Figure 6: Overall seroprevalence according to Vaccination status*

Those antenatal women with a history of contact with a COVID 19 positive case had higher seropositivity compared to those who had no such contact. Those who had household contacts had higher seropositivity (82.5%), compared with hospital (81.8 %) and Community contacts (76.9%).

**Table 3.9. Seropositivity among subjects with history of contact**

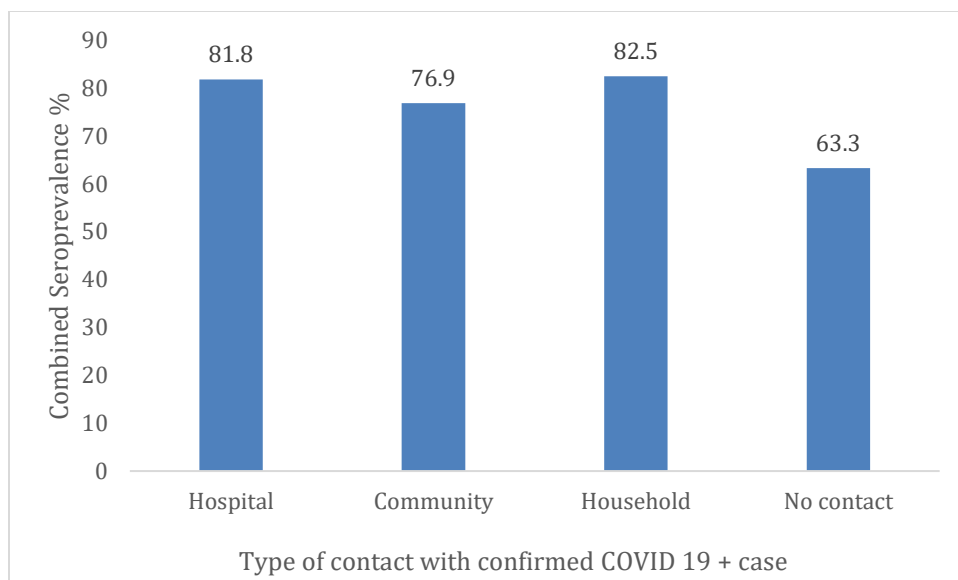| Contact history | Total N=2274 | % | IgG S | % | IgG N | % | IgG | % |
|---|---|---|---|---|---|---|---|---|
| None | 2015 | **88.6** | 1254 | 62.7 | 298 | 14.8 | **1275** | **63.3** |
| Community | 26 | 1.1 | 20 | 76.9 | 7 | 26.9 | **20** | **76.9** |
| Hospital | 33 | 1.5 | 26 | 78.8 | 10 | 30.3 | **27** | **81.8** |
| Household | 200 | 8.8 | 157 | 78.5 | 61 | 30.5 | **165** | **82.5** |

*Figure 7: Overall seropositivity and type of contact with confirmed COVID 19*

### 3.3. Determinants of Seroprevalence among antenatal women in Kerala

Mean age of the seropositive antenatal women was less than that of seronegative women (26.85 vs 27.00).However this difference was not statistically significant. A higher proportion of women belonging to BPL families was found among seropositives compared to seronegatives, but it was not statistically significant. Among the seropositives, a significantly higher proportion lived in urban areas, had previous history of COVID positivity and took vaccine.. The corresponding odds ratios are shown in the table below

Table 3.10. Bivariable analysis on determinants of seropositivity

| Variable | Category | Seropositive No (%) N=1487 | Seronegative No (%) N=787 | Chi square Value | p-value | OR |
|---|---|---|---|---|---|---|
| SES | BPL | 648 (43.8) | 335 (42.6) | 0.21 | 0.643 | 0.96(0.81-1.14) |
|  | APL | 839 (56.4) | 452(57.4) |  |  |  |
| Locality | **Urban** | 881(59.2) | 426 (54.1) | 5.51 | **0.019** | **1.23(1.03-1.47)** |
|  | Rural | 606 (40.9) | 361(45.9) |  |  |  |
| **COVID positive** | **Yes** | 307 (20.6) | 42(5.3) | 92.83 | **<0.001** | **4.62 (3.30-6.45)** |

29

| | | | | | | |
|---|---|---|---|---|---|---|
| | No | 1180 (79.4) | 745 (94.7) | | | |
| Taken at least one dose | Yes | 821 (55.2) | 116 (14.7) | 347.95 | **<0.001** | **7.13 (5.71-8.90)** |
| | No | 666 (44.8) | 671(85.3) | | | |
| Taken two dose of vaccine | Yes | 172 (11.6) | 27 (3.4) | 42.67 | **<0.001** | **3.68(2.43-5.58)** |
| | No | 1315 (88.4) | 760 (96.6) | | | |

After multivariable analysis the independent determinants of COVID seropositivity were being positive with COVID (Adjusted OR 6.25 ; 95%CI -4.41-8.84) and first dose of vaccine (adjusted OR -8.6 ; 6.7 to 11.03)

## 4. Discussion

A hospital based cross-sectional survey was done among antenatal women attending antenatal care clinics in selected Government and private hospitals in Kerala during the months of August – September 2021. The study included pregnant women in any trimester 18-49. The serum samples were tested to identify the SARS CoV-2 IgG S1 RBD antibodies and SARS CoV-2 IgG Nucleocapsid antibodies using Chemiluminescent immunoassay (CLIA) technology. The data of 2274 antenatal women with complete information was analysed.

The seroprevalence among antenatal women in Kerala was 65.4 % (95% CI; 63.4-67.4). It is not meaningful to compare the seroprevalence obtained from studies across different places in the world since the time points vary. Rather a longitudinal study in the same population will give an understanding of the progression of COVID 19 in the community. Cohort studies or repeated cross sectional surveys may be done. Since in the previous serosurveys in Kerala antenatal women were not included this comparison is difficult, but we could use the sentinel surveillance data from antenatal women to compare with the understanding of the limitation of the differences in the test used, to a certain extent. The prevalence obtained in this study cannot be extrapolated to other populations. In general pregnant women are not regarded to be at higher risk of contracting COVID

19. However, studies have shown an increased risk of developing severe COVID-19 if they are infected, compared with non-pregnant women of a similar age. [3] Seroprevalence estimated in Spain among antenatal women ranges from 6.8% to 14 % during the early phase of the pandemic [4] In the 4th round of serosurvey by ICMR, Kerala state reported 42.7 % in general population against the national estimate of 67.6 %. The survey was done in May 2021. The seroprevalence among antenatal women in the survey is higher than this, the survey having being done in September and vaccination among antenatal women having increased, this is expected.[5]

In this study both anti spike and antinucleocapsid antibodies were tested. After SAR COV 2 infection, the infected person develops immunity against receptor binding domain (RBD), S1, S2 domains of spike glycoprotein and Nucleocapsid N protein within 3 weeks of infection. Among the four antigens, spike glycoprotein is the only target for neutralising antibody. The prevalence of antibody to nucleocapsid in our study subjects was 16.3 %, much lower than that of IgG anti spike antibody (64.2 %). Antibody to nucleocapsid is more sensitive than Spike antibody for detecting early infection. In a study among positive healthcare and frontline workers from Bhubaneswar, India 40 % of study subjects did not show antibody to N at the end of 16 weeks, while they were still positive for antibody to spike protein. The early decline without total disappearance of antibody to N may also depend on other variables such as duration of measurement of antibody and infection, whether symptomatic or asymptomatic at infection, gender, age and the type of vaccine etc. [6] The threshold set for IgG levels for nucleocapsid may also influence the lower prevalence of antibody to nucleocapsid as those subjects may still have neutralising antibodies.[7]

15.3 % of antenatal women gave a history of COVID positivity. Those women who gave a history of COVID positivity showed a higher seropositivity compared to those with no such history. There are reports on higher antibody titres among antenatal woman with severe infections.[8] In a systematic review it was found that 95% (95% CI 45-100%) COVID infection in pregnancy was found to be asymptomatic and 59 percent (95% CI 49-68 percent) remained asymptomatic through follow-up . [9] So the seropositivity among unvaccinated antenatal was 49.8%, could be due to mainly asymptomatic infections. Among those who took at least one dose of vaccine, the seropositivity was above 80 % and in the study we had 41.2% immunized with at least one dose, the overall seroprevalence has come to 65 %

The vaccination was started in the state on 16 January 2021 with chimpanzee adenovirus-vectored vaccine, ChAdOx1 nCoV-19 COVISHIELD. The vaccination was administered to health care workers, frontline workers in the first stage and then extended to other high risk groups such as elderly, those with co morbidities and higher risk of mortality and morbidity. The killed vaccine COVAXIN was also introduced in our state on a later stage. The vaccination was not administered to pregnant mothers in the initial phase. But the evidence indicated that pregnant women are at an increased risk of severe illness from COVID-19 compared to non-pregnant women in case they get infected. Thus WHO recommended vaccination in pregnant women. Based on the recommendations of NTAGI and NEGVAC, the Government of India, Ministry of health and family welfare approved the vaccination against COVID 19 among pregnant women.[10] 58.8% of antenatal women were unimmunised against COVID in our sample. 41.2% of the antenatal women have taken at least one dose of vaccine. 8.8% of the antenatal women have taken two doses of COVID vaccine.  Low coverage among pregnant women might be attributable to various factors including limited available safety data on COVID-19 vaccines during pregnancy; need for increased vaccine confidence among health care providers and pregnant women; vaccine prioritization, access, and availability; and cultural and language barriers.[11]

The independent determinants of COVID seropositivity were being positive with COVID (Adjusted OR 6.25 ; 95%CI -4.41-8.84) and first dose of vaccine  (adjusted OR -8.6 ; 6.7 to 11.03)

The seroprevalence among antenatal women is higher than that obtained among children, but lesser than that of the general community in Kerala, probably because vaccination was started later in antenatal women. Unvaccinated antenatal women have a lower seroprevalence (49.8%) compared to the unvaccinated among general community (above 70%). This could be because these women were more protected from exposures and since they were pregnant they adhered to COVID appropriate behavior more.

One **limitation** of the study was that it being cross sectional, the change in seroprevalence over time could not be calculated. As reports in other parts of the country the figures can change depending on the coverage of vaccination, effect of lock down and easing of restrictions and waning of immune response.

### 5. Conclusions and Recommendations

It is seen that the first dose of COVID vaccine is a significant determinant of seropositivity. So emphasizing on taking the first dose of vaccine at the earliest in pregnancy may be useful in protecting antenatal women from COVID. The priority has to be to cover maximum antenatal women with first dose of COVID vaccine.

Since more than 50 % of antenatal women are yet to take even the first dose of COVID vaccine and only 8.8% have taken the second dose of vaccine, there should be a massive campaign to vaccinate them at the earliest

Although the low vaccination coverage may be attributable to the delayed initiation of vaccination program in this age group, it will be useful to identify the factors determining low COVID 19 coverage specially focusing on concerns of safety among this group, so that education messages can be designed targeting them

Since the unvaccinated antenatal women have a seropositivity of 49.8%, we may conclude that half of antenatal women at least would have been infected with COVID 19.  A cohort study among pregnant women with COVID 19 will enable an understanding of the effect of COVID on maternal and foetal outcomes

A sentinel surveillance program for COVID 19 among antenatal women will enable the monitoring of trends of infection in a more meaningful way.  A surveillance of febrile illness in them could be a broader frame to understand and act upon other infectious diseases' with collateral benefits. The testing can be made as a part of routine antenatal investigations as done in UK without additional visits

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# CHAPTER- 4
## SERO-PREVALENCE OF SARS CoV-2 IgG ANTIBODY AMONG CHILDREN AGED 5 TO 17 YEARS IN KERALA

### 1. Introduction

COVID-19 data from across the globe suggests that the proportion of children affected are less. Moreover, they show clinical symptoms less often than adults. Symptoms, if present will be milder and often recover faster. Hence most of them do not get tested and thereby infections among children are not adequately captured in our routine testing data. Estimation of infection rate among children thus becomes an important epidemiological exercise, especially in the context of relaxation in COVID-19 restrictions. Therefore, estimation of seroprevalence among children was made part of the comprehensive state wide study.

### 2. Objective

To estimate the seroprevalence of SARS CoV-2 IgG antibodies among the children aged 5 to 17 yrs in Kerala

### 3. Methodology

A community based cross sectional survey was done among children of Kerala during September 2021.

Included subjects:

Children aged 5 to 17 years from selected households in Kerala

Excluded subjects:

1. Those children not willing to give oral consent or written assent or parents not willing to informed parental consent for the study.
2. Presently active COVID cases in home treatment
3. Children on quarantine
4. Children who have arrived in Kerala within the last 4 weeks
5. Contraindication to venepuncture: a. Cellulitis or abscesses in the area b. Venous fibrosis on palpation c. Presence of hematoma d. Presence of vascular shunt or graft e. Presence of vascular access devices

Sample Size, Sampling technique and Procedure:

Children are assumed to have lower seroprevalence compared to adult, but at least 20%. The sample size formula for estimation of proportions in population is used.

[(z alpha/2) x p x q ] / d2

Where Z alpha= 3.84, p= 20%, q=80% and d =3%

= 3.84 x20 x 80 / (3)2

= 683

A design effect of 2 is applied to adjust for clustering

= 683X2

= 1366

A sample wastage factor of 5 % (1366 x 0.05) is applied to reach the final sample size as follows:

= 1366+68

= 1434

The children were sampled according to the following age categories from each rural or urban institution.

