Dynamic changes in host immune system and gut microbiota are associated with the production of SARS-CoV-2 antibodies

Recently, we read the article by Ng *et al* with great interest,[1] which identified several gut microbiota harbour the

potential to improve immune response and reduce adverse events following COVID-19 vaccines, and demonstrated that gut microbiota has the potential to complement the effectiveness of vaccines. Together with several recent studies, gut microbiota plays a key role in modulating immune responses of vaccination[2–4] and is related to the severity of COVID-19 patients,[5 6] however, the comprehensive assessment of host's response, particularly the role of gut microbiota in antibodies production is limited and should be seriously considered because the vaccination of SARS-CoV-2 is the most promising approach for curbing the COVID-19 pandemic.[4 7]

Therefore, we recruited 30 young volunteers (20–23 years old), including 15 male and 15 female volunteers, and collected 143 faecal and 120 blood samples at multiple time points to monitor their responses to Sinovac vaccine from multiple perspectives (figure 1A and online supplemental figure 1). Through routine blood test, flow cytometry and ELISA, the blood immunological indices, immune cell subsets and antibodies levels were measured, respectively, while by whole-genome shotgun sequencing, the structure of gut microbiota communities was profiled. Particularly, our results were compared with a published gut microbiota dataset derived from patients with SARS-CoV-2 infection (online supplemental material 1).

Interestingly, our results showed that a majority of healthy individuals can produce SARS-CoV-2 antibodies (90%, 96.67% and 80% of the subjects produce anti-(N+S) IgA, IgG and IgM antibodies, respectively, online supplemental table 1), at the end of 2 weeks after second dose of Sinovac vaccine. Moreover, the levels of these antibodies first increased over the first 2 weeks after the first dose and reached a peak 2 weeks after the second dose during the vaccination process (figure 1B).

In addition, the alterations in cytokines, lymphocytes and indicators of physiological and biochemical systems were measured to visualise the response of immune system of host (figure 1C-E, online supplemental tables 2–4). In addition, based on the taxonomical compositions of gut microbial communities across different vaccination time points, we found that the alpha diversities of the gut microbial communities did not significantly differ (figure 1F). However, the compositions of gut microbial communities during the vaccination process exhibited significant differences (analysis of similarities, Bray-Curtis dissimilarity, $p=0.015$, figure 1G), these gut microbial communities could be distinctly separated depending on the time points of vaccination (figure 1H), and the taxonomical compositions of gut microbial communities undergo changed (figure 1I).

Furthermore, the comparison of the gut microbiota of healthy individuals who vaccinated with Sinovac vaccine and COVID-19 patients with different clinical diagnoses, without accounting for factors such as age, suggest that the alterations of gut microbiota during vaccination were not as substantial as those caused by SARS-CoV-2 infection (figure 1J).

Finally, our results showed that the correlations among gut microbiota, cytokines, lymphocytes and SARS-CoV-2 antibodies (figure 1K and online supplemental figures 2, 3). In particular, we found that several gut microorganisms have a significant association with SARS-CoV-2 antibodies production. For example, *Prevotella copri* was negatively correlated with IgG, whereas *Clostridium leptum*, *Lactobacillus ruminis*, *Ruminococcus torques*, etc, presented a positive correlation with antibodies production (all $p<0.01$, figure 1K). Moreover, a variation partitioning analysis based on the metadata of body features and the compositions of gut microbial communities was performed, which showed that the production of antibodies is mainly affected by the gut microbiome (22%) and body features (18%, online supplemental table 5, online supplemental figure 4). These results suggest that gut microbiota plays an important role in the production of SARS-CoV-2 antibodies in young healthy individuals and the dynamic changes of immune system and gut microbiota and their associations with the production of SARS-CoV-2 antibodies in elderly population remain elusive and should be further investigated.

Overall, our study systematically investigated the dynamic changes of host, including lymphocytes, cytokines, gut microbiota and antibodies, and linked these factors to the production of antibodies. Our results provide an optional perspective for evaluating the safety and effectiveness of SARS-CoV-2 vaccines and settling the treatment of COVID-19 patients, and can alleviate the public's concerns and fears about the vaccination.

Maozhen Han,[1] **Yixuan Huang**,[2] **Hongya Gui**,[3] **Yixuan Xiao**,[3] **Maozhang He**,[3] **Jiling Liu**,[3] **Xiujing Cao**,[4] **Meijuan Zheng**,[5] **Min Lu**,[5] **Weihua Jia**,[1] **Hui Li**,[6] **Xiaoyan Wang**,[7] **Na Zhang**,[1] **Shu-an Kong**,[2] **Xiaohui Liu**,[8] **Yonggui Wu**,[9] **Fengchang Wu**,[8] **Shenghai Huang**[1,3]

[1]School of Life Sciences, Anhui Medical University, Hefei, Anhui, China
[2]Department of Clinical Medicine, The First School of Clinical Medicine, Anhui Medical University, Hefei, Anhui, China
[3]Department of Microbiology, The Key Laboratory of Microbiology and Parasitology of Anhui Province, The Key Laboratory of Zoonoses of High Institutions in Anhui, School of Basic Medical Sciences, Anhui Medical University, Hefei, Anhui, China
[4]Department of Epidemiology and Biostatistics, School of Public Health, Anhui Medical University, Hefei, Anhui, China
[5]Department of Clinical Laboratory, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, China
[6]Hefei City Maternal and Child Health & Family Planning Service Center, Hefei, Anhui, China
[7]Department of Pediatrics, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, China
[8]State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing, China
[9]Department of Nephropathy, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, China

Correspondence to Professor Shenghai Huang; huangshh68@aliyun.comProfessor Fengchang Wu; wufengchang@vip.skleg.cnProfessor Yonggui Wu; wuyonggui@medmail.com.cn

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Contributors MHa and SH designed the study. MH, WJ and SH recruited the healthy volunteers from School of Life Sciences, Anhui Medical University. MHa, YX, MHe, HL, XW, NZ and SaK collected the blood and fecal samples. MHa, YH, HG, YX, NZ and XC analysed the data of indicators obtained from routine blood tests, lymphocytes, cytokines and metagenomic sequencing data. HL and ML conducted the measurement of the indicators obtained from routine blood tests, lymphocytes and cytokines. MHa, YW, FW and SH organised the structure of the manuscript. MH, YH, HG and YX wrote the initial draft of the manuscript. All authors read, modified and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The study protocols were all approved by the Biomedical Ethics Committee of Anhui Medical University (No 2021H021). Participants gave

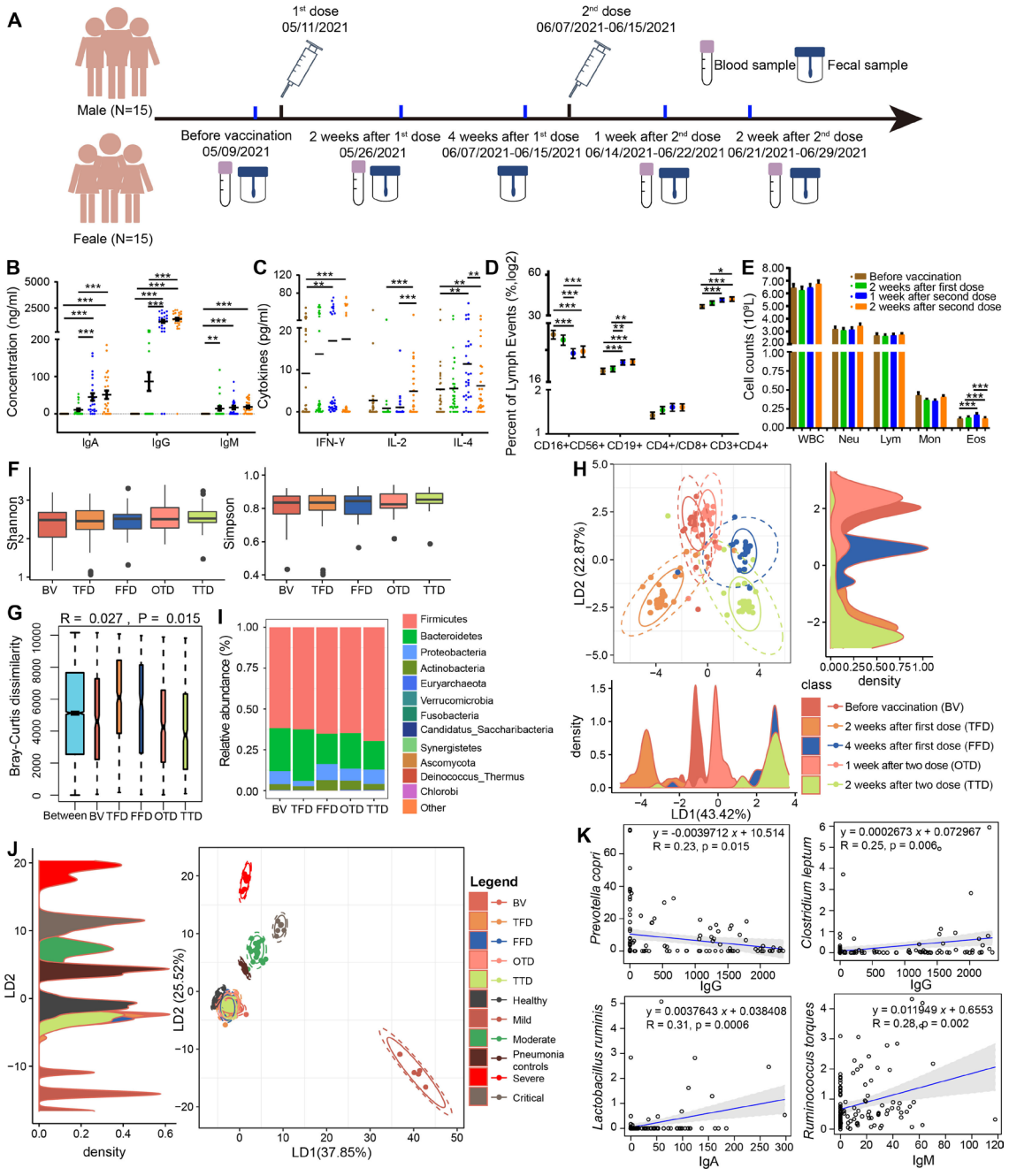

Figure 1 The response of healthy individuals during the vaccination of two dose of SARS-CoV-2 vaccine and the interplay between host immune systems and gut microbiota that contributes to the production of SARS-CoV-2 antibodies. (A) Study design for collecting the faecal and blood samples from 30 healthy individuals to explore the dynamics changes of host immune systems, gut microbiota and the production of SARS-CoV-2 antibodies. Dynamic changes in SARS-CoV-2 antibodies, cytokines, lymphocytes and indicators obtained from routine blood tests. (B) Concentrations of IgA, IgG and IgM detected at different time points during the vaccination process. The differences between different time-points were assessed by two-way ANOVA, and two-sided exact p values are reported. (C) Concentrations of IFN-γ, IL-2 and IL-4 measured at different time points during the vaccination process. (D) The levels of NK cells, B cells and CD4+T cells and the CD4+/CD8+ratio are illustrated in chronological order. (E) Dynamic changes in the counts of white cell count, neutrophils (Neu), lymphocyte (Lym), monocytes (Mon) and eosinophils (EOSs) during the vaccination process. (F) The alpha diversities, including the Shannon and Simpson indices, of the human gut microbial communities did not significantly differ among different time points during the vaccination process. (G) A significant difference in the human gut microbial compositions was found among different time points during the vaccination process according to their Bray-Curtis dissimilarity at the species level. (H) Based on the taxonomic compositions of all 143 samples at the species level, LDA can successfully separate the human gut microbial communities at different time points during the vaccination process. The density curves in the bottom and right panels show the distribution of the human gut microbial communities along the LD1 and LD2 axes, respectively. (I) Compositional differences in the gut microbiota among different time points during the vaccination process visualised with the average relative abundances at the phylum level. (J) Comparison of the taxonomic structure of the human gut microbiota among unvaccinated healthy individuals, healthy individuals at different time points during the vaccination process, and COVID-19 patients with different clinical diagnoses. (K) Correlations between the production of antibodies against SARS-CoV-2 and gut microbiota.*, p<0.05; **, p<0.01; ***, p<0.001; ANOVA, analysis of variance; LDA, linear discriminant analysis.

informed consent to participate in the study before taking part.

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ORCID iDs
Maozhen Han http://orcid.org/0000-0002-5958-1941
Shenghai Huang http://orcid.org/0000-0002-5699-8928

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Supplementary Table S1 The levels of SARS-CoV-2 antibodies were measured in different time points during the SARS-CoV-2 vaccination process from the healthy volunteers using ELISA method.

Sample ID	The measurement of antibodies before vaccination (pg/ml)			The measurement of antibodies at 2 weeks after first dose (pg/ml)			The measurement of antibodies at 1 week after second dose (pg/ml)			The measurement of antibodies at 2 weeks after second dose (pg/ml)		
	IgA	IgG	IgM	IgA	IgG	IgM	IgA	IgG	IgM	IgA	IgG	IgM
F01	0	0	5.790462	3.115225	69.69946	21.88886	9.895591	2143.419	45.06539	11.53869	2349.821	61.44432
F02	0	0	0	8.183167	216.1954	21.79543	10.05505	1589.309	28.90224	63.45216	2044.093	28.95619
F03	0	0	0	1.513727	82.36792	13.26068	52.46353	1652.449	25.93505	39.4713	1566.937	21.03647
F04	0	0	0	0	218.9582	21.63666	8.065308	2182.503	35.54106	14.90807	2303.729	43.2342
F05	0	0	0	12.53009	167.8801	10.4877	162.8074	1997.462	16.58028	115.1646	2020.036	12.70673
F06	0	0	0	0	0	0	0	1532.166	19.38563	0	1534.457	29.06409
F07	0	0	0	0.258874	0	7.380233	5.798253	247.058	0.395555	0	526.5054	7.732628
F08	0	0	0	0	218.9582	23.40311	11.99626	2182.503	2.790893	50.51539	2303.729	9.685585
F09	0	0	0	8.210899	375.0903	54.45619	25.73031	2040.926	62.49094	74.54479	1819.43	46.24148
F10	0	0	20.81355	52.15849	333.5135	39.32887	123.8168	1778.19	55.82283	58.95272	1684.861	35.23587
F11	0	0	0	2.435801	0	0	11.33763	1343.621	0.07186	21.7231	1532.57	1.916918
F12	0	0	0	3.905574	292.6779	117.814	154.689	2283.513	85.75378	72.70757	2200.023	50.50345
F13	0	0	0	53.10136	0	54.45619	63.52149	1287.961	62.49094	89.15932	1381.627	46.24148
F14	0	0	5.790462	3.115225	69.69946	21.88886	9.895591	2143.419	45.06539	11.53869	2349.821	61.44432
F15	0	0	0	8.183167	216.1954	21.79543	10.05505	1589.309	28.90224	63.45216	2044.093	28.95619
M01	0	0	0	29.72366	189.1065	0	43.23586	813.9043	5.488347	169.3867	2152.718	40.14523
M02	137.2597	0	23.36707	90.22005	0	5.89836	109.6945	865.3868	21.55438	94.17873	1270.508	46.24148
M03	0	0	0	38.05006	0	0	77.3942	668.2844	0	110.6513	872.1253	0
M04	0	0	0	0	0	0	96.32793	566.1954	2.851008	0	1075.899	18.72745
M05	0	0	0	2.934969	63.9717	18.94325	33.97352	1354.605	28.31959	98.39393	1928.662	44.0943
M06	0	0	0	13.07779	0	0	45.80796	1063.567	0	28.75305	1077.247	0
M07	0	0	0	0	0	0	0	0	0	0	534.4569	0
M08	0	0	0	5.812119	0	0	21.39725	566.1954	3.913034	26.05616	1075.899	10.5164
M09	0	0	0	5.701192	0	0	46.96575	1380.212	13.72098	12.19038	1221.317	12.83621
M10	0	0	0	0	0	0	25.03009	0	0	0	0	0
M11	0	0	0	45.17707	0	0	114.2148	249.2143	0	184.4866	729.6051	0
M12	0	0	0	44.01927	0	0	104.8692	1503.055	15.68472	98.8099	1555.818	10.68904
M13	0	0	0	0	0	0	12.28744	1172.125	31.30837	4.799917	1402.179	30.36966
M14	0	0	0	0	0	0	0	1249.282	13.72098	0	1249.282	13.72098
M15	0	0	0	0	0	0	6.699529	1057.705	0	6.914448	1322.53	0
Mean	4.575323333	0	1.858718133	14.38092597	83.810468	15.1477941	46.60084307	1283.45132	21.7251829	50.72498917	1504.332623	23.72468903
Standard deviation	24.6388702	0	5.60546677	21.93383041	115.5800836	24.58475213	47.88433717	664.0600361	22.63510932	50.48868568	598.5702092	19.52003028

Supplementary Table S2 The levels of cytokines were measured in different time points during the SARS-CoV-2 vaccination process from the healthy volunteers using ELISA method.

Sample ID	The measurement of antibodies before vaccination (pg/ml)			The measurement of antibodies at 2 weeks after first dose (pg/ml)			The measurement of antibodies at 1 week after second dose (pg/ml)			The measurement of antibodies at 2 weeks after second dose (pg/ml)		
	IFN-γ	IL-2	IL-4	IFN-γ	IL-2	IL-4	IFN-γ	IL-2	IL-4	IFN-γ	IL-2	IL-4
F01	0	0	5.30952381	1.563830234	0	1.845238095	2.12103855	0	7.55952381	0.16977455	1.256704981	2.595238095
F02	0.71778095	0	8.55952381	1.899606059	0	3.202380952	1.380776684	0	11.5952381	0.573108359	0	9.202380952
F03	0	0	0	0.329546159	0	6.666666667	0.923442059	0	6.380952381	0.436089659	0.233716475	0.952380952
F04	0	0	2.738095238	0.010055309	0	2.488095238	1.091081784	0	8.916666667	0	7.848659004	1.273809524
F05	0	0	0	0	0	2.05952381	0.6264038	0	9.273809524	1.007254738	0	4.130952381
F06	0	0	10.98809524	0	0	7.845238095	0.740627909	0	22.23809524	0.04807895	5.01532567	19.41666667
F07	35.36339925	0.003831418	8.988095238	41.1621525	0	12.8452381	55.59690017	0	13.27380952	55.66326781	0	7.130952381
F08	26.66961361	0	20.52380952	55.66326781	0	7.130952381	48.80945445	0	23.05952381	72.1957744	0	18.02380952
F09	28.56347588	2.95210728	1.773809524	48.91852025	1.739463602	3.80952381	50.73268094	3.27394636	16.02380952	69.2889882	13.14176245	3.130952381
F10	19.2487545	3.762452107	2.380952381	49.34411681	0.337164751	1.05952381	70.35860913	1.825670498	15.63095238	52.4438621	1.314176245	0.880952381
F11	23.62786936	0.699233716	6.880952381	48.79854925	0	3.773809524	45.97171826	2.394636015	9.095238095	56.31636444	3.963601533	9.05952381
F12	18.36213757	1.986590038	0	28.34452878	0	2.880952381	37.33770025	0.164750958	0	36.44500463	9.601532567	0
F13	26.815	0	7.952380952	19.20794882	0	1.202380952	40.16555505	0	3.488095238	30.12013815	5.095785441	1.630952381
F14	16.75682023	2.285440613	11.91666667	34.98227997	0	0	35.36339925	0	16.77380952	32.11323122	0	15.66666667
F15	19.72852226	0	0.773809524	36.99741679	0	1.130952381	63.08627129	0	0.952380952	54.83432213	0	0
M01	0.086105559	1.03256705	9.238095238	0.740627909	0	1.166666667	3.444072809	1.049808429	15.66666667	1.007254738	6.69348659	10.95238095
M02	0.177381534	16.28544061	0	1.624863284	0	0	2.037035159	2.567049808	4.666666667	0.146954309	10.89463602	1.345238095
M03	0	2.181992337	0.666666667	0.299109434	0	0	0.47414655	3.69348659	3.630952381	0	10.91762452	5.416666667
M04	1.518060434	3.739463602	3.238095238	1.731689409	2.561302682	5.916666667	2.747698438	1.727969349	32.88095238	1.243531409	7.888888889	29.52380952
M05	0	0.331417625	0	0.177381534	0	15.30952381	1.14443375	0	2.880952381	0.35237495	12.74521073	0
M06	0	0	0	0.0176598	0	1.273809524	0.512206409	0	6.130952381	0.580721637	0	0
M07	0	0.078544061	0	0.847261184	0	0	0.847261184	0	0	0	0	0
M08	47.94050518	42.44636015	0	34.20473375	21.13601533	0	33.61222628	14.56130268	0	53.00380941	32.17624521	1.202380952
M09	0	1.388888889	0	0.41325695	0	10.30952381	0	0	7.095238095	0	1.572796935	3.166666667
M10	0	0	43.77380952	0	0	29.66666667	0.154560938	0	57.80952381	0	2.647509579	2.702380952
M11	0	1.090038314	0	0.367594737	0	5.238095238	0.192595859	0	6.916666667	0	0	0.130952381
M12	0.53504375	0	2.845238095	1.281651238	0	4.773809524	0.771092184	0.130268199	3.666666667	0.314327559	0.584291188	5.416666667
M13	1.601975	0	6.738095238	0.314327559	0.584291188	5.416666667	2.166864638	0	0	0.0176598	0	10.70238095
M14	0.672090238	0	3.845238095	1.960680909	0	11.80952381	2.51834	0	31.70238095	0	14.07279693	22.02380952
M15	5.777552109	1.03256705	9.238095238	2.533627238	0	1.166666667	1.914874059	1.049808429	15.66666667	0.83964375	6.69348659	10.95238095
Mean	9.138736247	2.709897829	5.612301587	13.79120946	0.878607918	4.999603175	16.89476893	1.081289911	11.76587302	17.30538456	5.145274585	6.554365079
Standard deviation	13.24771576	7.965012354	8.592282657	19.37038178	3.801813905	6.099503626	23.06971263	2.721566662	12.16137412	25.25703494	6.825979293	7.541293906

Supplementary Table S3 The indicators of lymphocytes were measured in different time points during the SARS-CoV-2 vaccination process from the healthy volunteers using flow cytometry.