Table A. Age category wise distribution of samples

| Age group | No of Children | |
|---|---|---|
| | Male | Female |
| 5 yrs - 8 yrs | 1 | 1 |
| 9 yrs - 11 yrs | 1 | 1 |
| 12 yrs -14 yrs | 1 | 1 |
| 15 yrs- 17 yrs | 1 | 1 |
| **Total in each gender** | **4** | **4** |
| **TOTAL** | **8** | |

Table B.

| District | No.of Panchayaths (rural health institutions) to be sampled from Rural areas (a) | No of samples from Rural areas (b=8 x a) | No.of samples from (Urban health institutions) from Urban areas (c) | No of samples from Urban areas (d= 8xc) | Total Number of Samples from children (e= b+d) |
|---|---|---|---|---|---|
| Thiruvananthapuram | 9 | 72 | 10 | 80 | 152 |
| Kollam | 8 | 64 | 7 | 56 | 120 |
| Pathanamthitta | 6 | 48 | 1 | 8 | 56 |
| Alappuzha | 5 | 40 | 6 | 48 | 88 |
| Kottayam | 8 | 64 | 3 | 24 | 88 |
| Idukki | 6 | 48 | 1 | 8 | 56 |
| Ernakulam | 6 | 48 | 13 | 104 | 152 |
| Thrissur | 6 | 48 | 12 | 96 | 144 |
| Palakkad | 12 | 96 | 4 | 32 | 128 |
| Malappuram | 13 | 104 | 10 | 80 | 184 |
| Kozhikode | 6 | 48 | 12 | 96 | 144 |
| Wayanad | 4 | 32 | 1 | 8 | 40 |
| Kannur | 5 | 40 | 9 | 72 | 112 |

| Kasaragod | 4 | 32 | 3 | 24 | 56 |
|-----------|---|-----|---|-----|------|
| **Total** | | **784** | | **736** | **1520** |

Operationally the sample collection approximates 1520 samples.

1. The distribution of the number of samples to be selected from each health institution (urban and rural) is given in the table 7 above. The DSO selected the health institutions from the list of corresponding master list of all health institutions and selected using simple random methods. A ward was selected randomly using simple random methods. The Medical officer in charge of the health institution took a map of the selected ward and place it on a table rotate a pen/pencil (proportionate to size of map) on the map. When the pen/pencil comes to rest the road/street/neighbourhood closest to the tip of the pen was selected for the survey.

2. A house to house visit of the selected area was made to select the children according to the **age and gender category** and sample required **(refer table A),** till the target was achieved. If the number of children were found to be inadequate for the sample then the next contiguous street/road/neighbourhood area was selected in the same ward.

3. Only one child was selected to any category from a household

4. For children aged 5 to 11 years participating in the survey, **verbal assent was obtained** in the presence of parent /Legally acceptable/authorized representative (LAR) followed by Informed parental consent by the parent /LAR**. (Annexure 4A/B, Part-2)**

5. For children between 12 and 17 years of age, **written assent was obtained** and **informed parental consent (parent /LAR)- (Annexure 4A/ B part-2 & 3).**

## Type of Test

The serum samples were tested to identify the following antibodies using Chemiluminescent immunoassay (**CLIA**) technology:

1. SARS CoV-2 IgG S1 RBD antibodies

2. SARS CoV-2 IgG Nucleocapsid antibodies

The tests were performed using Siemens and Abbott assays respectively.

## Data analysis:

The seroprevalence of SARS CoV-2 IgG antibodies was expressed in proportions for both types of antibodies as well as for either test positive. Age, gender, district and urban/rural strata specific seropositivity was estimated. Basic demographic and clinical details were described in proportions. Univariable analysis for determinants of positivity was done using Chi square and multivariable analysis done using binary logistic regression. P value less than 0.05 was considered significant.

### 4. Results

A total of 1471 and 1496 samples were collected for Anti S1RBD and Nucleocapsid antibody testing respectively. Among the samples for nucleocapsid antibody, five were rejected. Descriptive analysis was done separately for each antibody as well as for combined either test

positivity. As data from children is a unique opportunity to study the difference in proportion of both types of antibodies due to natural infection as they are unvaccinated. Final seroprevalence estimate was made based on positivity for any one of the antibodies. Determinants of positivity was analyzed based on the same.

**Section 1: Descriptive Analysis**
**Seroprevalence**

**Table 1. Seroprevalence according to test types**

| Test | Anti S1 RBD | Antinucleocapsid | Either test |
|---|---|---|---|
| Total samples | 1471 | 1496 | 1459 |
| Samples rejected | 0 | 5 | 0 |
| Samples analysed | 1471 | 1491 | 1459 |
| Samples tested positive | 583 | 269 | 586 |
| Seroprevalence | **39.6%** | **18%** | **40.2%** |

Sero-prevalence of SARS CoV-2 IgG antibodies among children aged 5 to 17 years in Kerala during September 2021 was 40.2% with 95% confidence interval of 40.11- 40.39 with a standard error of 0.0007 and design effect of 1.45. Seroprevalence of Anti S1 RBD was 39.6% and nucleocapsid antibody was separately estimated as 39.6% and 18% respectively.

**Table 2. District wise seropositivity**

| District | Anti S1 RBD | | | Anti-nucleocapsid | | | Either test | | |
|---|---|---|---|---|---|---|---|---|---|
| | T | P | S (%) | T | P | S (%) | T | P | S (%) |
| **Alappuzha** | 80 | 44 | 55 | 80 | 19 | 23.8 | 80 | 44 | 55 |
| **Ernakulam** | 153 | 51 | 33.3 | 152 | 20 | 13.2 | 152 | 51 | 33.6 |
| **Idukki** | 56 | 12 | 21.4 | 55 | 6 | 10.9 | 56 | 12 | 21.4 |
| **Kannur** | 86 | 30 | 34.9 | 112 | 17 | 15.2 | 86 | 31 | 36 |
| **Kasaragod** | 52 | 33 | 63.5 | 50 | 14 | 28.0 | 49 | 31 | 63.3 |
| **Kollam** | 109 | 45 | 41.3 | 109 | 24 | 22 | 109 | 45 | 41.3 |
| **Kottayam** | 91 | 35 | 38.5 | 91 | 17 | 18.7 | 91 | 36 | 39.6 |
| **Kozhikode** | 157 | 60 | 38.2 | 154 | 25 | 16.2 | 154 | 60 | 39.0 |
| **Malappuram** | 174 | 88 | 50.6 | 174 | 43 | 24.7 | 173 | 88 | 50.9 |
| **Palakkad** | 125 | 49 | 39.2 | 127 | 28 | 22 | 125 | 52 | 41.6 |
| **Pathanamthitta** | 55 | 14 | 25.5 | 55 | 7 | 12.7 | 55 | 14 | 25.5 |
| **Thiruvananthapuram** | 151 | 62 | 41.1 | 149 | 23 | 15.4 | 149 | 63 | 42.3 |
| **Thrissur** | 143 | 56 | 39.2 | 144 | 25 | 17.4 | 142 | 56 | 39.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Wayanad** | 39 | 4 | 10.3 | 39 | 1 | 2.6 | 38 | 3 | 7.9 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Seroprevalence among children was highest in Kasargod district (63.3%). Other two districts with prevalence above 50 % were Alappuzha (55%) and Malappuram (50.9%). Lowest prevalence was recorded in Wayanad district (7.9%) followed by Idukki (21.4%) and Pathanamthitta (25.5%).

**Table 3. Age wise distribution of seropositivity**

| Age | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|---|---|---|---|---|---|---|---|---|---|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **5** | 53 | 21 | 39.6 | 55 | 12 | 21.8 | 53 | 21 | 39.6 |
| **6** | 77 | 28 | 36.4 | 75 | 11 | 14.7 | 76 | 28 | 36.8 |
| **7** | 94 | 45 | 47.9 | 96 | 24 | 25 | 94 | 45 | 47.9 |
| **8** | 97 | 41 | 42.3 | 99 | 18 | 18.2 | 97 | 41 | 42.3 |
| **9** | 108 | 44 | 40.7 | 112 | 23 | 20.5 | 106 | 44 | 41.5 |
| **10** | 113 | 46 | 40.7 | 114 | 23 | 20.2 | 113 | 45 | 39.8 |
| **11** | 130 | 49 | 37.7 | 131 | 18 | 13.7 | 130 | 49 | 37.7 |
| **12** | 114 | 52 | 45.6 | 119 | 26 | 21.8 | 114 | 54 | 47.4 |
| **13** | 150 | 57 | 38 | 150 | 32 | 21.3 | 148 | 57 | 38.5 |
| **14** | 124 | 50 | 40.3 | 123 | 18 | 14.6 | 121 | 50 | 41.3 |
| **15** | 162 | 67 | 41.4 | 167 | 31 | 18.6 | 161 | 69 | 42.9 |
| **16** | 137 | 42 | 30.7 | 138 | 17 | 12.3 | 136 | 42 | 30.9 |
| **17** | 112 | 41 | 36.6 | 112 | 16 | 14.3 | 110 | 41 | 34.3 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

**Table 4. Age group wise distribution of seropositivity**

| Age in years | Total | Positive | Seroprevalence# (%) |
|---|---|---|---|
| **5-8** | **320** | **135** | **42.1** |
| **9-11** | **349** | **138** | **39.5** |
| **12-14** | **383** | **161** | **42.0** |
| **15-17** | **407** | **152** | **37.3** |
| **Total** | **1459** | **586** | **40.2** |

#positive for either of the tests

Lowest age group of 5-8 years as well as 12-14 age group had higher prevalence of 42%.

**Table 5. Gender wise distribution of Seropositivity**

| Gender | Anti S1 antibody | | | Nucleocapsid antibody | | | Either | | |
|--------|------|-----|-------|------|-----|-------|------|-----|-------|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Boys** | 715 | 280 | 39.2 | 731 | 131 | 17.9 | 703 | 257 | 36.6 |
| **Girls** | 756 | 303 | 40.1 | 760 | 138 | 18.2 | 756 | 329 | 43.5 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Girls had slightly higher seropositivity (43.5%) compared to boys (36.6%).

**Table 6. Seropositivity according to Socioeconomic status**

| Socioeconomic status | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|--------|------|-----|-------|------|-----|-------|------|-----|-------|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **APL** | 708 | 256 | 36.2 | 727 | 113 | 15.5 | 703 | 257 | 36.6 |
| **BPL** | 763 | 327 | 42.9 | 764 | 156 | 20.4 | 756 | 329 | 43.5 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Children belonging to BPL families had higher (43.5%) seropositivity.

**Table 7. Seropositivity according to Local body**

| Type of Local body | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|--------|------|-----|-------|------|-----|-------|------|-----|-------|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Corporation** | 178 | 82 | 46.1 | 177 | 34 | 19.2 | 176 | 81 | 46.0 |
| **Grama panchayat** | 858 | 311 | 36.2 | 853 | 147 | 17.2 | 849 | 312 | 36.7 |
| **Municipality** | 435 | 190 | 43.7 | 461 | 88 | 19.1 | 434 | 193 | 44.5 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Seropositivity was high among children residing in urban area (46%) compared to rural areas (36.7%).

**Table 8. Seropositivity according to previous history of confirmed COVID-19 positivity**

| H/O COVID-19 test positivity | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|--------|------|-----|-------|------|-----|-------|------|-----|-------|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Yes** | 51 | 48 | 94.1 | 55 | 32 | 58.2 | 51 | 48 | 94.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **No** | 1420 | 535 | 37.7 | 1436 | 237 | 16.5 | 1408 | 538 | 38.2 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Among children who had confirmed COVID-19 infection, seropositivity was as high as 94.1%.

**Table 9**

**Seropositivity according to history of symptoms**

| H/O COVID-19 symptoms | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|---|---|---|---|---|---|---|---|---|---|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Yes** | 51 | 48 | 94.1 | 55 | 32 | 58.2 | 51 | 48 | 94.1 |
| **No** | 1420 | 535 | 37.7 | 1436 | 237 | 16.5 | 1408 | 538 | 38.2 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

**Table 10**

**Seropositivity among subjects with history of contact**

| H/O contact | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|---|---|---|---|---|---|---|---|---|---|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Yes** | 93 | 59 | 63.4 | 100 | 36 | 36 | 93 | 60 | 64.5 |
| **No** | 1378 | 524 | 38.0 | 1391 | 233 | 16.8 | 1366 | 526 | 38.5 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

Those children who had a history of contact with COVID-19 patients, seroprevalence was 64.5%.

**Table 11**

**Seropositivity among subjects according to type of contact**

| Type of Contact | Anti S1 antibody | | | Nucleocapsid antibody | | | Either test | | |
|---|---|---|---|---|---|---|---|---|---|
| | T | P | S (%) | T | P | S (%) | T | p | S (%) |
| **Household** | 86 | 55 | 64 | 92 | 36 | 39.1 | 86 | 56 | 65.1 |
| **Community** | 7 | 4 | 57.1 | 8 | 0 | 0 | 7 | 4 | 57.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **No contact** | 1378 | 524 | 38 | 1391 | 233 | 16.8 | 1366 | 526 | 38.5 |
| **Total** | 1471 | 583 | 39.6 | 1491 | 269 | 18 | 1459 | 586 | 40.2 |

T-Total samples, P-Positive for antibody, S- seroprevalence

## Section B: Factors Associated with COVID-19 Seroprevalence among Children

Seroconversion either in terms of Spike S1 RBD or nucleocapsid is considered as the outcome variable for this analysis

Table 12. Difference in District specific seropositivity

| District | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| Alappuzha | 80 | 44 | 55 | **<0.001** |
| Ernakulam | 152 | 51 | 33.6 | |
| Idukki | 56 | 12 | 21.4 | |
| Kannur | 86 | 31 | 36 | |
| Kasargod | 49 | 31 | 63.3 | |
| Kollam | 109 | 45 | 41.3 | |
| Kottayam | 91 | 36 | 39.6 | |
| Kozhikode | 154 | 60 | 39.0 | |
| Malappuram | 173 | 88 | 50.9 | |
| Palakkad | 125 | 52 | 41.6 | |
| Pathanamthitta | 55 | 14 | 25.5 | |
| Thiruvananthapurm | 149 | 63 | 42.3 | |
| Thrissur | 142 | 56 | 39.4 | |
| Wayanad | 38 | 3 | 7.9 | |

*chi-square test

## Table 13. Differences in age wise distribution of seropositivity

| Age | Total | Positive | Seroprevalence (%) | P value** |
|---|---|---|---|---|
| 5 | 53 | 21 | 39.6 | **0.216** |
| 6 | 76 | 28 | 36.8 | |
| 7 | 94 | 45 | 47.9 | |
| 8 | 97 | 41 | 42.3 | |
| 9 | 106 | 44 | 41.5 | |
| 10 | 113 | 45 | 39.8 | |
| 11 | 130 | 49 | 37.7 | |
| 12 | 114 | 54 | 47.4 | |
| 13 | 148 | 57 | 38.5 | |
| 14 | 121 | 50 | 41.3 | |
| 15 | 161 | 69 | 42.9 | |

| | | | | |
|---|---|---|---|---|
| **16** | 136 | 42 | 30.9 | |
| **17** | 110 | 41 | 34.3 | |