Sample ID	The measurement of lymphocytes before vaccination								The measurement of lymphocytes at 2 weeks after first dose								The measurement of lymphocytes at 1 week after second dose								The measurement of lymphocytes at 2 weeks after second dose							
	CD3	CD3CD8	CD3CD4	CD3CD4CD8	CD16CD56	CD19	4/8Ratio	Lym	CD3	CD3CD8	CD3CD4	CD3CD4CD8	CD16CD56	CD19	4/8Ratio	Lym	CD3	CD3CD8	CD3CD4	CD3CD4CD8	CD16CD56	CD19	4/8Ratio	Lym	CD3	CD3CD8	CD3CD4	CD3CD4CD8	CD16CD56	CD19	4/8Ratio	Lym
F01	85.03	38.25	44.13	1.16	4.68	9.31	1.15	4403	82.56	37.01	43.04	1.2	6.95	9.6	1.16	6576	83.91	35.91	44.88	0.67	5.48	9.06	1.25	5825	85.45	35.42	47.7	0.95	3.89	8.97	1.35	5706
F02	58.91	16.27	39.34	0.62	26.68	12.97	2.42	5668	65.82	16.51	45.66	0.28	17.73	15.28	2.77	5725	66.3	15.27	47.41	0.36	17.42	15.12	3.11	6066	64.96	15.98	45.57	0.29	16.04	16.5	2.85	7480
F03	75.53	34.47	37.36	2.5	14.01	9.8	1.08	5530	77.58	28.36	43.76	0.66	8.24	13.09	1.54	6806	75.8	31.9	37.55	1.27	10.66	12.9	1.18	4335	71.45	31.82	34.78	1.88	16.69	10.05	1.09	4638
F04	71.22	28.93	41.51	1.69	17.79	9.9	1.43	3958	68.76	30.7	36.86	1.7	22	8.48	1.2	4069	71.68	25.45	44.92	1.59	16.92	9.72	1.76	3210	71.62	25.94	44.56	1.4	15.21	11.08	1.72	4845
F05	71.75	23.99	38.45	0.74	17.39	10.18	1.6	3243	75	25.8	40.55	0.52	14.95	9.41	1.57	6600	76.4	24.26	45.54	0.95	12.09	10.76	1.88	3911	76.4	24.26	45.54	0.95	9.74	12.82	1.93	6583
F06	71.18	33.56	35.81	1.18	13.41	13.7	1.07	5233	73.92	33.52	38.41	0.9	10.57	14.82	1.15	5126	72.12	33.54	37.35	1.12	9.31	16.34	1.11	4627	71.04	31.71	37.12	0.88	10.48	16.43	1.17	5477
F07	58.74	22.67	32.52	0.3	30.09	9.87	1.43	4001	59.01	22.56	31.46	0.13	29.55	10.77	1.39	6065	69.71	25.96	38.99	0.17	16.22	11.66	1.5	7091	76.69	32.3	49.47	0	16.66	12.38	1.53	5295
F08	66.4	21.8	42.25	0.63	24.02	8.55	1.94	4738	74.48	25.21	45.87	0.52	16.8	8.1	1.82	6680	70.1	22.5	44.78	0.55	17.39	9.76	1.99	3986	70.42	24.14	43.11	0.64	15.42	11.41	1.79	5767
F09	72.67	26.74	41.62	0.45	14.64	12.19	1.56	4618	73.91	28.34	40.74	0.31	11.91	13.56	1.44	5879	74.1	24.43	46.72	0.44	8.42	14.61	1.91	4347	72.72	26.53	43.14	0.16	8.07	17.83	1.63	6762
F10	63.26	19.01	38.79	0.56	26.71	7.7	2.04	4298	66.72	19.22	41.59	0.57	24.62	8.12	2.16	5468	73.45	21.36	49.25	0.88	9.89	13.03	2.31	4258	71.1	21.84	44.41	0.39	13.86	9.65	2.03	5325
F11	71.97	28.38	40.53	0.24	10.81	16.75	1.43	4246	76.91	25.93	47.09	0.25	4.26	17.97	1.82	6744	71.56	27.45	40.56	0.38	10.65	16.73	1.48	4423	74.32	27.04	44.56	0.23	6.96	16.06	1.65	7458
F12	76.88	36.39	33.47	0.41	11.43	10.59	0.92	3702	82.45	37.45	38.76	0.73	8.32	8.7	1.04	5082	75.96	34.73	35.49	1.15	7.07	11.57	1.02	4184	78.4	34.94	38.11	0.52	6.93	12.92	1.09	6772
F13	63.12	24.91	33.79	0.55	29.53	6.75	1.36	3850	66.11	22.69	38.17	0.58	22.76	9.62	1.68	6696	68.35	26.08	36.13	0.51	13.19	11.78	1.39	4329	72.24	22.31	44.14	0.34	14.2	10.11	1.98	6429
F14	61.1	26.64	28.38	0.3	33.28	4.67	1.07	5740	69.59	26.01	37.45	0.41	23.45	6.07	1.44	8120	76.65	28.48	42.91	0.41	14.29	7.71	1.51	6591	79.92	32.71	50.85	0.2	19.88	7.32	1.55	5246
F15	70.12	29.18	36.75	0.73	18.79	10.01	1.26	3976	70.58	27.44	38.05	0.41	16.09	11.35	1.39	6098	69.92	28.99	38.24	1.29	15.47	9.88	1.32	5037	69.52	29.89	36.36	0.4	14.28	14.16	1.22	5762
M01	77.86	29.96	41.09	0.11	15.34	5.88	1.37	4459	81.76	28.51	47.15	0.14	9.46	7.29	1.65	6490	78.72	27.13	46.12	0.52	11.4	9.43	1.7	4412	82.33	28.04	49.57	0.2	7.59	8.34	1.77	6548
M02	66.29	27.43	36.11	0.84	17.83	15.31	1.32	2501	59.72	25.39	30.67	0.3	23.28	15.35	1.21	6293	68.35	26.08	36.13	0.51	13.19	11.78	1.39	4329	63.12	26.77	33.17	0.33	14.73	20.62	1.24	6747
M03	48.49	24.29	21.26	0.67	41.86	7.52	0.88	3273	44.47	21.12	20.18	0.51	48.02	6.61	0.96	4540	51.96	24.5	24.15	0.54	38.53	7.63	0.99	5739	48.5	23.81	21.31	0.41	41.83	7.57	0.89	4913
M04	67.83	32.13	27.6	0.65	20.33	9.82	0.86	2627	67.05	30.4	28.77	0.54	22.15	9.98	0.95	4049	70.58	33.83	29.88	0.62	15.11	13.15	0.88	4327	68.91	30.82	30.88	0.41	18.35	11.36	1	5140
M05	75.8	30.9	39.76	0.3	14.55	8.45	1.29	3951	79.98	25.02	48.87	0.2	7.29	9.67	1.95	4500	81.38	23.04	52.15	0.31	4.95	11.33	2.26	4140	80.7	23.35	52.14	0.37	5.09	10.91	2.23	5362
M06	68.19	31.14	32.72	0.49	19.03	12.09	1.05	3863	64.03	29.6	29.6	0.19	23.31	10.8	1	4835	79.28	32.27	41.09	0.55	18.02	11.53	1.27	4025	65.73	29.54	31.34	0.2	18.13	13.75	1.06	4908
M07	63.2	26.74	33.21	0.48	21.87	13.01	1.24	5195	67.5	26.84	38.47	0.47	15.71	16.16	1.43	5742	68.22	25.75	35.76	0.58	16.18	15.39	1.39	5022	70.1	22.33	44.78	0.55	16.73	9.76	2.01	3986
M08	57.27	23.78	30.47	0.51	21.61	10.57	1.28	4730	61.94	24.87	33.66	0.34	17.55	12.62	1.35	6103	60.36	24.53	32.25	0.27	19.27	18.32	1.31	4142	70.5	28.57	38.98	0.63	9.34	15.2	1.36	7145
M09	67.54	26.54	37.52	0.28	14.96	15.44	1.41	3937	61.52	23.92	34.6	0.52	21.2	14.98	1.45	4821	67.24	25.58	39.47	0.51	13.57	17.3	1.54	4930	63.64	23.86	36.43	0.24	15.05	18.34	1.53	5528
M10	63.97	23.28	35.56	0.52	25.92	9.3	1.53	3819	66.24	24.2	36.41	0.28	21.77	10.39	1.5	5388	63.95	22.63	35.4	0.39	22.74	11.74	1.56	5334	74.05	33.78	48.08	0.22	17.94	11.28	1.42	5331
M11	76.28	31.05	36.98	0.28	12.26	11.11	1.19	3221	76.74	31.52	38.57	0.22	12.15	10.37	1.22	4493	79.28	32.27	41.09	0.55	8.02	11.53	1.27	4025	75.75	31.08	37.87	0.48	9.63	13.34	1.22	5855
M12	71.02	32.08	36.09	0.54	14.64	13.22	1.13	4810	67.3	28.96	34.75	0.41	18.27	11.79	1.2	5666	71.17	31.61	35.72	1.15	10.96	16	1.13	4863	69.2	29.68	35.96	0.23	14.99	13.34	1.21	6910
M13	49.62	24.34	22.21	0.23	32.91	15.79	0.91	4363	52.82	24.95	25.17	0.32	30.9	13.47	1.01	5559	57.52	27.02	27.79	0.36	22.08	18.24	1.03	6196	50.46	22.37	25.39	0.21	27.85	18.92	1.14	6586
M14	55.75	28.37	24.68	0.41	26.39	17.31	0.87	4194	52.01	27.49	22.06	0.5	31.48	15.75	0.8	6370	56.4	28.28	24.8	0.41	24.31	17.99	0.88	5665	55.76	28.05	24.6	0.57	26.56	16.08	0.88	6617
M15	45.71	14.46	28.79	0.14	41.67	10.13	1.99	4946	51.47	14.69	34.17	0.18	35.29	11.42	2.33	5543	56.57	16.82	37.53	0.25	30.2	12.31	2.23	5963	50.46	16.03	31.93	0.23	37.25	11.14	1.99	6288
Mean	66.42333	27.256	34.9583	0.617	21.14767	10.92967	1.336	4236	67.932	26.47433	37.0187	0.476333	19.201	11.3863	1.45267	5737.53	70.233	26.9217	39.00167	0.642	15.1	12.81	1.51833	4844.4	69.79	27.12	39.689	0.472667	15.64567	12.921	1.51767	5913.633
Standard deviation	9.039099	5.379678	5.81577	0.47884	8.787076	3.111263	0.368254	798.7	9.5627	4.968588	7.09762	0.322382	9.455711	3.0402	0.43076	924.261	7.68163	4.8321	6.778944	0.355053	7.10977	3.0663	0.48851	904.229	8.926	4.95462	7.948821	0.380184	8.426919	3.4313	0.44435	876.4852

Supplementary Table S4 The indicators of host body were measured in different time points during the SARS-CoV-2 vaccination process from the healthy volunteers using routine blood test. Note: First represents the measurement of indicators of routine blood test before vaccination. Second represents the measurement of indicators of routine blood test at 2 weeks after first dose. Third represents the measurement of indicators of routine blood test at 1 week after second dose. Fourth represents the measurement of indicators of routine blood test at 2 week after second dose.

Sample ID	batch	Blood																								
		White blood cells WBC 10*9/L	Neutrophils Neu 10*9/L	Lymphocyte Lvm 10*9/L	Monocytes Mon 10*9/L	Eosinophils Eos 10*9/L	Basophil Bas 10*9/L	Red blood cells RBC 10*9/L	Hemoglobin concentration HGB g/L	Mean corpuscular volume MCV fL	Mean corpuscular hemoglobin MCH pg	Mean corpuscular hemoglobin concentration MCHC g/L	Red blood cell volume distribution width-SD RDW-SD fL	Platelet PLT 10*9/L	Mean platelet volume MPV fL	Platelet Distribution Width PDW	Plateletcrit PCT %	P-LCC	NEU%	LVM%	MON%	EOS%	BAS%	Hematocrit HCT %	RDW-CV	P-LCR
F01	First	6.12	2.84	2.85	0.37	0.04	0.02	4.04	116	83.1	28.6	28.6	42.7	149	12.1	16.5	0.18%	62	46.30%	43.30%	6.30%	0.80%	0.20%	34.90%	13.70%	41.80%
	Second	6.11	3.02	2.65	0.38	0.05	0.01	4.16	119	83.8	28.5	28.5	40.8	169	12.1	16.4	0.21%	71	49.40%	54.40%	6.30%	4.00%	0.20%	36.10%	13.00%	42.00%
	Third	5.45	1.92	2.96	0.34	0.22	0.01	4.29	124	84	28.8	28.8	40.9	174	12.3	16.6	0.21%	76	35.10%	40.20%	6.30%	1.30%	0.40%	33.90%	13%	43.50%
	Fourth	6.21	3.22	2.5	0.39	0.08	0.02	4.05	117	83.6	28.9	28.9	39.9	163	11.6	16.5	0.19%	64	51.80%	34.00%	5.50%	1.20%	0.01%	35.40%	12.80%	39.00%
F02	First	4.89	1.81	2.58	0.43	0.05	0.02	4.59	118	79.2	25.6	324	49	263	9.8	15.6	0.26%	65	36.90%	46.30%	7.70%	1.10%	0.10%	37.20%	16.60%	24.90%
	Second	5.3	2.37	2.45	0.41	0.06	0.01	4.61	119	80.8	25.9	320	48.1	236	10.2	15.9	0.24%	68	44.80%	58.70%	6.60%	1.80%	0.30%	34.20%	16.00%	28.80%
	Third	4.03	1.35	2.37	0.27	0.03	0.01	4.22	113	81.1	26.7	330	46.2	210	10.3	15.9	0.22%	59	33.60%	60.70%	9.00%	0.90%	0.30%	36.00%	15.30%	28.20%
	Fourth	4.24	1.24	2.57	0.38	0.04	0.01	4.45	118	81	26.5	327	45.1	225	9.5	15.7	0.21%	53	29.10%	52.80%	7.90%	1.10%	0.90%	37.90%	14.90%	23.50%
F03	First	4.91	1.93	2.74	0.18	0.05	0.01	3.98	117	85.7	29.4	343	40.7	250	9.1	15.9	0.23%	52	39.20%	47.50%	5.30%	1.90%	0.30%	36.40%	12.80%	20.70%
	Second	5.2	2.33	2.47	0.28	0.1	0.02	4.2	123	86.5	29.4	339	41.8	199	9.4	16	0.19%	46	45.00%	43.40%	4.10%	1.90%	0.00%	35.50%	13.00%	23.20%
	Third	5.62	2.9	2.44	0.23	0.05	0	4.17	120	25.1	28.8	338	40.7	213	9.2	15.9	0.20%	46	51.60%	33.70%	3.70%	0.30%	0.20%	36.50%	12.90%	21.70%
	Fourth	8.62	5.35	2.9	0.32	0.03	0.02	4.35	124	83.9	28.5	340	40.1	222	8.9	15.9	0.20%	43	62.10%	38.30%	7.00%	2.40%	0.20%	33.20%	12.80%	19.30%
F04	First	6.24	3.2	2.53	0.42	0.07	0.02	4.95	140	83.8	28.2	337	37.5	200	11.2	16.2	0.22%	72	51.30%	34.30%	6.40%	1.40%	0.20%	40.40%	12.00%	36.00%
	Second	7.14	4.12	2.45	0.46	0.1	0.01	4.87	140	83	28.8	347	37	190	11.7	16.2	0.22%	76	57.70%	29.60%	5.10%	1.90%	0.30%	40.00%	11.90%	40.30%
	Third	8.53	3.8	2.52	0.44	0.16	0.03	4.81	135	83	28	338	36.3	198	11.3	16.3	0.22%	73	63.10%	38.90%	6.30%	0.70%	0.40%	38.90%	11.80%	36.80%
	Fourth	7.28	3.91	2.83	0.46	0.05	0.03	4.76	134	81.7	28.2	345	36.5	198	11.1	16.4	0.22%	72	53.70%	36.60%	6.30%	1.30%	0.20%	38.10%	12.00%	36.10%
F05	First	5.06	3.14	1.61	0.23	0.06	0.02	4.19	124	86.5	29.6	342	39.6	204	9.2	15.7	0.19%	42	62.10%	37.20%	6.00%	2.20%	0.50%	36.40%	12.30%	20.70%
	Second	6.24	3.38	2.32	0.37	0.14	0.03	4.18	123	87.1	29.4	338	40.5	232	8.8	15.8	0.21%	42	54.10%	37.20%	4.70%	2.80%	0.40%	36.70%	12.50%	17.90%
	Third	5.61	3.08	2.09	0.26	0.16	0.02	4.2	124	87.5	29.6	338	40.7	204	9.1	15.6	0.19%	39	54.90%	36.10%	6.70%	1.70%	0.50%	34.80%	12.50%	19.00%
	Fourth	5.22	2.87	1.88	0.35	0.09	0.03	4.06	118	85.7	29.1	339	39.5	196	8.7	15.8	0.17%	35	55.00%	27.90%	6.10%	1.70%	0.40%	36.20%	12.30%	17.80%
F06	First	6.46	2.61	3.34	0.42	0.08	0.01	4.17	134	92.2	32	347	41.2	235	9.5	15.9	0.22%	53	40.40%	46.90%	5.80%	1.20%	0.30%	39.20%	12.10%	22.60%
	Second	5.64	2.57	2.65	0.33	0.07	0.02	4.28	132	91.5	30.9	337	40.1	255	9.2	15.6	0.23%	52	45.80%	45.50%	5.50%	1.20%	0.30%	38.30%	11.80%	20.30%
	Third	6.57	3.12	2.99	0.36	0.08	0.02	4.24	133	90.3	31.4	348	38.7	278	9	15.7	0.25%	55	47.50%	43.70%	6.60%	0.80%	0.30%	40.10%	11.50%	19.70%
	Fourth	7.28	3.54	3.18	0.48	0.06	0.02	4.47	137	89.7	30.7	342	37.9	272	9.4	16.1	0.26%	65	48.60%	44.10%	7.70%	2.10%	0.40%	36.80%	11.30%	24.00%
F07	First	5.35	2.65	2.14	0.48	0.05	0.03	4.98	134	80.6	26.9	333	38.5	177	10.3	16	0.18%	52	49.60%	39.10%	6.50%	1.20%	0.60%	42.20%	12.90%	29.20%
	Second	4.97	2.62	1.94	0.32	0.06	0.03	5.19	136	81.3	26.1	321	38.7	219	9.9	15.8	0.22%	56	52.60%	38.50%	6.90%	1.40%	0.20%	37%	12.80%	25.70%
	Third	4.76	2.52	1.83	0.33	0.07	0.01	4.61	128	80.2	27.6	345	38.4	195	10	16	0.20%	51	53%	39.40%	7.50%	1.20%	0.30%	37.50%	12.80%	26.20%
	Fourth	5.29	2.73	2.08	0.4	0.06	0.02	4.65	129	80.5	27.8	345	39	196	10.2	16.1	0.20%	56	51.60%	31.00%	6.90%	0.90%	0.50%	38.90%	13.00%	28.30%
F08	First	8.1	3.68	3.9	0.32	0.17	0.03	4.34	135	90.7	31	341	40.9	317	8.4	16	0.27%	51	45.40%	41.60%	4.40%	2.40%	0.40%	38.80%	12.10%	16.20%
	Second	7.57	3.88	3.15	0.33	0.18	0.03	4.28	132	90.8	31	341	40.8	319	8.4	15.9	0.27%	48	51.20%	37.50%	4.20%	1.70%	0.40%	40.90%	12.10%	15.10%
	Third	7.58	4.26	2.84	0.32	0.13	0.03	4.53	141	90.4	31.3	346	40.8	334	2.2	16	0.28%	53	56.20%	32.90%	4.20%	1.50%	0.50%	41.00%	12.20%	15.80%
	Fourth	8.77	5.34	2.89	0.37	0.13	0.04	4.57	141	89.6	30.8	344	40.7	370	8.3	15.9	0.31%	59	60.90%	32.10%	4.20%	1.30%	0.40%	37.80%	12.20%	15.90%
F09	First	5.32	2.27	2.48	0.51	0.05	0.01	4.53	128	85.4	28.3	331	41.6	194	9.6	16.2	0.19%	45	42.80%	45.50%	9.40%	0.90%	0.10%	39.80%	13.10%	23.20%
	Second	6.36	2.8	2.89	0.6	0.06	0.01	4.74	134	83.8	28.2	336	39.7	191	9.1	15.9	0.17%	39	44.10%	41.50%	9.30%	1.50%	0.10%	93.10%	12.70%	20.50%
	Third	5.36	2.55	2.22	0.5	0.08	0.01	4.66	130	83.9	27.8	332	40.2	209	9.4	15.9	0.20%	46	47.60%	44.40%	7.80%	0.90%	0.10%	39.30%	12.80%	21.90%
	Fourth	6.05	2.83	2.69	0.47	0.05	0.01	4.7	130	83.6	27.6	330	40.2	207	9.2	15.9	0.19%	43	46.80%	42.10%	9.30%	2.00%	0.10%	36.80%	12.90%	20.50%
F10	First	5.2	2.4	2.21	0.32	0.25	0.02	4.39	109	79	24.9	315	43.9	237	10.3	15.6	0.24%	69	46.20%	33.80%	7.70%	3.40%	0.50%	35.50%	14.90%	29.20%
	Second	5.29	2.88	1.79	0.41	0.18	0.03	4.5	111	79	24.6	312	42.2	225	10.5	26.1	0.26%	72	54.60%	40.70%	3.20%	6.80%	0.50%	33.55%	14.30%	32.10%
	Third	4.61	2.25	1.88	0.15	0.31	0.02	4.27	106	78.5	24.7	315	41.5	252	11.6	15.8	0.29%	99	48.80%	39.60%	5.70%	5.30%	0.10%	32.30%	14.20%	39.20%
	Fourth	4.54	2.24	1.8	0.26	0.24	0	4.15	103	77.7	24.9	320	41.3	199	10.2	16	0.20%	58	49.30%	32.00%	5.30%	2.90%	0.40%	32.40%	14.30%	28.90%
F11	First	4.05	1.99	1.66	0.32	0.06	0.02	4.47	97	69.6	21.6	311	41.2	234	10.5	15.7	0.25%	76	49.20%	48.80%	7.70%	2.20%	0.50%	31.60%	15.80%	32.60%
	Second	3.04	1.24	1.48	0.23	0.07	0.02	4.54	99	69.7	21.9	314	41	286	20.6	15.9	0.30%	96	40.80%	39.20%	6.90%	2.30%	0.30%	30.80%	15.80%	33.70%
	Third	4.46	2.29	1.75	0.31	0.1	0.01	4.47	96	68.9	21.4	311	39.9	290	10.7	15.7	0.31%	98	51.30%	50.60%	7.50%	2.20%	0.40%	30.50%	15.50%	34.00%
	Fourth	4.14	1.63	2.09	0.31	0.09	0.02	4.5	97	67.8	21.6	318	39.2	277	10.4	16	0.29%	88	39.30%	45.70%	8.10%	2.90%	0.50%	29.70%	15.50%	31.80%
F12	First	6.81	3.81	2.45	0.41	0.12	0.02	4.17	128	87.1	30.7	352	38	215	10.6	16	0.23%	66	56.00%	35.20%	7.30%	1.50%	0.40%	36.30%	11.70%	30.80%
	Second	5.26	2.63	1.85	0.38	0.08	0.02	4.2	127	86.4	30.4	358	36.8	228	9.9	15.9	0.23%	58	55.60%	35.20%	7.00%	2.10%	0.30%	38.40%	11.40%	25.30%
	Third	6.78	3.76	2.39	0.47	0.14	0.02	4.56	134	84.2	29.5	350	35.7	239	9.7	15.9	0.23%	58	55.40%	44.90%	6.20%	1.90%	0.30%	36.80%	11.40%	24.40%
	Fourth	6.74	3.14	3.03	0.42	0.13	0.02	4.34	129	84.9	29.7	349	36.7	255	9.4	15.8	0.24%	56	46.70%	39.80%	6.90%	1.90%	0.40%	39.80%	11.60%	21.90%
F13	First	5.68	3.06	2.23	0.31	0.06	0.02	3.98	126	89	31.6	355	37.4	239	8.5	15.7	0.20%	38	53.80%	35.80%	5.50%	1.30%	0.40%	36.10%	11.30%	16.00%
	Second	4.9	2.8	1.75	0.27	0.06	0.02	4.04	129	89.4	31.9	357	37.9	232	8.25	15.7	0.20%	37	57%	45.50%	5.70%	3.80%	0.40%	35.00%	11.40%	16.10%
	Third	4.2	1.87	1.91	0.24	0.16	0.02	3.95	122	88.8	30.8	347	38.6	220	8.3	15.9	0.18%	33	45%	38.90%	4.80%	1.80%	0.30%	38.40%	11.70%	15.10%
	Fourth	5.52	2.99	2.15	0.26	0.1	0.02	4.27	133	89.8	31.2	347	39.7	251	8.3	15.7	0.21%	38	54.20%	43.20%	6.20%	2.00%	0.50%	34.10%	11.90%	15.30%
F14	First	9.12	3.42	4.98	0.48	0.21	0.03	4.72	134	81.7	28.3	347	36	261	9.1	15.9	0.24%	53	37.50%	55.60%	6%	2.30%	0.40%	39%	11.80%	20.20%
	Second	5.85	2.1	3.25	0.35	0.13	0.02	4.62	130	85	28.1	331	37.8	242	9.2	16	0.22%	51	35.70%	44.70%	4.90%	2.30%	0.10%	37.90%	12%	21.10%
	Third	5.84	2.8	2.61	0.29	0.13	0.01	4.64	132	81.7	28.4	347	39.5	239	9.1	15.9	0.22%	49	48%	55.30%	4.70%	1.60%	0.40%	36.70%	11.70%	20.50%
	Fourth	4.96	1.89	2.74	0.23	0.08	0.02	4.41	124	83.2	28	336	37.3	208	9.3	15.9	0.19%	46	38.00%	51.20%	5.90%	1.30%	0.40%	36.80%	12.10%	22.00%
F15	First	12.36	6.7	4.78	0.72	0.12	0.04	4.57	144	85.7	31.4	367	37.5	287	9.2	15.9	0.26%	61	54.20%	38.70%	5.80%	1.00%	0.30%	39.10%	11.70%	21.30%
	Second	11.92	6.74	4.46	0.57	0.14	0.01	4.99	140	87.5	29.9	342	39.6	260	9.7	15.8	0.25%	63	56.50%	37.40%	4.80%	1.20%	0.10%	41%	12.10%	24.30%
	Third	10.33	4.64	4.98	0.51	0.19	0.01	4.65	140	87.4	30	343	39.3	259	10.5	15.9	0.27%	82	45%	48.20%	4.90%	1.80%	0.10%	40.70%	12.10%	31.50%
	Fourth	8.23	4.23	3.37	0.5	0.12	0.01	4.14	124	86.6	30	347	38.5	205	9.4	16	0.19%	45	51.40%	41.00%	6.10%	1.40%	0.10%	35.80%	11.90%	22.00%
M01	First	8.48	4.2	3.69	0.38	0.2	0.01	5.39	159	85.7	29.6	345	39.2	294	9.6	16.2	0.28%	73	49.50%	43.50%	4.50%	2.40%	0.10%	46.20%	12.30%	24.90%
	Second	6.58	2.78	3.17	0.32	0.28	0.03	5.08	155	85.4	30.5	357	38.6	256	9.7	16.2	0.25%	65	42.30%	48.20%	4.80%	4.30%	0.40%	43.40%	12.10%	25.50%
	Third	7.1	3.46	2.89	0.38	0.36	0.01	5.22	154	85.8	29.4	343	40.1	234	10.2	16.4	0.24%	67	48.70%	40.70%	5.30%	5.10%	0.20%	44.80%	12.60%	28.70%