**chi-square for trend
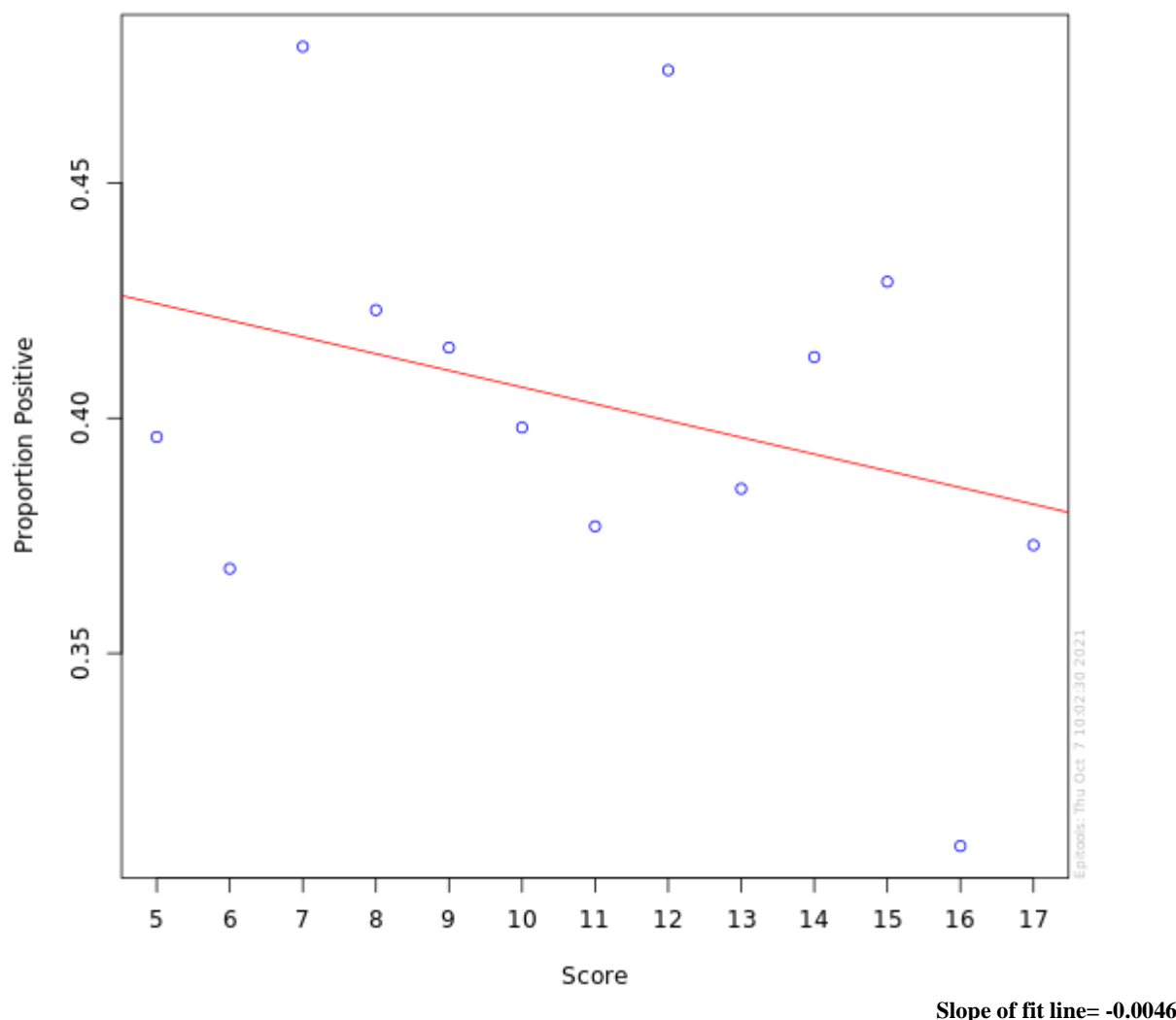


**Slope of fit line= -0.0046**

Figure 1. Trend of sero-prevalence with increasing age.

Table 14. Difference in Gender wise distribution of Seropositivity

| Gender | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| **Boys** | 703 | 257 | 36.6 | **0.735** |
| **Girls** | 756 | 329 | 43.5 | |

* Chi-square test

Point estimation of seroprevalence was more among girls, but the relationship was not significant statistically.

Table 15. Difference in Seropositivity according to Socioeconomic status

| Socioeconomic Status | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| **APL** | 703 | 257 | 36.6 | **0.007** |
| **BPL** | 756 | 329 | 43.5 | |

* Chi-square test

Seroprevalence for SARS CoV 2 antibodies were found significantly low among children belonging to above poverty line families (APL)

Table 16. Difference in Seropositivity according to Local body

| Type of Local body | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| **Corporation** | 176 | 81 | 46.0 | **0.007** |
| **Grama panchayat** | 849 | 312 | 36.7 | |
| **Municipality** | 434 | 193 | 44.5 | |

* Chi-square test

Seroprevalence among children appears to be more in urban areas compared to rural areas

Table 17. Difference in Seropositivity according to previous history of confirmed COVID-19 positivity

| History of confirmed COVID-19 positivity | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| **Yes** | 51 | 48 | 94.1 | **<0.001** |
| **No** | 1408 | 538 | 38.2 | |

* Chi-square test

Almost all children (94.1%) reported to have a history of COVID-19 infection still harbor antibodies, where the seroprevalence among children without a known infection was onlt 38.2%

Table 18. Difference in Seropositivity according to history of symptoms

| History of symptoms | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| **Yes** | 51 | 48 | 94.1 | **<0.001** |
| **No** | 1408 | 538 | 38.2 | |

* Chi-square test

Table 19. Difference in Seropositivity among subjects with history of contact

| History of contacts | Total | Positive | Sero prevalence (%) | P value* |
|---|---|---|---|---|
| **Yes** | 93 | 60 | 64.5 | **<0.001** |

| | | | | |
|---|---|---|---|---|
| **No** | 1366 | 526 | 38.5 | |

\* Chi-square test

Around 2/3<sup>rd</sup> of children with a contact with an infected person at their house or community stay seroconverted. Seroprevalence among children without a contact was 38.5%

Table 20. Difference in Seropositivity among subjects according to type of contact

| Type of contact | Total | Positive | Sero prevalence (%) | P value\* |
|---|---|---|---|---|
| **Household** | 86 | 56 | 65.1 | **<0.001** |
| **Community** | 7 | 4 | 57.1 | |
| **No contact** | 1366 | 526 | 38.5 | |

\* Chi-square test

Among the type of contact, the household contact was found to be very risky for children get infected as evidenced by high rate of seroconversion in that group compared to the rest.

**Section 3: Multivariable Analysis**

Table 21. Results of Multiple Logistic (Binary) Regression

| Variable | Adjusted Odds ratio | 95% CI of AOR | P value |
|---|---|---|---|
| Contact with a COVID-19 positive patient | 2.05 | 1.28- 3.27 | 0.003 |
| Confirmed COVID-19 positivity | 20.39 | 6.27- 66.31 | <0.001 |
| Municipality compared to Panchayat | 1.13 | 0.79-1.62 | 0.512 |
| Corporation compared to Panchayat | 1.50 | 1.07-2.09 | 0.018 |
| APL Category of Socio-economic Status | 0.759 | 0.611- 0.943 | 0.013 |

On multivariable analysis, history of contact, history of COVID-19 infection, urban residence, and low socioeconomic status are determinants of COVID-19 seropositivity in children.

**5. Discussion**

Seropositivity against SARS Co V 2 among children is a very important data in many dimensions. It indicates the stick-on and perseverance of COVID appropriate behaviors of the community as observing the proper protocols is the only option to keep children away from infection, as there is no vaccination for them.[1] It is again an indicator that how the community could protect their children from getting infected. Children are often the priority group of the society even if they are less vulnerable epidemiologically in case of COVID-19 and its complications.[2] Third aspect is that children are the only group where we can conclusively say that the seroconversion is because of natural infection as they are not vaccinated. In that sense, the seropositivity among children is the measure of natural infection swept in a community. Presence of antibody (either Anti S1 RBD or Anti Nucleocapsid) more than optimum level was found in 40.2%, which is around 15 percentage points less than the national average of the same measured three to four months before by the ICMR nationwide study.[3,4] Or in other words

infections among children still lags and the natural infections in Kerala was much less compared to the national averages. The low levels of seropositivity among children is a surrogate of flattening of the curve of natural COVID-19 infection of the State and an indicator of the State's fight against the rapidly spreading infection. At the same time the finding indicates the chances of clustering of infections among children need to be monitored in all settings.[5]

Seroconversion is largely contributed by Anti-Spike antibodies compared to that of Anti-Nucleocapsid antibodies. It is interesting to note that the positivity for anti-nucleocapsid was present in only less than half of samples positive for anti-spike antibody. There could be multiple explanation for that. Spike protein of SARS Co V 2 is known for antibody response following its exposure.[6] Nucleocapsid protein of the virus may not be causing such an immunological reaction as the spike protein do. The differences in sensitivity and specificity may be another attributing factor for the differences in rates. High sensitivity, low specificity or its combination can result in high positivity and the performance of the diagnostic test in opposite direction can swing the rates to the opposite side. There is another argument that the seroconversion following exposure to nucleocapsid protein is short-lived and the duration of seroconversion with spike protein is more. Data from elsewhere also showing the same patten of high anti-spike positivity and low anti-nucleocapsid positivity.[7] However, the presence of anti-spike antibody is considered as protective, and it may be a reason for developing most of the vaccine against COVID-19 targeting spike protein of the virus. Anti-nucleocapsid antibody is often not considered as a good marker.[8]

District wise distribution seroprevalence among children ranged between 7.9% in Wayanad and 63.3% in Kasaragod. Very low rate of Wayanad may be because of the low sample size. The sample size for the present analysis may not be enough for inter-district comparison also. However, three districts (Kasaragod, Alappuzha, and Malappuram) recorded seropositivity more than half of the samples tested. The district specific seroprevalence reported in children is not well correlated to the population adjusted incidence of reported COVID-19 cases of the district.[9] Districts with high density of reported cases like Ernakulam has reported comparatively low seroprevalence among children.

Seropositivity among children was not found to be statistically associated to age or gender. The scattered plot drawing the relationship between age and seropositivity showed a minimal downward trend indicating mild reduction in seropositivity with age. But the relationship was not statistically significant. Seropositivity for both the antibodies were more among girls, but that also was not significant statistically.

In contrast to what is noted in general population, children belonging to low socio-economic status recorded significantly higher seropositivity than children from 'above poverty line' (APL) families. As the seroconversion among children are considered solely from natural infection, this pattern may be a surrogate for high natural infections happened among economically vulnerable group. This pattern may not be observed with adults, may be because of comparatively high vaccination among people belonging to APL families might have helped them to bridge the gap. It is well-known that COVID-19 is non-neutral to socio-economical vulnerabilities, and it often spread more rapidly and more severely among people with socio-economic deprivation.[10-13] We have also noticed rampant spread of COVID-19 in coastal areas and urban slums. The current survey has also documented high seroprevalence in such geo-

spatial areas. Similarly, children residing in urban areas reported significantly higher proportion of seropositivity as expected. High population density, population mobility and occupational risk of adults in the household, etc may be making urban children more vulnerable for COVID-19 infection.[13-15]

A high seropositivity (94.1%) was observed among children reported to had previous COVID-19 infection. Seroconversion was not recorded in a small proportion (5.9%), may be because of waning of antibodies or inadequate antibody response. High seropositivity was noted among children with a history of contact with COVID-19 patient(s), especially at their homes.

Multivariable analysis showed that seroconversion among children were more among those already tested positive for COVID-19 infection, those with a contact with a COVID-19 patient, those belonging to urban areas and those in BPL category. That of rural areas, of families of high socio-economic status, neither tested positive nor in contact with another COVID-19 patient may be having low chances of seroconverted yet.

## 6. References

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# CHAPTER 5

## SEROPREVALENCEOF SARS CoV-2 IgG ANTIBODY AMONG TRIBAL POPULATION IN KERALA

### 1. INTRODUCTION

The objective of the survey was to estimate the seroprevalence of SARS CoV-2 IgG antibodies among the tribal population aged ≥18 yrs. The design applied was a community based correctional survey using a multistage cluster sampling method. The expected seropositivity for the adult segments of tribal populations in this survey was hypothesized to be at least one third- 33% with a precision of 4%, design effect of 3 and a significance level of 95%. The effective sample size was estimated to be 1670 and operationally at 1710. Tribal communities/hamlets in rural parts of the respective districts identified and sampled. Kish grid methodology was adopted to select one individual from a household. The districtwide distribution of the samples based on the 2011 census population of tribals are given in the table A below. Seroprevalence was estimated based on an individual's positivity if any of the 2 types of antibody was positive similar to the study done by the Indian Council of Medical Research (ICMR) in the 4th round of their survey.

Table A. District wise distribution of tribal samples.

| District | Samples from Tribal communities/hamlets in rural areas |
|---|---|
| Thiruvananthapuram | 80 |
| Kollam | 30 |
| Pathanamthitta | 30 |
| Alappuzha | 20 |
| Kottayam | 80 |
| Idukki | 220 |
| Ernakulam | 40 |
| Thrissur | 30 |
| Palakkad | 180 |
| Malappuram | 70 |
| Kozhikode | 40 |
| Wayanad | 570 |
| Kannur | 140 |
| Kasaragod | 180 |
| **TOTAL** | **1710** |

The protocol with the methodology is given in the government order G.O (Rt) No. 1803/2021/H&FWD Dated, 25.08.2021, Thiruvananthapuram.

## 2. RESULTS

A total of 1521 samples were analyzed for estimating the seroprevalence among the tribal population aged ≥18 yrs.