	Fourth	7.25	3.37	3.1	0.46	0.28	0.04	5.11	153	85.7	29.9	349	39.9	255	9.6	16.3	0.25%	63	46.60%	42.80%	6.30%	3.80%	0.50%	43.80%	12.50%	24.80%
M02	First	5.51	3.33	1.41	0.7	0.05	0.02	4.71	145	87.2	30.8	354	37.9	183	9.7	16.2	0.18%	45	60.50%	25.60%	12.70%	0.90%	0.30%	41.00%	11.60%	24.40%
	Second	5.15	2.48	2.09	0.41	0.14	0.03	4.7	142	87.9	30.2	344	38.3	198	8.9	15.8	0.18%	37	48.30%	40.60%	7.90%	2.70%	0.50%	41.30%	11.70%	18.60%
	Third	5.7	2.95	2.21	0.42	0.11	0.01	4.81	148	87.9	30.9	351	40.3	208	9.2	16	0.19%	42	51.80%	38.70%	7.30%	2.00%	0.20%	42.30%	12.30%	20.10%
	Fourth	7.38	3.9	2.81	0.61	0.05	0.01	4.91	150	87.3	30.6	350	39.2	205	9.2	16.1	0.19%	43	52.80%	38.10%	8.20%	0.70%	0.20%	42.90%	12.10%	20.80%
M03	First	7.12	4.38	2.23	0.41	0.09	0.01	5.22	150	83.7	28.8	345	38	248	9	16.1	0.22%	53	61.70%	31.30%	5.70%	1.20%	0.10%	43.60%	12.20%	21.40%
	Second	6.46	3.59	2.34	0.42	0.1	0.01	5.53	155	83.2	27.9	336	37.4	250	9.1	16	0.23%	51	55.50%	36.30%	6.50%	1.50%	0.20%	46%	12.00%	20.50%
	Third	6.71	3.29	2.87	0.4	0.14	0.01	5.31	150	83.7	28.3	338	38.7	236	9.1	15.9	0.22%	48	49%	42.70%	6.00%	2.10%	0.20%	44.50%	12.40%	20.20%
	Fourth	9.13	4.9	3.5	0.58	0.14	0.01	5.52	155	81.2	28.1	346	36.4	248	8.7	15.9	0.22%	46	53.70%	38.30%	6.40%	1.50%	0.10%	44.80%	12.00%	18.60%
M04	First	7.4	4.7	1.88	0.4	0.41	0.01	5.03	151	85.5	29.9	350	40.1	250	9.1	16.1	0.23%	51	63.40%	25.40%	5.40%	5.60%	0.20%	43.00%	12.60%	20.30%
	Second	7.06	3.98	2.24	0.35	0.47	0.02	5.01	149	85.9	29.8	347	40.5	245	9	16.1	0.22%	51	56.40%	31.70%	5%	6.60%	0.30%	43%	12.60%	20.90%
	Third	8.57	5.06	2.52	0.46	0.51	0.02	5.09	148	86.2	29.1	337	39.8	285	8.6	16	0.24%	52	59%	29.40%	5.40%	6.00%	0.20%	43.90%	12.40%	18.20%
	Fourth	8.66	5.11	2.69	0.42	0.42	0.02	5.12	150	84.5	29.3	346	38.8	294	8.6	16.1	0.25%	52	59.00%	31.10%	4.90%	4.80%	0.20%	43.30%	12.30%	17.70%
M05	First	5.24	2.66	2.03	0.34	0.19	0.02	5.26	153	85.2	29.1	342	38.4	231	9.2	16.1	0.21%	51	50.70%	38.80%	6.50%	3.60%	0.40%	44.80%	12.20%	22.10%
	Second	5.53	3.08	1.92	0.34	0.18	0.01	5.17	152	84.4	29.3	348	38	245	9.7	16.4	0.24%	61	55.70%	34.70%	6.20%	3.20%	0.20%	43.60%	12.10%	25.00%
	Third	5.85	2.95	2.32	0.27	0.3	0.01	5.18	152	83.4	29.3	351	37.7	261	9.1	16.1	0.24%	56	50.20%	39.70%	4.17%	5.20%	0.20%	43.20%	12.10%	21.50%
	Fourth	6.52	3.91	2.05	0.31	0.24	0.01	5.06	149	83.1	29.5	356	37.4	272	9.1	16.1	0.25%	58	60.00%	31.40%	4.70%	3.70%	0.20%	42.00%	12.10%	21.30%
M06	First	5.6	2.92	2.19	1.44	0.19	0.01	5.4	155	83.9	28.6	341	36.5	311	9	16	0.28%	64	52.10%	39.10%	5.20%	3.40%	0.20%	45.30%	11.70%	20.60%
	Second	5.02	2.29	2.27	0.26	0.18	0.02	5.44	153	83.9	28.2	336	36.9	254	8.8	15.7	0.22%	46	45.70%	45.30%	5.20%	3.50%	0.30%	45.60%	11.80%	18.10%
	Third	5.66	3.09	2.1	0.27	0.19	0.01	5.51	156	83.6	28.3	339	38	306	8.7	16	0.27%	55	54.60%	37.10%	4.70%	3.40%	0.20%	46.10%	12.20%	17.90%
	Fourth	4.91	2.81	1.67	0.32	0.1	0.01	5.43	151	83.3	27.8	334	37.7	312	8.4	15.6	0.26%	49	57.10%	34.00%	6.50%	2.10%	0.30%	45.20%	12.10%	15.80%
M07	First	4.01	1.14	2.17	0.28	0.09	0.03	4.95	146	87.9	29.4	334	39.7	185	11.3	16.6	0.21%	67	35.80%	54.20%	7.00%	2.20%	0.80%	43.50%	12.20%	36.10%
	Second	4.47	1.69	2.46	0.24	0.07	0.61	5.01	146	87.5	29.2	334	39.1	183	11.7	16.6	0.21%	72	38.00%	55%	5.30%	1.50%	0.20%	43.80%	12%	39.40%
	Third	5.56	2.33	2.69	0.36	0.16	0.02	4.89	144	87.8	29.5	336	39.6	177	12.6	16.4	0.22%	82	42.10%	48.30%	6.40%	2.80%	0.40%	42.90%	12.10%	46.20%
	Fourth	5.08	2.43	2.24	0.34	0.06	0.01	5	147	87.7	29.3	335	39.9	164	11.4	16.5	0.19%	59	47.80%	44.10%	6.70%	1.20%	0.20%	43.80%	12.20%	36.20%
M08	First	5.98	2.57	2.81	0.45	0.14	0.01	5.74	167	85.4	29.2	342	39	240	9	15.7	0.22%	46	42.90%	47.00%	7.60%	2.30%	0.20%	49.00%	12.30%	19.30%
	Second	6.32	2.69	3.01	0.45	0.15	0.02	5.54	166	85.3	30	352	38.9	244	7.9	15.5	0.19%	30	42.60%	47.70%	7.10%	2.30%	0.30%	47.30%	12.20%	12.30%
	Third	6.36	2.61	3.05	0.44	0.24	0.02	5.58	167	86.1	29.9	347	39.5	235	8.2	15.6	0.19%	34	41%	48.00%	6.90%	3.80%	0.30%	48.00%	12.40%	14.60%
	Fourth	6.74	2.65	3.38	0.49	0.18	0.04	5.52	165	84.9	29.8	352	38.5	249	7.9	15.6	0.20%	33	39.50%	50.10%	7.20%	2.60%	0.60%	46.90%	12.20%	13.40%
M09	First	6.11	3.28	2.34	0.36	0.13	0	4.9	144	87.8	29.4	335	42.2	266	8.8	16	0.24%	51	53.70%	38.30%	5.90%	2.10%	0.00%	43.00%	12.90%	19.30%
	Second	7.16	4.4	2.58	0.36	0.21	0.01	5.2	152	88.1	29.2	332	41.4	267	8.8	16.2	0.24%	54	55.90%	36.00%	5.00%	2.90%	0.20%	45.80%	12.70%	20.20%
	Third	9.81	5.57	3.57	0.46	0.21	0	5.3	156	85.9	29.5	344	38.8	290	8.8	16.1	0.26%	56	56.80%	36.40%	4.70%	2.10%	0.00%	45.50%	12.20%	19.40%
	Fourth	8.69	4.58	3.34	0.56	0.18	0.03	5.37	156	85.1	29.1	342	39	295	8.5	16	0.25%	49	52.80%	38.40%	6.40%	2.10%	0.30%	45.70%	12.30%	16.70%
M10	First	7.84	4.34	2.91	0.42	0.14	0.03	5.31	150	83.8	28.2	337	37.4	248	9.9	16.4	0.25%	66	55.40%	37.10%	5.30%	1.80%	0.40%	44.50%	12.00%	26.60%
	Second	6.92	3.14	3.22	0.34	0.18	0.04	5.25	149	84.7	28.3	335	37.8	266	9.8	16.4	0.26%	69	45.30%	46.60%	4.90%	2.60%	0.60%	44.40%	12.00%	25.90%
	Third	7.7	3.51	3.59	0.37	0.21	0.02	5.25	151	83.7	28.8	344	37.3	237	9.8	16.3	0.23%	64	45.60%	46.60%	4.80%	2.70%	0.30%	44%	11.90%	26.80%
	Fourth	8.39	4.59	3.26	0.42	0.09	0.03	4.84	140	84.3	28.9	343	37.7	228	9.6	16.3	0.22%	56	54.70%	38.80%	5.00%	1.10%	0.40%	40.80%	12.00%	24.40%
M11	First	6.29	3.78	2.13	0.28	0.09	0.01	5.56	165	87	29.7	342	40	183	11.4	16.8	0.21%	68	60.20%	33.80%	4.40%	1.40%	0.20%	48.40%	12.40%	37.30%
	Second	6.25	3.47	2.39	0.31	0.06	0.02	5.24	154	86.8	29.4	338	40	177	11.3	16.5	0.20%	65	55.70%	38.20%	4.90%	0.90%	0.30%	45.50%	12.40%	36.90%
	Third	7.84	4.59	2.69	0.38	0.16	0.02	5.4	162	87.2	30	344	41.3	219	10.7	16.7	0.24%	73	58.50%	34.30%	4.90%	2.10%	0.20%	47.10%	12.70%	33.10%
	Fourth	8.83	5.14	3.21	0.36	0.1	0.02	5.29	159	86.4	30.1	348	40.7	206	10.8	16.6	0.22%	70	58.20%	36.40%	4.10%	1.10%	0.20%	45.70%	12.60%	34.10%
M12	First	7.06	2.91	3.39	0.44	0.3	0.02	4.56	135	87.7	29.5	337	37.2	326	8.1	15.6	0.26%	45	41.20%	48.00%	6.30%	4.20%	0.30%	40.00%	11.40%	13.90%
	Second	8.01	3.29	3.8	0.54	0.34	0.04	4.57	139	88.3	30.4	344	38.5	291	8.2	15.5	0.24%	40	41.10%	47.40%	6.80%	4.20%	0.50%	40.30%	11.70%	13.60%
	Third	6.47	2.39	3.38	0.37	0.3	0.03	4.41	136	89	30.7	345	39.2	268	8.47	15.7	0.23%	39	37%	52.30%	5.70%	4.60%	0.40%	39.20%	11.80%	14.60%
	Fourth	7.25	2.78	3.65	0.46	0.32	0.04	4.61	141	87.8	30.6	348	38.3	276	8.3	15.7	0.23%	41	38.30%	50.40%	6.40%	4.40%	0.50%	40.50%	11.70%	14.90%
M13	First	5.95	3.03	2.59	0.26	0.06	0.01	5.26	155	85.1	29.4	346	39.3	303	8.6	15.8	0.21%	51	51.00%	43.50%	4.40%	1.00%	0.10%	44.80%	12.40%	16.90%
	Second	7.84	4.26	3.22	0.25	A	0.02	5.03	152	85.7	30.2	352	38.1	291	9	15.8	0.26%	55	54.40%	41.10%	3.20%	1.10%	0.20%	43.10%	11.90%	18.80%
	Third	7.14	3.56	2.91	0.4	0.21	0.06	5.21	154	85.6	29.6	346	38.7	329	8.4	15.7	0.28%	52	49.80%	40.70%	5.60%	3.00%	0.90%	44.60%	12.10%	15.70%
	Fourth	6.95	3.39	2.98	0.47	0.09	0.02	5.15	156	84.3	30.3	359	37.5	297	8.2	15.7	0.25%	44	48.80%	42.90%	6.70%	1.30%	0.30%	43.40%	11.90%	14.80%
M14	First	7.37	3.96	3	0.35	0.05	0.01	5.47	157	85.3	28.7	336	43.5	191	9.5	16.2	0.18%	45	53.60%	40.70%	4.80%	0.70%	0.20%	46.70%	13.70%	23.80%
	Second	8.4	3.53	4.42	0.36	0.06	0.03	5.42	155	85.6	28.5	333	43	205	9.4	16.2	0.19%	48	42.10%	52.60%	4.30%	0.70%	0.30%	46.40%	13.50%	23.20%
	Third	7.35	3.3	3.76	0.23	0.06	0	5.55	158	85.4	28.5	334	43.5	206	8.8	15.9	0.18%	38	44.90%	51.20%	3.10%	0.80%	0.00%	47.40%	13.60%	18.40%
	Fourth	6.39	2.82	3.23	0.28	0.05	0.01	5.63	163	83.5	29.1	348	41.2	185	8.7	15.9	0.16%	35	44.20%	50.50%	4.40%	0.80%	0.10%	47.00%	13.20%	18.90%
M15	First	7.74	3.4	3.62	0.53	0.17	0.02	5.54	163	86.3	29.4	339	39.1	228	9.7	16.1	0.22%	56	43.80%	46.80%	6.90%	2.20%	0.30%	48.00%	12.20%	24.80%
	Second	6.22	2.77	2.9	0.4	0.14	0.01	5.28	156	86.1	29.5	342	38.2	221	9.4	16	0.21%	49	44.40%	46.70%	6.50%	2.20%	0.20%	45.50%	11.90%	22.00%
	Third	6.93	3.3	3.01	0.49	0.12	0.01	5.27	155	85.7	29.4	343	38.8	231	9.3	15.9	0.22%	52	47.50%	43.50%	7.00%	1.80%	0.20%	45.20%	12.10%	22.50%
	Fourth	8.18	3.91	3.42	0.65	0.16	0.04	5.44	161	84.5	29.6	350	37.8	236	9.4	15.9	0.22%	53	47.70%	41.80%	8.00%	2.00%	0.50%	46.00%	12.00%	22.60%
Mean	First	6.45	3.2	2.7	0.43	0.12	0.018	4.79	139.3	84.89	28.93	340.47	39.77	238.3	9.64	16.02	0.25%	56.3	49.54%	41.98%	6.26%	1.93%	0.29%	40.85%	12.63%	24.57%
	Second	6.27	3.1	2.65	0.37	0.14	0.04	4.83	138.97	85.15	28.85	338.77	39.62	235.87	9.92	16.33	0.23%	55.6	49.08%	42.55%	6.01%	2.17%	0.32%	40.99%	12.51%	24.24%
	Third	6.48	3.17	2.71	0.36	0.18	0.016	4.81	138.97	82.73	28.87	340.43	39.62	241.2	9.42	15.99	0.23%	57.57	49.07%	42.31%	5.58%	2.83%	0.26%	42.56%	12.54%	24.51%
	Fourth	6.78	3.45	2.77	0.41	0.13	0.02	4.8	138.47	84.1	28.9	342.7	39.05	238.87	9.3	16	0.22%	52.4	50%	41.65%	6.17%	1.89%	0.31%	40.34%	12.49%	22.71%
Standard deviation	First	1.65	1.04	0.84	0.22	0.09	0.0087	0.5127	17.174	4.0387	2.04	2.6351	44.5175	0.9433	0.2918	0.0003	10.116	1.65	0.078	0.078	0.0186	0.0123	0.00156	0.0473	0.01208	0.0674
	Second	1.55	0.99	0.71	0.09	0.09	0.1062	0.4513	15.41316176	3.934	1.9991	2.2957	35.9831	2.232	1.8363	0.0003	14.02	1.55	0.065	0.0646	0.013	0.0128	0.00146	0.0406	0.0109	0.077
	Third	1.52	0.94	0.67	0.09	0.1	0.0114	0.4731	16.96567	11.4384	1.9374	1.9665	41.0117	1.7564	0.27	0.000333	16.907	1.52	0.0684	0.0671	0.013	0.01456	0.0017	0.1042	0.0096	0.0851
	Fourth	1.5	1.09	0.55	0.1	0.09	0.0111	0.4761	17.4771	4.0705	1.8926	1.7511	46.5974	0.9598	0.2633	0.000333	12.071	1.5	0.0753	0.069	0.01302	0.0126	0.0014	0.0448	0.0091	0.0687

Supplementary Table 20. The features used in TR1 analysis to reveal the contribution of Gut factors and are microbiome to the prediction of SARS-CoV-2 seropositive during the vaccination process of Siaram women.

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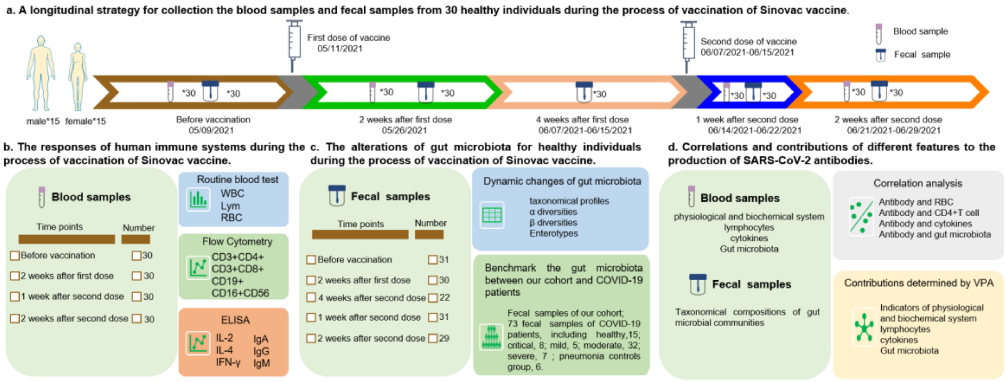
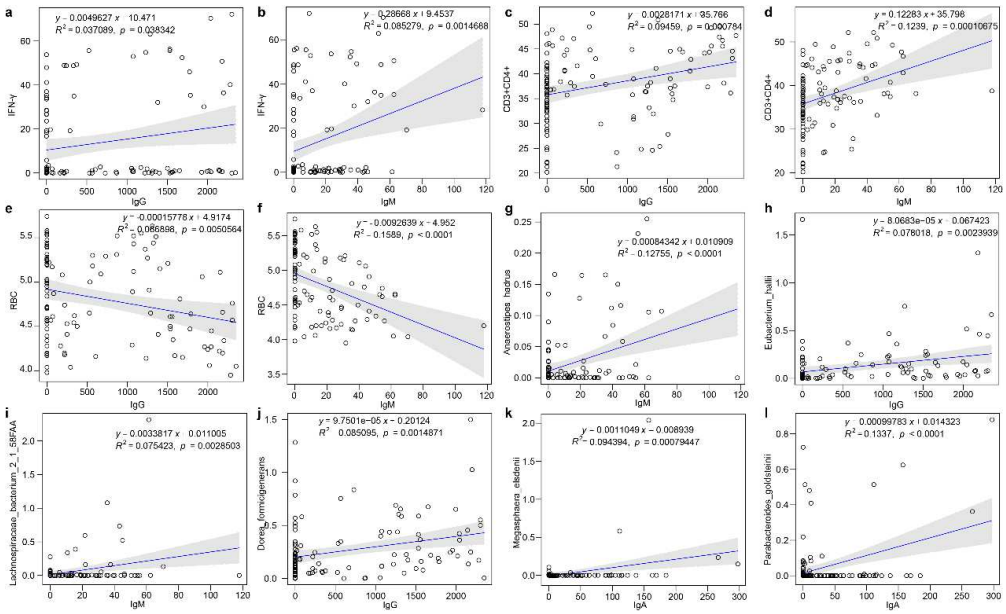
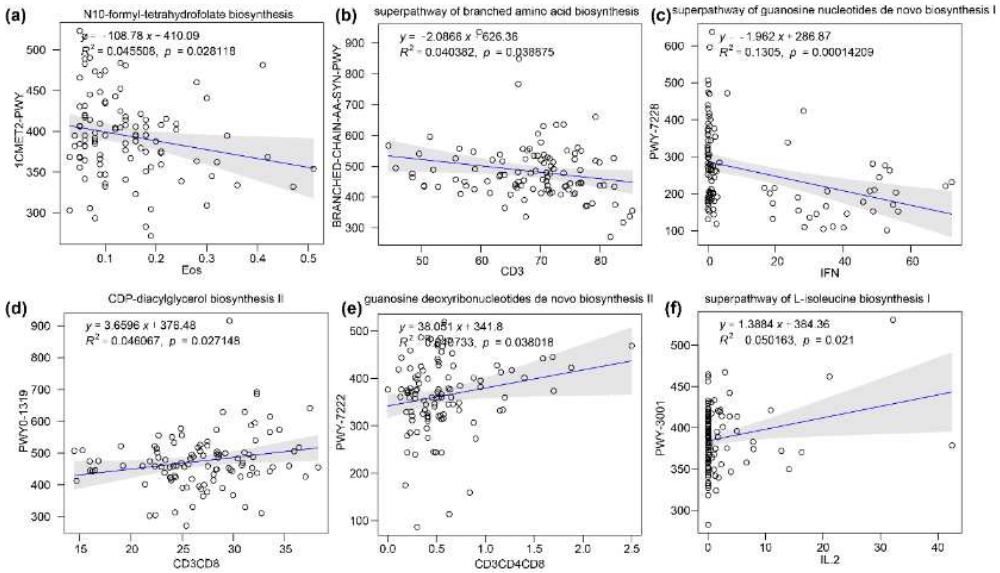