Table1.Seroprevalence among Tribal population

| Status | Number | Seroprevalence(%) |
|--------|--------|-------------------|
| Positive | 1189 | 78.2% |
| Negative | 332 | 21.8% |
| **Total** | **1521** | **100.0%** |



Seroprevalence among tribal population(n=1521)

332, 21.8%

1189, 78.2%

■ Sero Positive   ■ Sero Negative
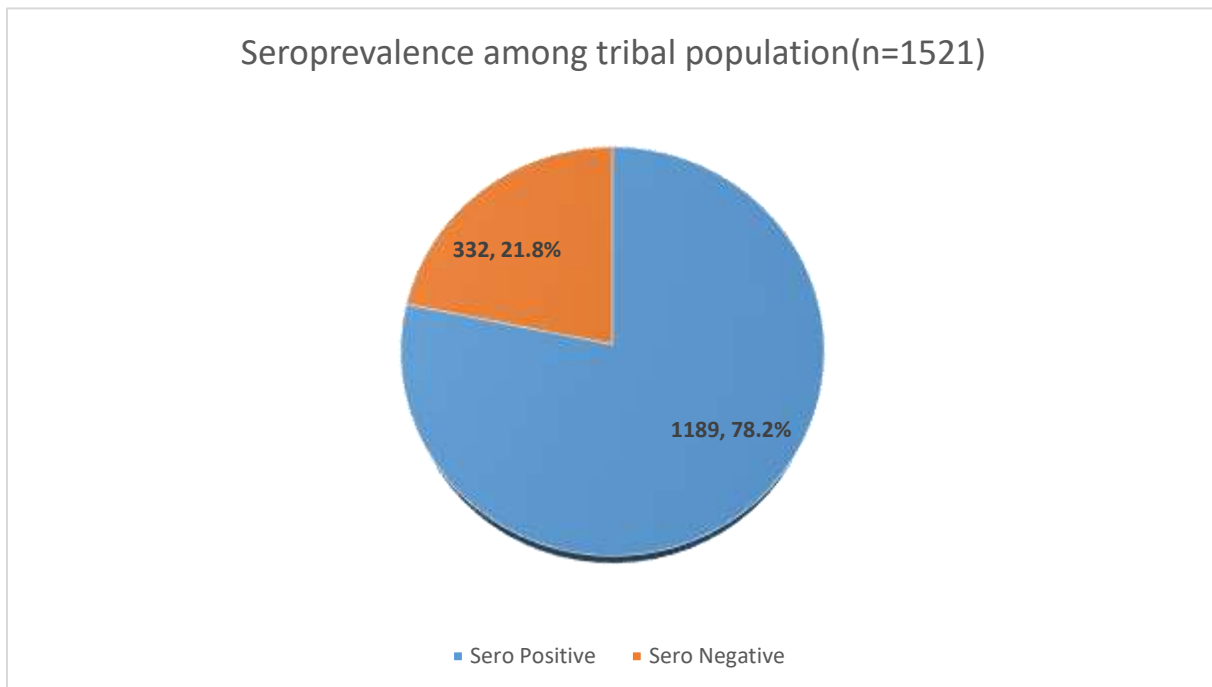
Table.2.District wise seroprevalence

| DISTRICT | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Alappuzha | 20 | 13 | 65.0 |
| Ernakulam | 39 | 30 | 76.9 |
| Idukki | 195 | 143 | 73.3 |
| Kannur | 117 | 81 | 69.2 |
| Kasaragod | 144 | 116 | 80.6 |
| Kollam | 28 | 27 | 96.4 |
| Kottayam | 72 | 67 | 93.1 |
| Kozhikode | 58 | 41 | 70.7 |
| Malappuram | 72 | 64 | 88.9 |
| Palakkad | 175 | 127 | 72.6 |
| Pathanamthitta | 30 | 21 | 70.0 |
| Thiruvananthapuram | 81 | 68 | 84.0 |
| Thrissur | 30 | 24 | 80.0 |
| Wayanad | 460 | 367 | 79.8 |
| **Total** | **1521** | **1189** | **78.2** |

District wise seroprevalence

| District | Seroprevalence |
|---|---|
| Total | 78.2% |
| Wayanad | 79.8% |
| Thrissur | 80.0% |
| Thiruvananthapuram | 84.0% |
| Pathanamthitta | 70.0% |
| Palakkad | 72.6% |
| Malappuram | 88.9% |
| Kozhikode | 70.7% |
| Kottayam | 93.1% |
| Kollam | 96.4% |
| Kasargod | 80.6% |
| Kannur | 69.2% |
| Idukki | 73.3% |
| Ernakulam | 76.9% |
| Alappuzha | 65.0% |
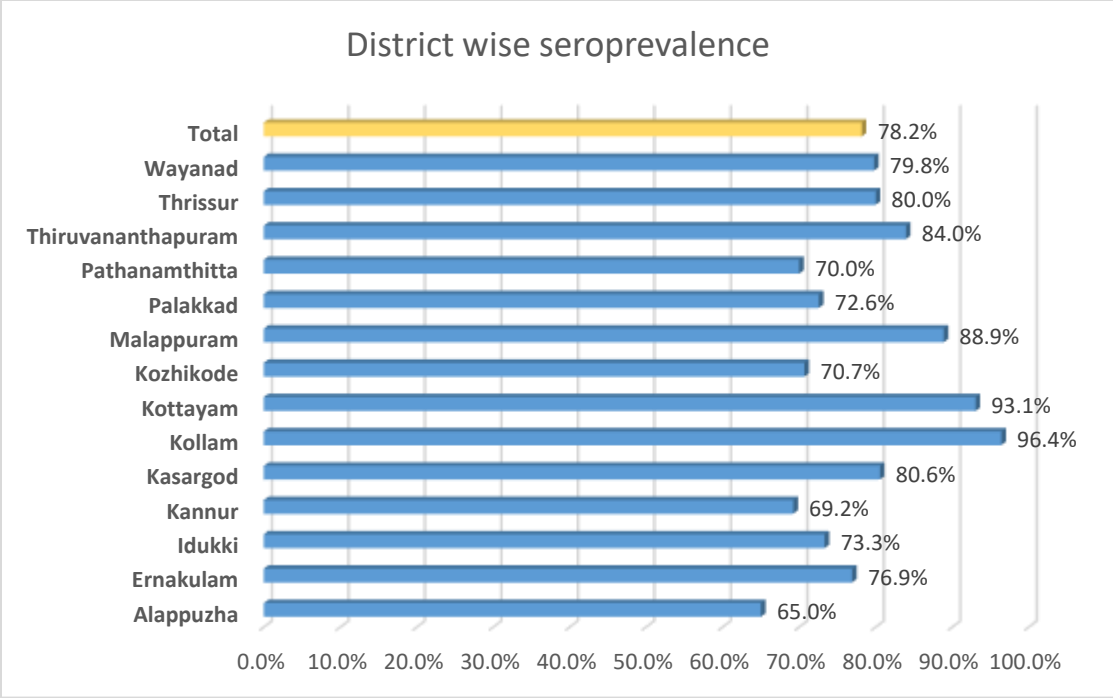
Age distribution

Table 3. Table showing age distribution of study participants

| Age Group | Number | Number positive | Seropositivity (%) |
|---|---|---|---|
| 18-29 years | 328 | 250 | 76.2 |
| 30-44 yrs | 506 | 377 | 74.5 |
| 45-59 yrs | 427 | 348 | 81.5 |
| 60-74yrs | 227 | 191 | 84.1 |
| ≥75 | 33 | 23 | 69.7 |
| **Total** | **1521** | **1189** | **78.2** |

Age distribution of seropositivity
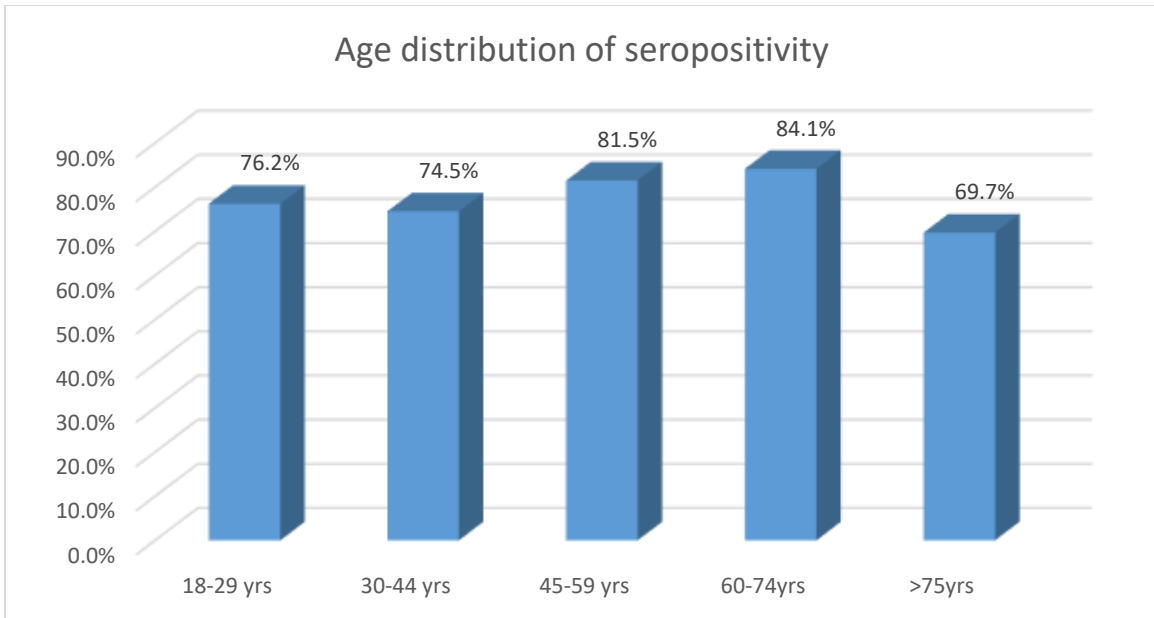
Gender Distribution

Table 4.Table showing gender distribution

| GENDER | Number | Number positive | Seropositivity (%) |
|---|---|---|---|
| Male | 661 | 497 | 75.2 |
| Female | 860 | 692 | 80.5 |
| Total | 1521 | 1189 | 78.2 |



Genderwise Seropositivity
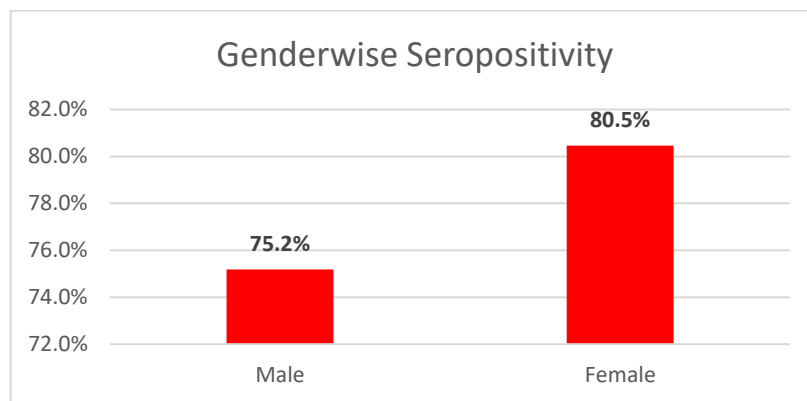
## Educational Qualification

Table 5.Table showing educational qualification of study participants

| Qualification | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Illiterate | 349 | 272 | 77.9 |
| 1-7th Class | 460 | 342 | 74.3 |
| 8-10th Class | 409 | 323 | 79.0 |
| 11-12 Class | 155 | 128 | 82.6 |
| Degree and above | 75 | 64 | 85.3 |
| Unknown | 73 | 60 | 82.2 |
| **Total** | **1521** | **1189** | **78.2** |

## Occupation

Table 6. Table showing occupation of study participants

| Occupation | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Manual Labourer and farming | 418 | 304 | 72.7 |
| Unskilled Labour | 84 | 62 | 73.8 |
| Skilled/Semi-Skilled Labour | 30 | 23 | 76.7 |
| Office Job, Clerical | 8 | 6 | 75 |
| Professional | 6 | 4 | 66.7 |
| House Wife | 362 | 294 | 81.2 |
| Health Care Workers | 14 | 10 | 71.4 |
| Fisherman | 2 | 1 | 50 |
| Business | 6 | 6 | 100 |
| Unemployed | 133 | 113 | 85 |
| Not applicable | 121 | 96 | 79.3 |
| Other | 337 | 270 | 80.1 |
| **Total** | **1521** | **1189** | **78.2** |

History of covid positivity

Table 7. Table showing seropositivity among those who had history of COVID positivity

| Covid Positive | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Yes | 127 | 116 | 91.3 |
| No | 1394 | 1073 | 77.0 |
| **Total** | **1521** | **1189** | **78.2** |

Seropositivity among those who had covid like symptoms

Table 8. Table showing seropositivity among those who had covid like symptoms

| Symptomatic | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Yes | 127 | 116 | 91.3 |
| No | 1394 | 1073 | 77.0 |
| **Total** | **1521** | **1189** | **78.2** |

Seropositivity among those who had travel history

Table 9.Table showing seropositivity among those who had travel history

| Travel History | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| YES | 41 | 23 | 56.1 |
| NO | 1480 | 1166 | 78.8 |
| **Total** | **1521** | **1189** | **78.2** |

**Seropositivity among those who had history of contact with confirmed covid case**

Table 10.Table showing seropositivity among those who had history of contact with confirmed covid case

| Covid Positive Contact | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 95 | 82 | 86.3 |
| No | 1426 | 1107 | 77.6 |
| Total | 1521 | 1189 | 78.2 |