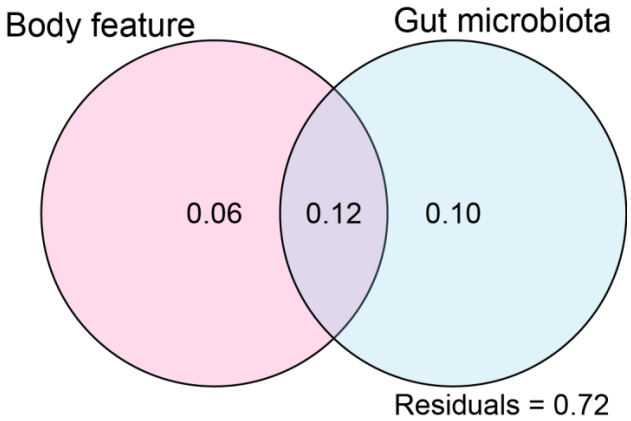
Supplementary Figure S1. A longitudinal sampling strategy for the collection of blood and fecal samples from 30 healthy individuals at different points during the process of SARS-CoV-2 vaccination was used to explore the dynamic patterns of immune systems, the gut microbiota, and the production of antibodies and their interactions. a: Longitudinal strategy for collecting blood and fecal samples from 30 healthy individuals during the process of vaccination with the Sinovac vaccine. **b:** Responses of human immune systems during the process of vaccination with the Sinovac vaccine. **c:** Alterations in the gut microbiota of healthy individuals during the process of vaccination with the Sinovac vaccine. **d:** Correlations and contributions of different features to the production of SARS-CoV-2 antibodies.



Supplementary Figure S2. **Correlations between the concentrations of antibodies against SARS-CoV-2 and the features of cytokines, indicators obtained from routine blood tests, lymphocytes, and the gut microbiota. (a)**A positive correlation was found between IFN-γ and IgG. **(b)** A positive correlation was found between IFN-γ and IgM. Positive correlations were detected between CD3CD4 and **(c)** IgG and between CD3CD4 and **(d)** IgM. Negative correlations were found **(e)** between RBCs and IgG and **(f)** between RBCs and IgM. The following correlations were also found between SARS-CoV-2 antibodies and gut microbes: **(g)** *Prevotella copri* and IgG, **(h)** *Eubacterium hallii* and IgG, **(i)** *Clostridium leptum* and IgG, **(j)** *Dorea formicigenerans* and IgG, **(k)** *Mgeasphaera elsdenii* and IgA, **(l)** *Parabacteroides goldsteinii* and IgA, **(m)** *Lactobacillus ruminis* and IgA, **(n)** *Ruminococcus torques* and IgM, **(o)** *Anaerostipe shadrus* and IgM, **(p)** *Lachnospiraceae bacterium* 2_1_58FAA and IgM.



Supplementary Figure S3. Correlations between metagenomic pathways and the features of cytokine and lymphocytes during the vaccination process of SARS-CoV-2 to highlight their relationship. Correlations between **(a)** 1CMET2-PWY: N10-formyl-tetrahydrofolate biosynthesis and Eos; **(b)** BRANCHED-CHAIN-AA-SYN-PWY: superpathway of branched amino acid biosynthesis and CD3; **(c)** PWY-7228: superpathway of guanosine nucleotides de novo biosynthesis I and IFN; **(d)** PWY0-1319: CDP-diacylglycerol biosynthesis II and CD3CD7; **(e)** PWY-7222: guanosine deoxyribonucleotides de novo biosynthesis II and CD3CD4CD8, and **(f)** PWY-3001: superpathway of L-isoleucine biosynthesis I and IL-2.



Supplementary Figure S4. Effects of gut microbiota, body features, and their interactions on the production of SARS-CoV-2 antibodies.

Dynamic changes in host immune system and gut microbiota are associated with the production of SARS-CoV-2 antibodies

Maozhen Han[1,†], Yixuan Huang[3,†], Hongya Gui[2,†], Yixuan Xiao[2,†], Maozhang He[2], Jiling Liu[2], Xiujing Cao[4], Meijuan Zheng[5], Min Lu[5], Weihua Jia[1], Hui Li[6], Xiaoyan Wang[7], Na Zhang[1], Shu-an Kong[3], Xiaohui Liu[8], Yonggui Wu[9,*], Fengchang Wu[8,*], Shenghai Huang[1,2*]

[1] School of Life Sciences, Anhui Medical University, Hefei, Anhui 230032, China

[2] Department of Microbiology, The Key Laboratory of Microbiology and Parasitology of Anhui Province, The Key Laboratory of Zoonoses of High Institutions in Anhui, School of Basic Medical Sciences, Anhui Medical University, Hefei, Anhui 230032, China

[3] Department of Clinical Medicine, the First School of Clinical Medicine, Anhui Medical University, Hefei, Anhui 230032, China

[4] Department of Epidemiology and Biostatistics, School of Public Health, Anhui Medical University, Hefei, Anhui 230032, China

[5] Department of Clinical Laboratory, the First Affiliated Hospital of Anhui Medical University, Hefei, Anhui 230032 China

[6] Hefei City Maternal and Child Health & Family Planning Service Center, Hefei, Anhui 230001, China

[7] Department of Pediatrics, the First Affiliated Hospital of Anhui Medical University, Hefei, Anhui 230032, China

[8] State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing 100012, China

[9] Department of Nephropathy, the First Affiliated Hospital of Anhui Medical University, Hefei, Anhui 230032, China

[†]These authors contributed equally to this work.