**Seropositivity among those who ever resided in a containment zone**

Table 11. Table showing seropositivity among those who ever resided in a containment zone

| Containment Zone | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 420 | 343 | 81.7 |
| No | 1101 | 846 | 76.8 |
| **Total** | **1521** | **1189** | **78.2** |
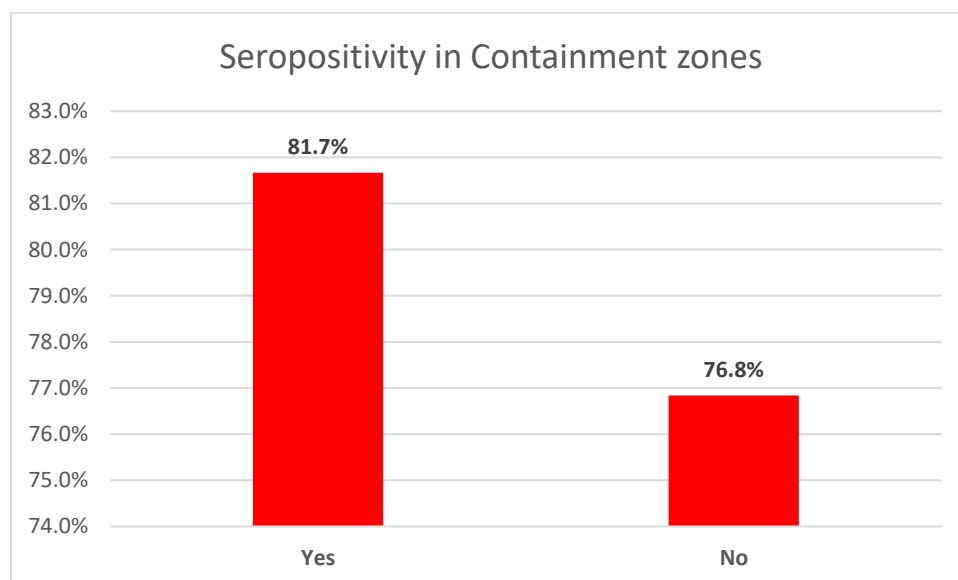
Seropositivity among those who have ever been in quarantine

Table 12. Table showing seropositivity among those who have ever been in quarantine

| Quarantined | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 193 | 160 | 82.9 |
| No | 1328 | 1029 | 77.5 |
| **Total** | **1521** | **1189** | **78.2** |

Seropositivity and type of contact with confirmed covid case

Table 13. Table showing seropositivity and type of contact with confirmed covid case

| Type of contact | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Community Contact | 46 | 41 | 89.1 |
| Household Contact | 49 | 41 | 83.7 |
| No history of contact | 1426 | 1107 | 77.6 |
| **Total** | **1521** | **1189** | **78.2** |

Seropositivity among vaccinated

Table 14. Table showing seropositivity among vaccinated

| Vaccination status | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Fully Vaccinated | 496 | 424 | 85.5 |
| Partially vaccinated | 691 | 541 | 78.3 |
| Unvaccinated | 334 | 224 | 67.1 |
| **Total** | **1521** | **1189** | **78.2** |
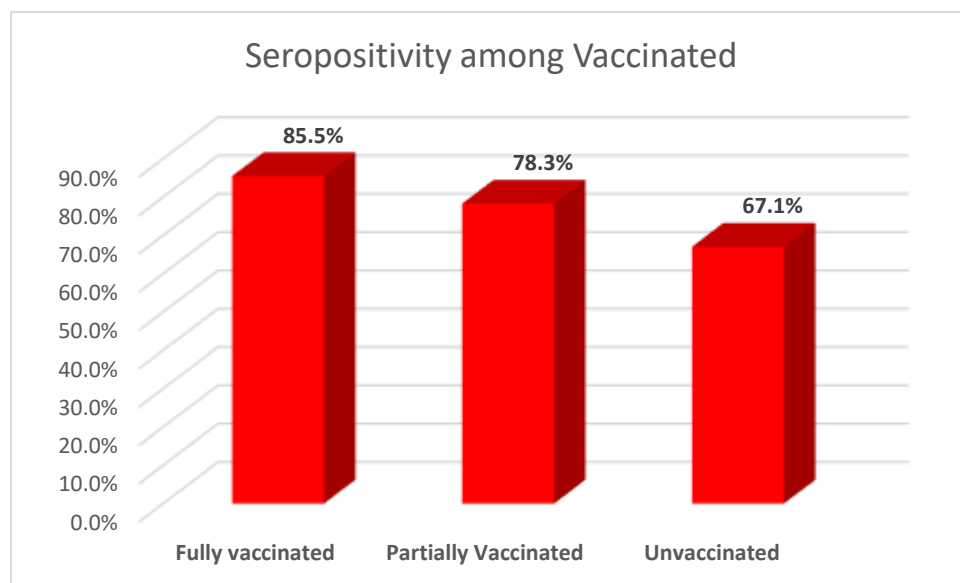


**Bivariable analysis**

The following exposure variables were found to be statistically significant in bivariable analysis with outcome as a positive test result in either of the tests done.

Table 15. Bivariable analysis

| Factor | Chi square | df | P value | Odds ratio |
|---|---|---|---|---|
| Gender | 6.097 | 1 | 0.014 | 0.736 (0.576-0.939) |
| Age group | 13.617 | 4 | 0.009 | - |
| History of being a Covid positive case(yes/no) | 14.078 | 1 | <0.001 | 3.155 (1.679-5.928) |
| Covid vaccinated status(vaccinated vs unvaccinated) | 30.939 | 1 | <0.001 | 2.135 (1.628-2.799) |
| History of residing in a containment zone(yes/no) | 4.15 | 1 | 0.042 | 1.343 (1.011-1.784) |

**Multivariable Binary Logistic regression**

Table 16. Multivariable Binary Logistic regression

| Type of variable | Adjusted Odds | 95% CI of Adjusted odds | P value |
|---|---|---|---|
| Gender (Male/Female) | 0.76 | 0.59 – 0.97 | 0.027 |
| Previous h/o confirmed COVID 19 positivity (Yes/No) | 3.37 | 1.77 – 6.42 | <0.001 |
| Vaccination status (Vaccinated/Unvaccinated) | 2.18 | 1.65 – 2.87 | <0.001 |
| History of residing in a containment zone(yes/no) | 1.10 | 0.82 – 1.48 | 0.508 |

# 3. DISCUSSION

This is one of the very first surveys to estimate seroprevalence of SARS CoV-2 IgG antibody among the tribal population in India. The seroprevalence estimate in this vulnerable population provides a measure of the interventions in the tribal population.

The seroprevalence among tribal population of Kerala is 78.2% (76.10-80.25%). Highest seroprevalence is seen in Kollam district (96.4%) and lowest in Alappuzha (65%). The seropositivity was highest among the age groups of 60-74yrs (84.1%) and seropositivity among males and females are 75.2% and 80.5% respectively. There may have been an over representation of females among in this sample, and so this finding should be examined at grass root level further. High seropositivity, 91.3% is seen among those with a history of covid. Those who ever resided in a containment zone had a seropositivity of 81.7%. Those who were fully vaccinated with 2 doses of COVID vaccine showed a seropositivity of 85.5%, those who received single dose of vaccine showed 78.3% seropositivity while unvaccinated tribal population showed a seroprevalence of 67.1 %.Vaccination status was statistically significant implying the role of vaccination in generating population immunity. Continued surveillance and serosurveys may be needed to keep track of the parameters in this vulnerable population.

# CHAPTER -6

# SEROPREVALENCE OF SARS CoV-2 IgG IN THE COASTAL AREAS OF KERALA -2021

## INTRODUCTION

Kerala is situated on the southwest coast of the Indian sub-continent with an area of about 38863 square kilometres , which makes about 1.27% of the Indian Territory. Kerala has a Coastline of 589.5 kilometres, which forms 10% of India's total coastline. With a coastline of over 590 Km Kerala has a significant marine fisheries sector that has long been an important source of occupation and livelihood for the coastal population of the state. It is estimated that about 8 lakh people earn their livelihood from capture and allied works in marine fisheries in the 222 fishing villages situated along the coastline of the state[1]. The coastal line spread over nine districts of Kerala. The marine districts of Kerala are: Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Trissur, Malappuram, Kozhikode, Kannur, Kasaragod. The average population density is 859 persons per square kilometre and it is approximately 2022 persons, in the coastal area[2]. This creates greater chances of COVID -19 infection in these areas. Serosurvey studies can show a comprehensive picture of the exposure of the community to COVID -19. In the case of coastal areas, the results would provide a indicator of the success of the vaccination campaigns conducted and the magnitude of spread of COVID-19 infection in this special group.

## OBJECTIVE AND METHODOLOGY

The objective of the survey was to estimate the seroprevalence of SARS CoV-2 IgG antibodies among the coastal population aged ≥18 yrs. The design applied was a community based correctional survey using a multistage cluster sampling method. The expected seropositivity for the adult segments of coastal populations in this survey was hypothesized to be at least one 33% with a precision of 4%, design effect of 3 and a significance level of 95%. The effective sample size was estimated to be 1670 and operationally at 1800.

The district wise distribution of samples are given in table A.

The KISH grid method should be used for the selection of an individual from a household so as to ensure the representativeness of the age and gender among the population. Informed consent was obtained from each participant.

Table A. District wise allocation of samples from coastal areas

| District | Samples from coastal communities/areas |
|---|---|
| Thiruvananthapuram | 200 |
| Kollam | 200 |
| Pathanamthitta | 0 |
| Alappuzha | 200 |
| Kottayam | 0 |
| Idukki | 0 |
| Ernakulam | 200 |
| Thrissur | 200 |
| Palakkad | 0 |
| Malappuram | 200 |
| Kozhikode | 200 |
| Wayanad | 0 |
| Kannur | 200 |
| Kasaragod | 200 |
| **Total** | **1800** |

## Data analysis:

The seroprevalence of SARS CoV-2 IgG antibodies was expressed in proportions for both types of antibodies as well as for either test positive. The rest of the analysis was done using the data of those who were positive in either one of the tests. Analysis was done with Age,

gender, district, socioeconomic status etc, strata specific seropositivity was estimated. Basic demographic details were described in proportions. Univariable analysis for determinants of positivity was done using Chi square and multivariable analysis done using binary logistic regression. P value less than 0.05 was considered significant.

**RESULTS**

Table.1 Overall seroprevalence based on the type of test and whether either one of the tests is positive.

| Type of test / either test positive | Total Samples (a) | Number Positive (b) | Rejected (c) | Total for analysis (d= a-c) | Seroprevalence (%) |
|---|---|---|---|---|---|
| Anti -spike IgG antibody | 1514 | 1311 | 0 | 1514 | 86.6% 84.9 – 88.3 |
| Anti- Nucleocapsid IgG antibody | 1499 | 503 | 0 | 1499 | 33.6% 31.2 – 35.9 |
| Either test positive | 1476 | 1294 | 0 | 1476 | **87.7%** 86.0 – 89.3 |

Overall seroprevalence based on the type of test and whether either one of the tests is positive



64
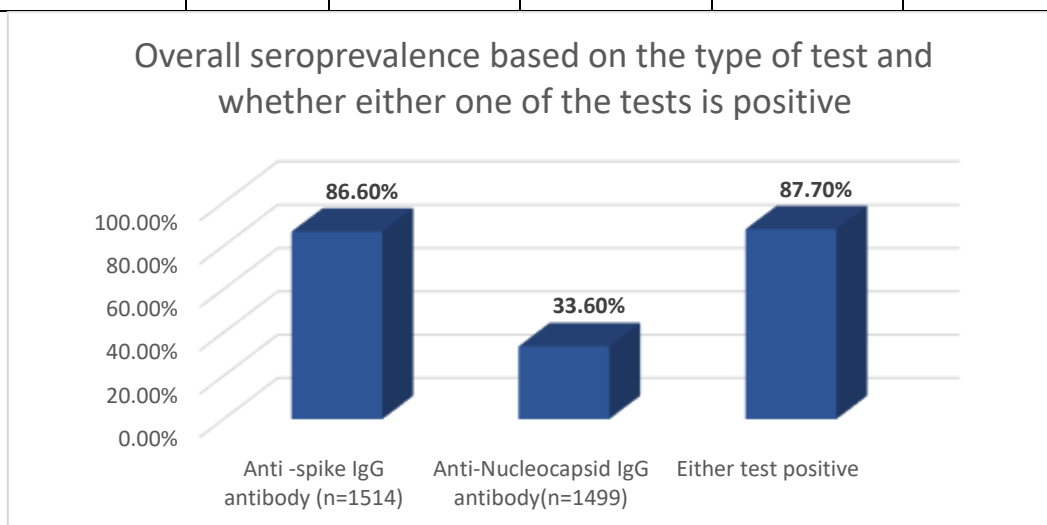
The seroprevalence of anti-spike IgG antibodies was 86.6% and that of nucleocapsid antibodies was 33.6% and the seroprevalence of either of them getting positive was 87.7%.

Table 2. District wise distribution of seropositivity

| District | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Alappuzha | 179 | 167 | 93.3 |
| Ernakulam | 196 | 161 | 82.1 |
| Kannur | 147 | 129 | 87.8 |
| Kasaragod | 132 | 122 | 92.4 |
| Kollam | 185 | 165 | 89.2 |
| Kozhikode | 113 | 96 | 85.0 |
| Malappuram | 176 | 146 | 83.0 |
| Thiruvananthapuram | 205 | 189 | 92.2 |
| Thrissur | 143 | 119 | 83.2 |
| **Total** | **1476** | **1294** | **87.7** |

District wise distribution of seropositivity
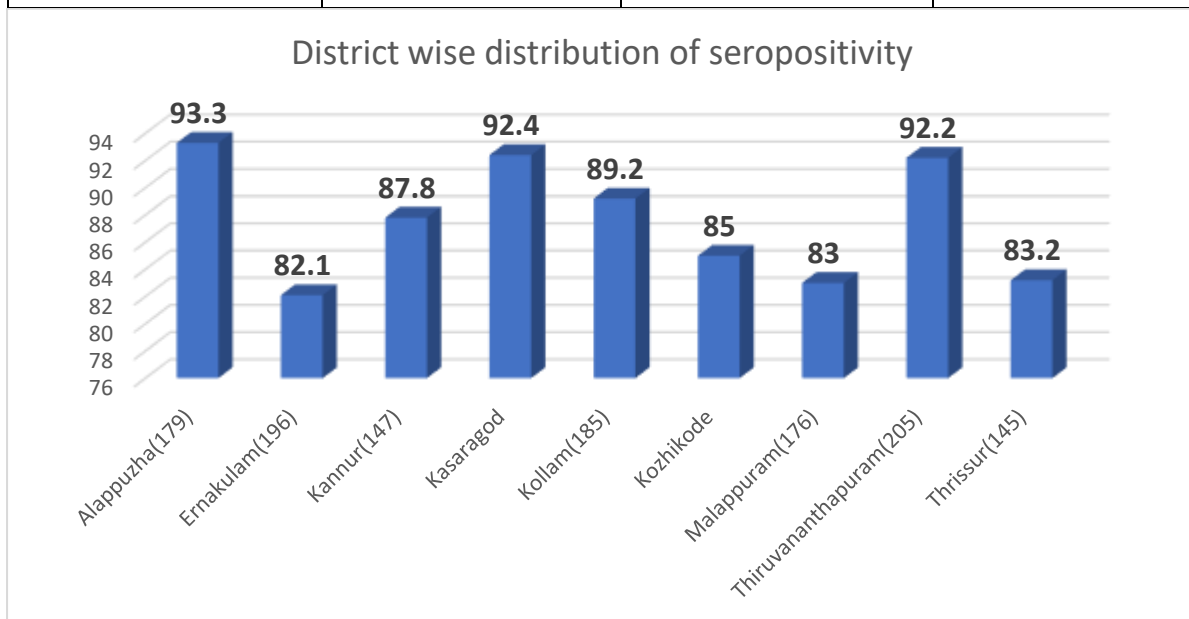
The highest seroprevalence was found in Alappuzha(93.3%) followed by Kasaragod(92.4%)

The lowest was found in Ernakulam(82.1%).

3. Age category wise distribution of seropositivity

| Age category | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| 18-29 | 231 | 206 | 89.2 |
| 30-44 | 452 | 388 | 85.8 |
| 45-59 | 494 | 436 | 88.3 |
| 60-74 | 267 | 241 | 90.3 |
| ≥75 | 32 | 23 | 71.9 |
| Total | 1476 | 1294 | 87.7 |
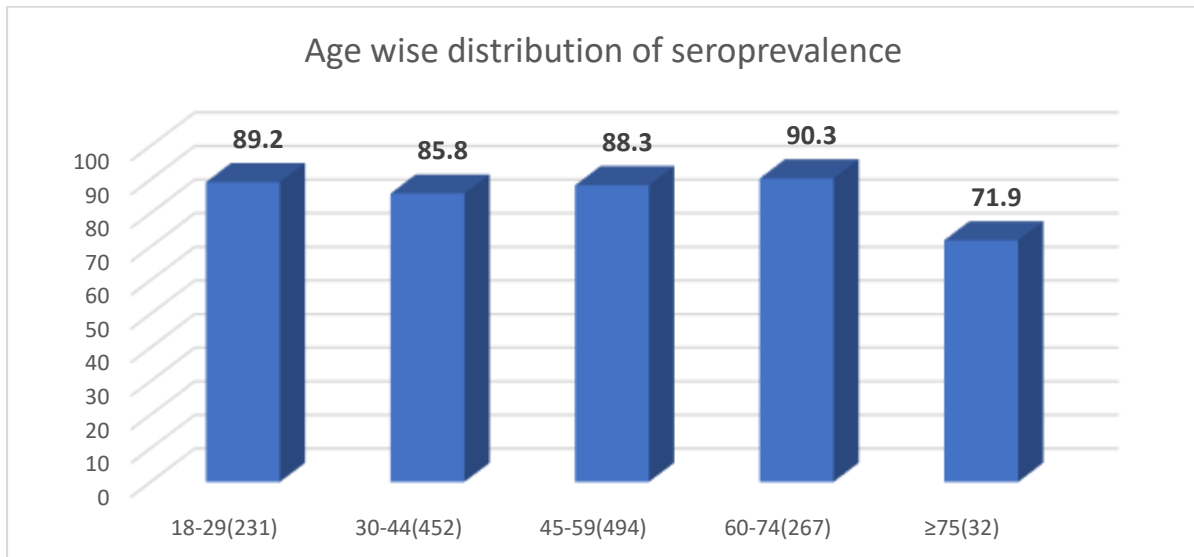


The age group with highest seroprevalence was 60-74 year age group(90.3%) followed by 18-29 age group(89.2%) .The lowest was found in the more that 75 years age group(71.9%).

4. Seropositivity according to Gender

| Gender | Total | Number positive | Percentage Seropositivity (%) |
|--------|-------|-----------------|-------------------------------|
| Male | 674 | 588 | 87.2 |
| Female | 802 | 706 | 88.0 |
| **Total** | **1476** | **1294** | **87.7** |



Seropositivity according to Gender
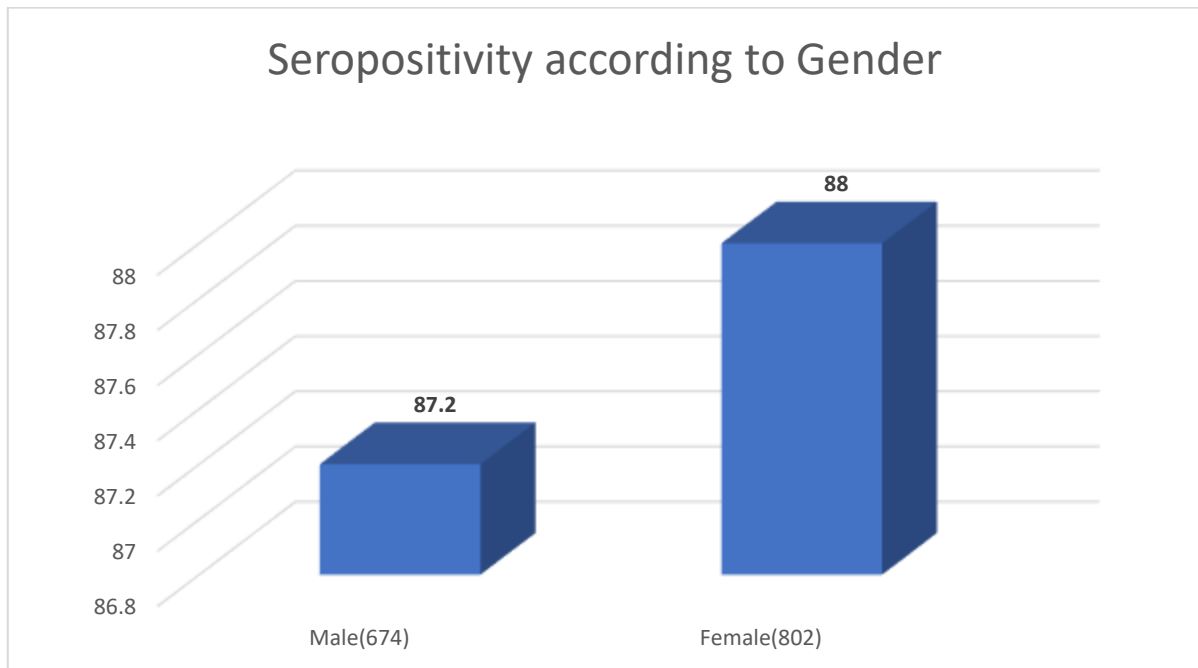
There was no difference of seroprevalence across gender .

5.  Seropositivity according to APL/ BPL status

| APL/ BPL | Total | Number positive | Percentage Seropositivity (%) |
|:---:|:---:|:---:|:---:|
| APL | 498 | 431 | 86.5 |
| BPL | 978 | 863 | 88.2 |
| **Total** | **1476** | **1294** | **87.7** |
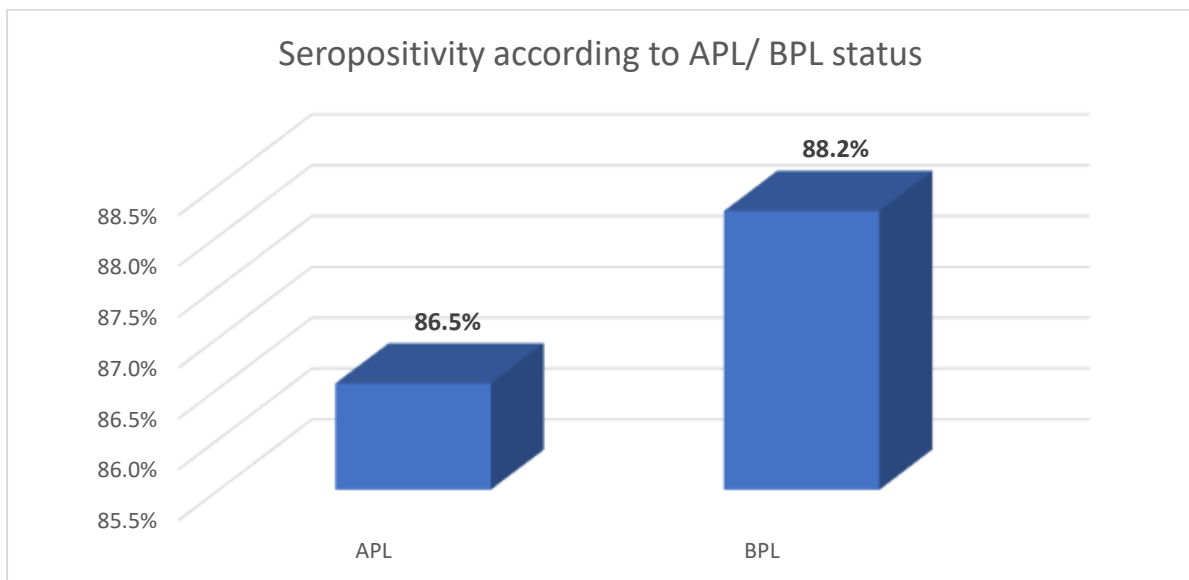


The seroprevalence was slightly higher in the BPL group compare to the APL group.

## 6. Seropositivity according to LSG Type

| Type of LSG | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Corporation | 182 | 169 | 92.9 |
| Municipality | 202 | 172 | 85.1 |
| Grama Panchayath | 1092 | 953 | 87.3 |
| **Total** | **1476** | **1294** | **87.7** |
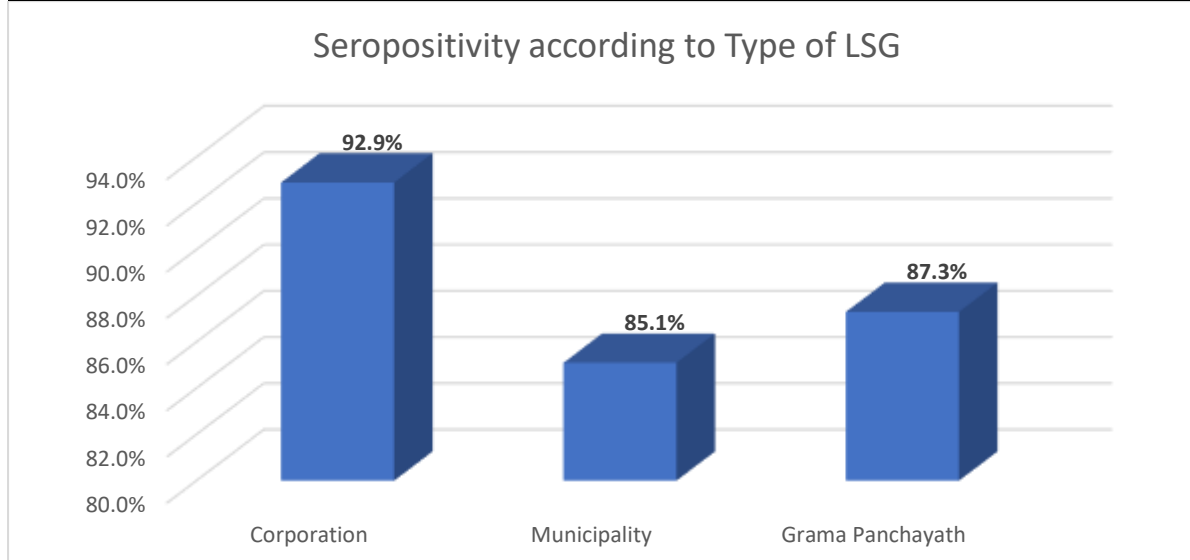


The seroprevalence was the highest in the corporation areas (92.9%) followed by Gramapanchayath areas(87.3%.
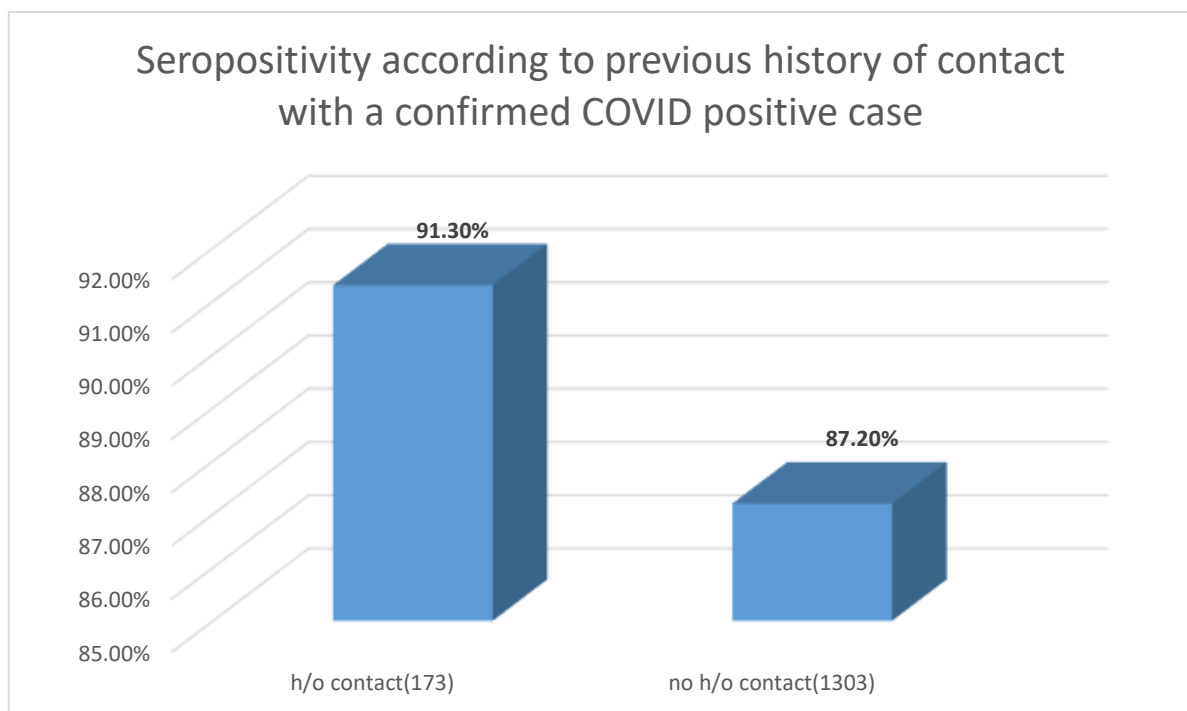
7. Seropositivity according to previous history of having been confirmed as COVID positive

| Previous history of having been confirmed as COVID positive | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 179 | 173 | 96.6 |
| No | 1297 | 1121 | 86.4 |
| **Total** | **1476** | **1294** | **87.7** |



Seropositivity with previous history COVID positive status

Among those who had given a history of COVID -19 infection in the past 96.6% were having antibodies compared to 86.4% with no history.

7. Seropositivity according to previous history of contact with a confirmed COVID positive case
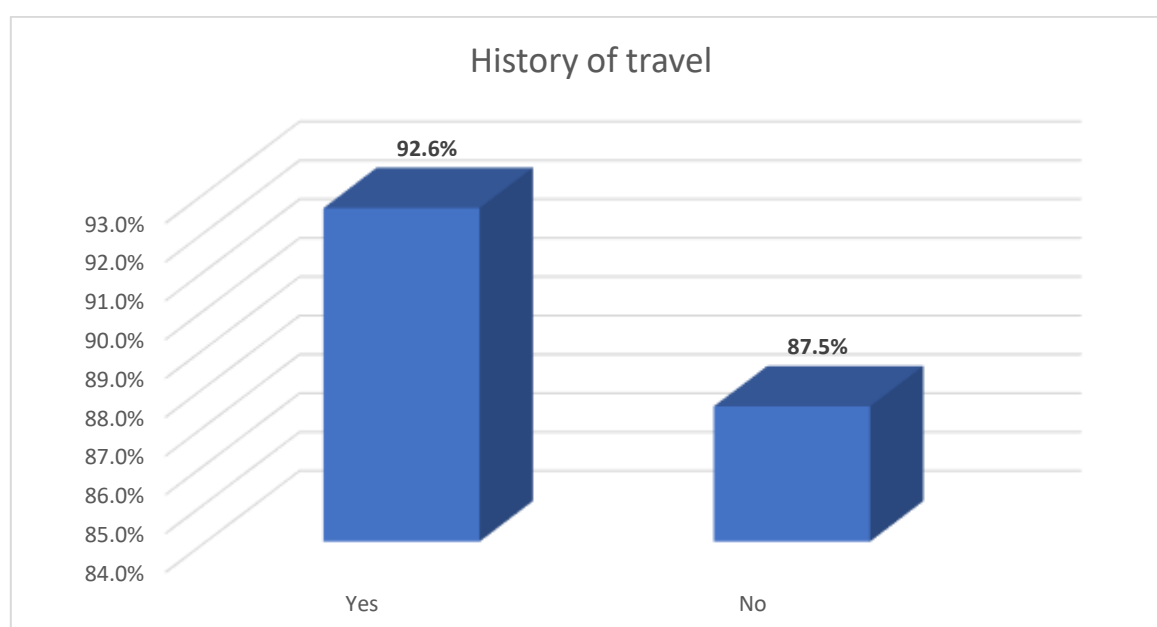
| History of contact with a confirmed COVID positive case | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 173 | 158 | 91.3 |
| No | 1303 | 1136 | 87.2 |
| **Total** | **1476** | **1294** | **87.7** |



Seropositivity according to previous history of contact with a confirmed COVID positive case

Those with a reported contact with a COVID Positive case also had a higher seroprevalence compared to those who did not.

8. Seropositivity according to travel history

| History of travel | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 54 | 50 | 92.6 |
| No | 1422 | 1244 | 87.5 |
| **Total** | **1476** | **1294** | **87.7** |

History of travel

92.6%

87.5%

93.0%
92.0%
91.0%
90.0%
89.0%
88.0%
87.0%
86.0%
85.0%
84.0%

Yes                    No

9. Seropositivity according to history of symptoms

| History of symptom | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Yes | 179 | 173 | 96.6 |
| No | 1297 | 1121 | 86.4 |
| **Total** | **1476** | **1294** | **87.7** |

# Seropositivity according to h/o symptoms
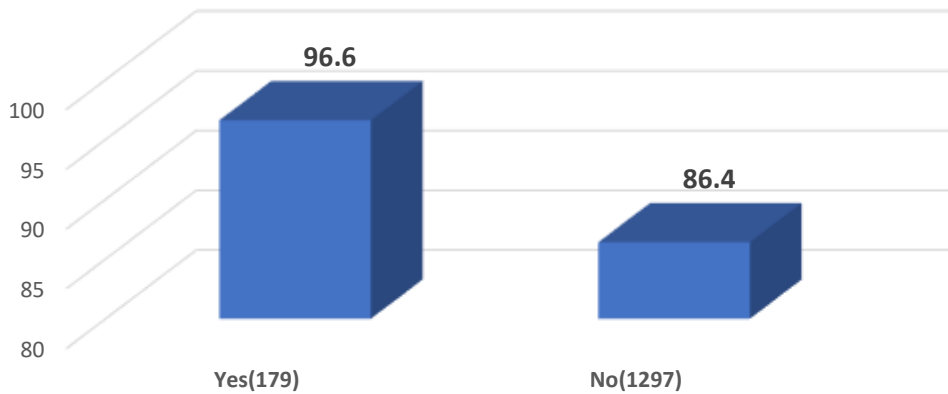


## 10. Seropositivity according to COVID vaccination status

| COVID vaccination status | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Unvaccinated | 341 | 259 | 76.0 |
| 1st Dose vaccinated | 645 | 578 | 89.6 |
| 2nd Dose Vaccinated | 490 | 457 | 93.3 |
| **Total** | **1476** | **1294** | **87.7** |
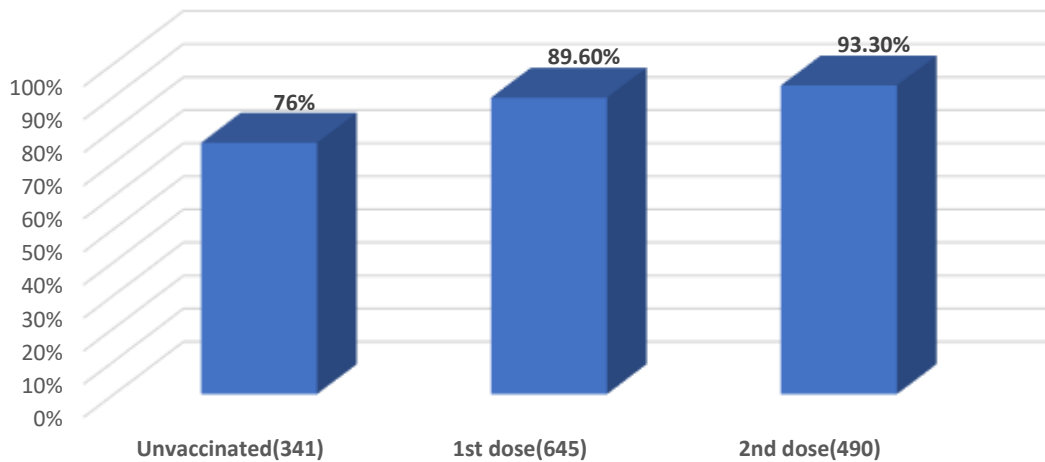
Among the unvaccinated group the seroprevalence was 76% compared to 89.6% in those with one dose of vaccine taken and 93.3% in those who had taken 2 doses.

11. The following exposure variable were found to be statistically significant in univariate analysis

| Factor | Critical values (Chi square value) | df | p Value | Odds Ratio (CI) |
|---|---|---|---|---|
| Age group | 11.088 | 4 | 0.026 | - |
| Previous h/o confirmed COVID 19 positivity Yes/No | 15.19 | 1 | 0.001 | 4.5(2- 10.4) |
| Vaccination status Vaccinated/Unvaccinated) | 56.311 | 1 | <0.001 | 3.2 (2.3- 4.5) |

In univariate analysis the seropositivity was found to be associated with age group distribution, history of previous COVID-19 positivity and vaccination status.

## 12. Multivariable Binary Logistic regression

| Type of variable | Adjusted Odds | 95% CI of Adjusted odds | P value |
|---|---|---|---|
| Vaccination status Vaccinated/Unvaccinated) | 3.69 | 2.67 - 5.12 | <0.001 |
| Previous h/o confirmed COVID 19 positivity Yes/No | 5.924 | 2.56 - 13.73 | <0.001 |

**DISCUSSION**

The seroprevalence among the coastal areas was found to be high (87.7%) with Anti -spike IgG antibody at 86.6% and Anti-Nucleocapsid IgG antibody at 33.6%. The seroprevalence among the unvaccinated was found to be 76%. The difference between seroprevalence of Anti -spike IgG antibody and Anti-Nucleocapsid IgG antibody could be due to waning of nucleocapsid antibodies with time[3]. In a study conducted in Bhubaneswar showed waning of antibodies against nucleocapsid antigen protein but not a complete disappearance by the end of 16 weeks[4]. The high seroprevalence among the unvaccinated group show that natural infection could have played a major factor in the high seroprevalence with high vaccination coverages. This highly possible considering the high population density of the coastal areas[5] and the possible close interactions which are possible in their line of work.

Among the districts the highest seroprevalence was seen in Alappuzha (93.3%) followed by Kasaragod. All the districts reported a seroprevalence of mor that 80%. Looking at the seroprevalence across age groups it can be seen that the seroprevalence is low among above 75-year age group This is a concern since many of them may be bedridden or not able to access vaccination and is an area to be focused on during the future vaccination campaigns. Those

with a previous history of COVID -19 or having symptoms almost everyone (96.6%) had a good antibody response which could be a good indicator of immunity after infection. Another major finding was that those who were vaccinated had 3.25 times chance being seroprotected compared t those who have not been vaccinated. This again shows the importance of universal COVID vaccination across age groups.

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# CHAPTER - 7

## SEROPREVALENCE OF SARS CoV-2 IgG ANTIBODY AMONG THE URBAN SLUM POPULATION

**INTRODUCTION**

A community based correctional survey was used to estimate the seroprevalence of SARS CoV-2 IgG Antibody among the urban slum populations in Kerala. The survey was conducted in the slum areas of 6 corporations in Kerala. The design applied was a community based correctional survey using a multistage cluster sampling method. The expected seropositivity for the adult segments of urban slum populations in this survey was hypothesized to be at least one 33% with a precision of 4%, design effect of 3 and a significance level of 95%. The effective sample size was estimated to be 1670 and operationally at 1800. A cluster sampling was used for the calculation. The clusters were randomly selected and individuals were selected using the KISH grid method to ensure the representation of the general population. The seropositivity was measured by IgG SARS CoV-2 S1 RBD antibody (anti spike antibody) and IgG SARS CoV-2 Nucleocapsid antibody (anti nucleocapsid antibody) tests. Overall Seroprevalence was estimated based on an individual's positivity if any of the 2 types of antibody was positive similar to the study done by the Indian Council of Medical Research (ICMR) in the 4th round of their survey.

The district wise (in corporations) distribution of the state are given below in table A.

Table A. district wise (in corporations) distribution of urban slum samples

| District | Samples from Urban Slum communities |
|---|---|
| Thiruvananthapuram Corporation | 300 |
| Kollam Corporation | 300 |
| Ernakulam Corporation | 300 |
| Thrissur Corporation | 300 |
| Kozhikode Corporation | 300 |
| Kannur Corporation | 300 |
| **Total** | **1800** |

## RESULTS

A total of 1706 samples were analysed for estimating the seroprevalence among the urban slum population aged ≥18 yrs.

Table.1 Overall seroprevalence based on the type of test and whether either one of the tests is positive.

| Type of test / either test positive | Total Samples (a) | Number Positive (b) | Rejected (c) | Total for analysis (d= a-c) | Seropositivity (95% Confidence interval) |
|---|---|---|---|---|---|
| Anti -spike IgG antibody | 1773 | 1501 | 3 | 1770 | 84.8% (83.13%-86.47%) |
| Anti-Nucelocapsid IgG antibody | 1774 | 535 | 6 | 1768 | 30.3% (28.17%- 32.43% |
| Anti -spike IgG antibody or anti-nucleocapsid IgG antibody | 1706 | 1455 | 0 | 1706 | **85.3%** (83.63%- 86.97%) |

Table 2. Corporation wise distribution of seropositivity

| Corporation | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Ernakulam | 272 | 240 | 88.2% |
| Kannur | 265 | 209 | 78.9% |
| Kollam | 227 | 195 | 85.9% |
| Kozhikode | 374 | 325 | 86.9% |
| Thrissur | 298 | 241 | 80.9% |
| Thiruvananthapuram | 270 | 244 | 90.4% |
| **Total** | **1706** | **1455** | **85.3%** |

## District-wise distribution of Seropositivity among Urban Slums

Thiruvananthapuram — 90.40%
Thrissur — 80.90%
Kozhikode — 86.90%
Kollam — 85.90%
Kannur — 78.90%
Ernakulam — 88.20%

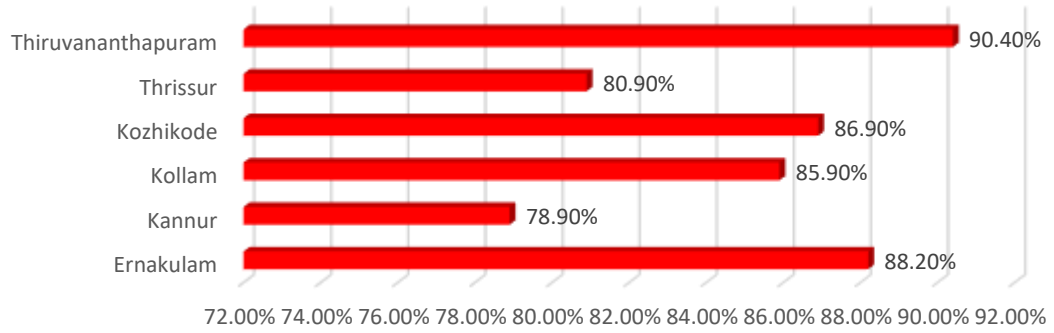72.00% 74.00% 76.00% 78.00% 80.00% 82.00% 84.00% 86.00% 88.00% 90.00% 92.00%

Table 3. Distribution of Seropositivity among the age categories

| Age category | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| 18-29yr | 251 | 200 | 79.7 % |
| 30-44yr | 547 | 457 | 83.5% |
| 45-59yr | 577 | 507 | 87.9% |
| 60-74yr | 294 | 259 | 88.1% |
| ≥75yr | 37 | 32 | 86.5% |
| **Total** | **1706** | **1455** | **85.3%** |
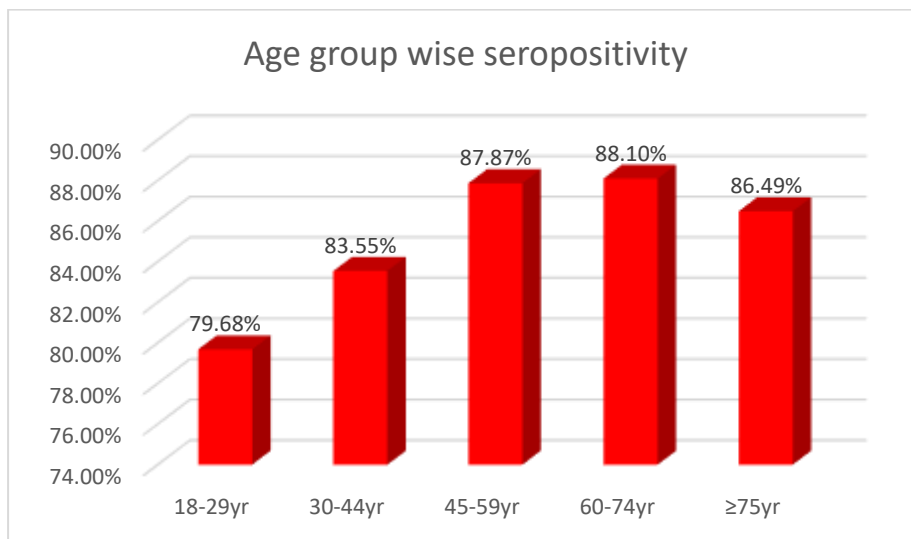


Table 4.Distribution of Seropositivity among the gender

| Gender | Total | Number positive | Seropositivity (%) |
|---|---|---|---|
| Male | 713 | 601 | 84.3% |
| Female | 993 | 854 | 86.0% |
| **Total** | **1706** | **1455** | **85.3%** |
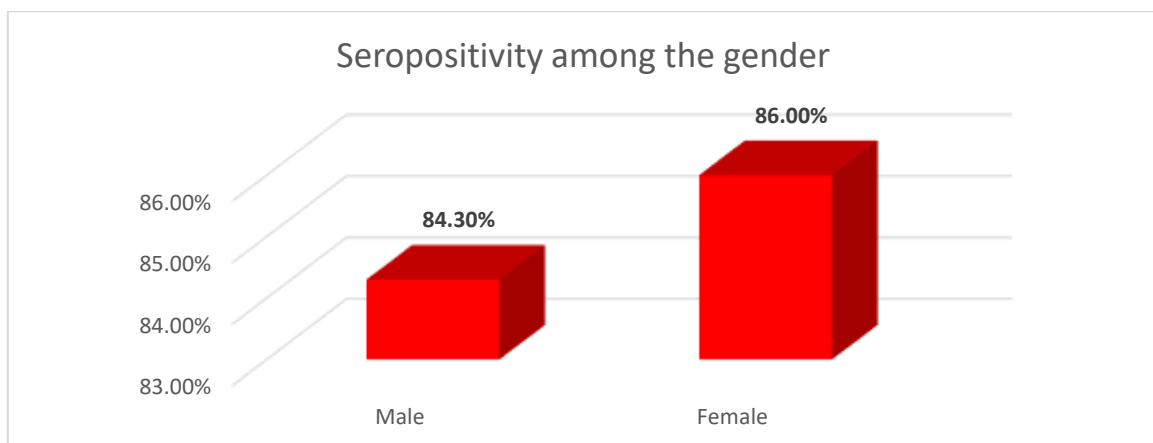
5. Seropositivity according to APL/ BPL status

| APL/ BPL | Total | Number positive | Seropositivity (%) |
|----------|-------|-----------------|---------------------|
| APL | 544 | 473 | 86.9% |
| BPL | 1162 | 982 | 84.5% |
| **Total** | **1706** | **1544** | **85.3%** |
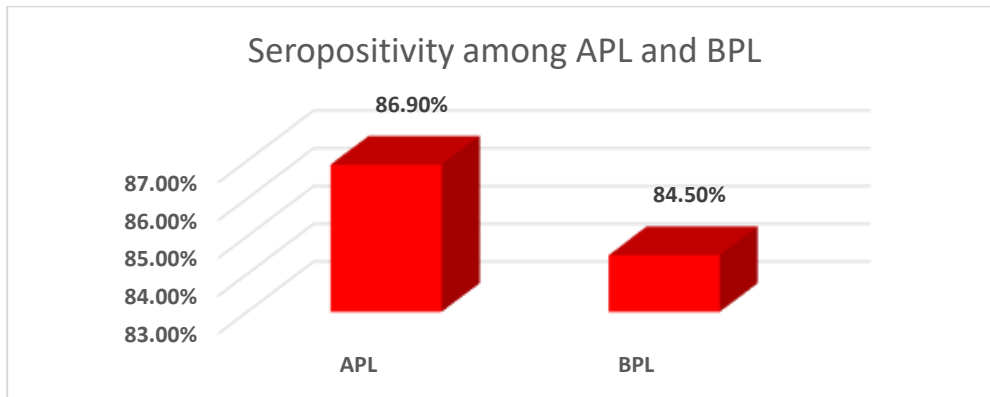


Seropositivity among APL and BPL

Seropositivity according to previous history of having been confirmed as COVID positive

| Previous history of having been confirmed as COVID positive | Total | Number positive | Percentage Seropositivity (%) |
|-------------------------------------------------------------|-------|-----------------|-------------------------------|
| Yes | 167 | 158 | 94.6% |
| No | 1539 | 1294 | 84.3% |
| **Total** | **1706** | **1455** | **85.3%** |
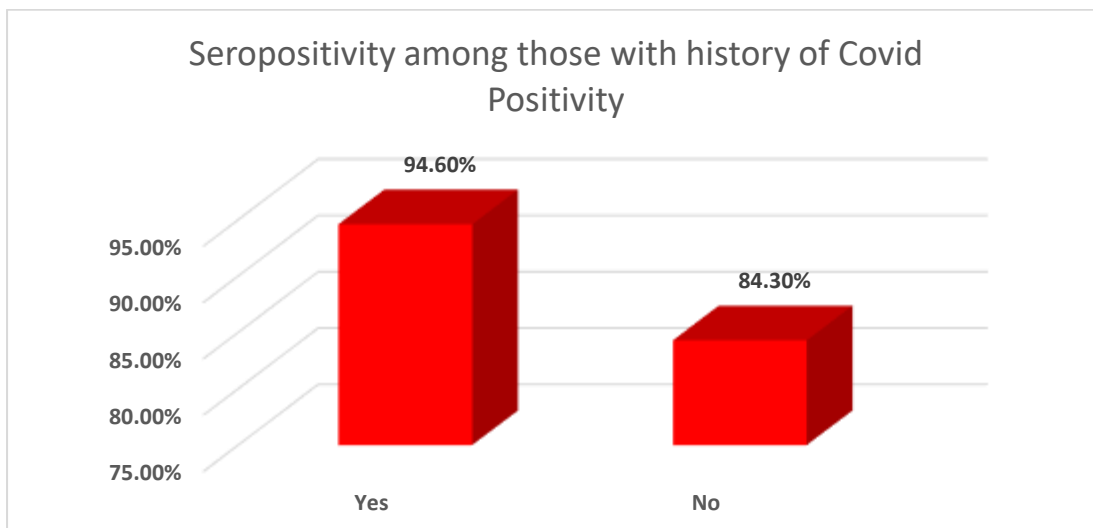


Seropositivity among those with history of Covid Positivity

6. Seropositivity according to type of contact with the confirmed COVID positive case

| Type of Contact with confirmed COVID positive case | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Hospital contact | 2 | 2 | 100% |
| Community Contact | 27 | 23 | 85.2% |
| Household | 56 | 48 | 85.7% |
| No contact | 1621 | 1382 | 85.3% |
| **Total** | **1706** | **1455** | **85.3%** |

7. Seropositivity according to COVID vaccination status

| COVID vaccination status | Total | Number positive | Percentage Seropositivity (%) |
|---|---|---|---|
| Unvaccinated | 352 | 255 | 72.4% |
| Partially Vaccinated | 845 | 736 | 88.2% |
| Fully Vaccinated | 509 | 464 | 91.2% |
| **Total** | **1706** | **1455** | **85.3%** |

*Partially vaccinated are those who have taken 1 dose of COVID-19 vaccination. Fully vaccinated are those that have received 2 doses of COVID-19 vaccine. Unvaccinated are those that have not received any doses of COVID-19 vaccine till the time of survey*.
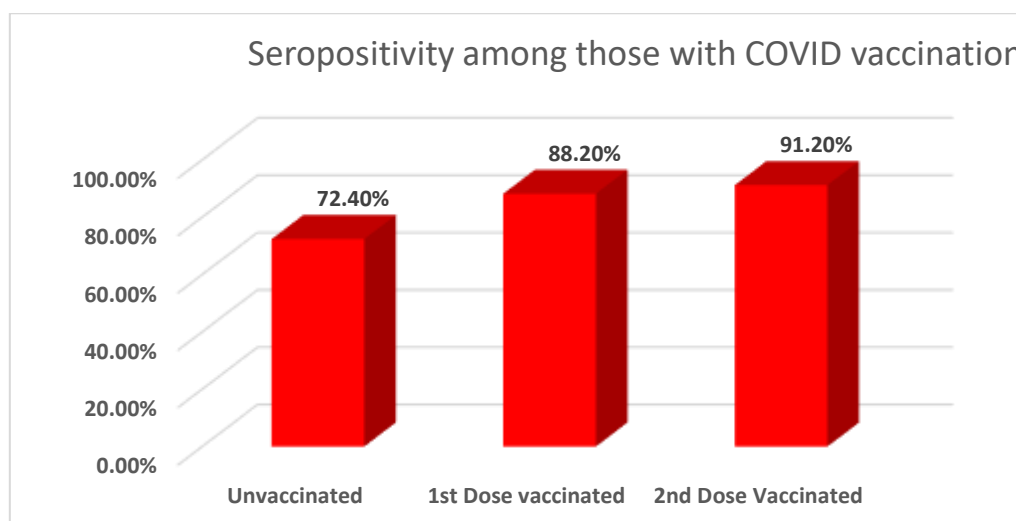
8. The following exposure variable were found to be statistically significant in Bivariate analysis

| Factor | Chi square Value | df | p Value | Odds Ratio(95% CI) |
|---|---|---|---|---|
| Previous history of having been confirmed as COVID positive | 12.82 | 1 | <0.001 | 3.28 (1.65,6.5) |
| Vaccination Status | 58.31 | 1 | <0.001 | 2.96 (2.22,3.95) |

## 10. Multivariable Binary Logistic regression

| Type of variable | Adjusted Odds | 95% CI of Adjusted odds | P value |
|---|---|---|---|
| Previous h/o confirmed COVID 19 positivity Yes/No | 3.809 | 1.90 – 7.63 | <0.001 |
| Vaccination status Vaccinated/Unvaccinated) | 3.136 | 2.34 – 4.20 | <0.001 |

**DISCUSSION**

The overall seropositivity of 85.3% in the urban slum samples ($\geq$18 yrs), for either Anti -spike IgG antibody or anti-nucleocapsid IgG antibody denotes that there is high level of seropositivity among adults in the Urban slum population. The seropositivity among the slum population in districts of Kerala was highest in Thiruvananthapuram (90.4%) and lowest in Kannur (78.9%). There was no statistically significant difference between seropositivity among the gender groups, APL/ BPL categories, or residence of the individual based on the local body type. A statistically significant difference was observed among those with history of COVID positivity and those who have taken at least first dose of vaccine.

The seroprevalence in this category is also higher as compared to the seroprevalence among the community $\geq$18yrs and may be correlated to the higher level of transmission in these areas during the pandemic and owing to the high density of population and mobility. Enhancing vaccinations while continuing COVID appropriate behavior will provide benefits to these vulnerable groups.

# CHAPTER -8

## SUMMARY AND RECOMENDATIONS

- The summary of the results with reference to the primary objectives show that there is a high level of seroprevalence among the general community ≥18 yrs(82.6%), Coastal belt (87.7%), Urban slums (85.3%) and tribal population(78.2). The high seroprevalence in Kerala is one among the highest observed among the serosurveys done in India and implies that a large number of the population are having antibodies against COVID-19.

- The high level of seroprevalence may have been achieved through natural infection , COVID vaccination or by a combination of both [hybrid immunity]. Considering the rapid vaccination coverage in the state, the contribution of vaccination is expected to be substantial.

- The remaining 17 % of the population are susceptible for infection and should get vaccinated at the earliest .

- The seroprevalence was lower among the antenatal women (65.4%). As seroconversion among the vaccinated pregnant woman observed in the survey is substantial, all pregnant woman should get vaccinated at the earliest. Sentinel surveillance program for COVID 19 among antenatal women may be initiated.

- The lowest seroprevalence was seen among children 5-17 yrs (40.2%). Children need to be protected from infection by following COVID appropriate behaviour.Strategies and facilities need to be tailored so as to ensure the children are not at significant risk of infection in places where there is chance of transmission.

- The general community and other categories surveyed (tribal, coastal and urban slum) are also urged to get COVID vaccination as per the eligibility and regimen at the earliest. As seropositivity alone is not a surrogate of protection against infection from immune escape variants, emphasis on covid appropriate behaviour has to be continued.

- Continued surveillance, vaccination coverage surveys and evaluation and further serosurveys may be needed to keep track of the parameters in the vulnerable populations like the tribal, coastal and the urban slum population. Further studies on antibody decay kinetics, breakthrough infections and their conversion rates in the various cohorts identified in this study will provide valuable information to predict the course of pandemic in the state.  Operational  research among subgroups needs to be conducted to optimize and further sharpen decision making.