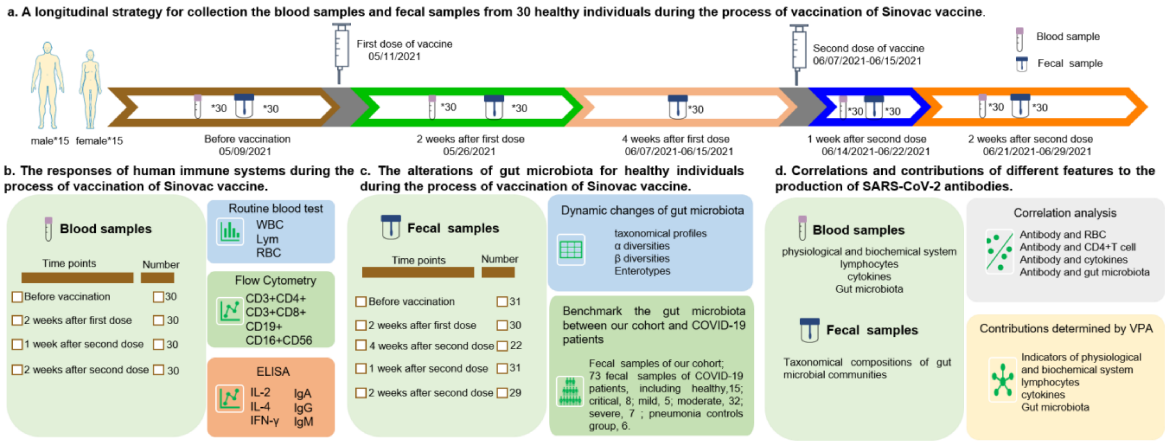
* Corresponding author:

Shenghai Huang, huangshh68@aliyun.com; Fengchang Wu, wufengchang@vip.skleg.cn; Yonggui Wu, wuyonggui@medmail.com.cn

Materials and methods

Study design and sample collection

In our present study, to highlight the dynamic changes in the gut microbiota, host response, and production of SARS-CoV-2 antibodies and their interactions during the process of SARS-CoV-2 vaccination, which involves various doses, a total of 30 healthy volunteers (undergraduates of School of Life Sciences, Anhui Medical University) whose age ranged from 20 to 23 years were recruited from May to July 2021. Their height and weight were measured to calculate the BMI. Blood samples were collected four times, and fecal samples were collected five times. The procedure is detailed in **Supplementary Figure S1**. Specifically, blood and fecal samples were collected before vaccination with the Sinovac vaccine, 2 weeks after vaccination with the first dose of the vaccine, and 1 and 2 weeks after vaccination with the second dose of the vaccine, and fecal samples were also obtained on the day at which the second dose was administered, which resulted in a total of four blood samples and five fecal samples **(Figure 1A, Supplementary Figure S1**). Each blood sample was divided into three parts: one part was used for routine blood test, a second part was utilized for flow cytometry, and the remaining serum was maintained at -80 °C for cytokine and antibody detection. The first blood sample was used as a control. Immediately after collection, the fecal samples were stored at -80 °C for the extraction of DNA and sequencing. Subsequently, 30 blood samples and 31, 30, 22, 31, and 29 fecal samples were collected at each of the four blood and five fecal sampling time points, respectively, to explore the dynamic patterns of the host response, gut microbiota, production of SARS-CoV-2 antibodies, and the interaction among the gut microbiota, host response, and production of SARS-CoV-2 antibodies and assess their interactions during the SARS-CoV-2 vaccination process (**Figure 1A, Supplementary Figure S1**). The study protocols were all approved by the Biomedical Ethics Committee of Anhui Medical University (No 2021H021).



Supplementary Figure S1. A longitudinal sampling strategy for the collection of blood and fecal samples from

30 healthy individuals at different points during the process of SARS-CoV-2 vaccination was used to explore the dynamic patterns of immune systems, the gut microbiota, and the production of antibodies and their interactions. a: Longitudinal strategy for collecting blood and fecal samples from 30 healthy individuals during the process of vaccination with the Sinovac vaccine. **b:** Responses of human immune systems during the process of vaccination with the Sinovac vaccine. **c:** Alterations in the gut microbiota of healthy individuals during the process of vaccination with the Sinovac vaccine. **d:** Correlations and contributions of different features to the production of SARS-CoV-2 antibodies.

Measurement of cytokines and SARS-CoV-2 antibodies in serum by ELISA

To monitor the response of the host's body based on cytokines and SARS-CoV-2 antibodies, the levels of inflammatory factors, including IL-2, IL-4, IFN-γ, and SARS-CoV-2 antibodies, including anti-(N+S) IgA, anti-(N+S) IgG, and anti-(N+S) IgM, were measured by ELISA. Specifically, the levels of cytokines and antibodies in whole-blood serum obtained from all the blood samples (n =30 at each sampling point) were measured. We selected IL-2 and IFN-γ as representatives of Th1 cells and IL-4 as representative of Th2 cells. IL-2, IL-4, IFN-γ, anti-(N+S) IgA, anti-(N+S) IgG and anti-(N+S) IgM were measured using a high-sensitivity enzyme linked assay quantitative kit (the kits for cytokines were procured from Bio-Techne USA Co., Ltd., Minnesota, USA, and the kits for antibodies were obtained from Wuhan Fine Biotechnology Co., Ltd., Wuhan, China) in accordance with the manufacturer's instructions. Specifically, taking the detection of SARS-CoV-2 antibodies as an example, the kit can detect the concentration of SARS-CoV-2 antibodies based on indirect enzyme-linked immunosorbent assay technology. Ninety-six-well plates were percolated with recombinant 2019-nCoV nucleocapsid and spike protein (antigen), and HRP-conjugated antibody was used as the detection antibody. Subsequently, the standards, test samples and HRP-conjugated detection antibody were added to the wells, and the plates were washed with wash buffer. 3,3',5,5'-Tetramethylbenzidine (TMB) substrates were used to visualize the HRP enzymatic reaction, which is catalyzed by HRP to produce a blue product that changes to a yellow color after addition of an acidic stop solution. The density of the yellow color is proportional to the target amount of sample captured in the plate. The O.D. absorbance at 450 nm is read using a microplate reader, and the concentration of the target was then calculated.

Characteristics of peripheral lymphocyte subset alterations measured by flow cytometry

To quantify the variation in lymphocytes during the process of SARA-CoV-2 vaccination, the levels of different types of lymphocytes, including CD3+ T cells, CD3+CD4+ T cells, CD3+CD8+ T cells, CD3+CD4+CD8+ T cells,

CD4+/CD8+ ratio, CD16+CD56+ cells, and CD19+ cells, were measured by flow cytometry. Specifically, a 50-μl peripheral blood sample with EDTA-K2 anticoagulant was first added to a prepared pipe in a biological safety cabinet. Second, the blood sample was incubated with 5 μl of antibodies (BD Multitest™ IMK kit (BD Biosciences, USA, Catalog No.340503) and BD Multitest™ 6-color TBNK reagent (BD Biosciences, USA, Catalog No.644611)) for 15 min in a dark room. Third, 450 μl of BD FACS lysing solution (10X) (BD Biosciences, USA, Catalog No.349202) and sterile water were injected to lyse the erythrocytes for 10 min. The processed samples were then examined using a flow cytometer (BD FACSCanto™, BD Biosciences) and FACSDiva v. 6.1 software, and the results were analyzed using FlowJo software (Version 7.6.1; Tree Star, Inc., Ashland, OR, USA) at the First Affiliated Hospital of Anhui Medical University.

Measurement of indicators using routine blood tests

Various indicators obtained from routine blood tests, such as eosinophils, neutrophils and hemoglobin, were measured via routine blood tests conducted at Hefei City Maternal and Child Health & Family Planning Service Center (Anhui Province). Specifically, a 2-ml blood sample was collected in an EDTA-K2 anticoagulant tube. Immediately after collection, the tube was mixed by being gently reversed several times to ensure adequate anticoagulation of the blood specimen. The blood samples were then sent to Hefei City Maternal and Child Health & Family Planning Service Center, and the indicators obtained from routine blood tests were directly measured using a three-classification blood cell analyzer (BC-5390 CRP, Marry).

DNA extraction and metagenomic sequencing

In this study, we collected fecal samples from 30 volunteers at five time points during the SARS-CoV-2 vaccination process to explore the dynamic changes in the human gut microbiota. A total of 143 fecal samples were collected, and metagenomic DNA was extracted using the Magen HiPure Stool DNA Kit (Magen, Guangzhou, China) according to the manufacturer's instructions. All extracted DNA was dissolved in TE buffer and stored at -20 °C until further use. The metagenomic DNA of the samples was then fragmented randomly to the desired size using a Covaris S/E210 and electrophoresed to obtain DNA fragments of the required lengths. Subsequently, the DNA fragments from each sample were ligated with adapters and evaluated for cluster preparation. All sequencing reactions of these samples were performed using the Illumina X Ten platform with a paired-end sequencing strategy (GENEWIZ, Inc., South Plainfield, NJ, USA). All sequencing data from the 143 fecal samples were deposited into NCBI's Sequence Read Archive (SRA) database with the BioProject number PRJNA778267.

Processing of metagenome datasets

To profile the taxonomic composition of the gut microbial community, 143 fecal samples were collected for metagenome sequencing. The generated sequencing reads were first quality-filtered against the human genome (hg38) using bowtie2 to identify the reads belonging to humans and filter the contaminants. To further obtain the high-quality reads, the 143 metagenome datasets were subjected to quality control using Trimmomatic (v 0.32) with the following parameters: TruSeq3-PE.fa, 2:30:10; leading, 3; trailing, 3; sliding window, 5:20; and min length, 25. Subsequently, an average of 16.7 Gb of high-quality sequences were obtained from each sample (fastq document), which resulted in the generation of 2.4 TB of sequence data in total (fastq document).

Taxonomical and functional compositions based on shotgun metagenomic datasets

We selected two popular tools currently used in metagenome analysis, namely, MetaPhlan2 and HuMAnN2, to accurately identify the taxonomic and functional compositions of the gut microbial communities with the default settings. The taxonomic compositions of the gut microbial communities were identified, and the relative abundance of each taxon was summarized at the phylum, class, order, family, genus, and species levels. The enterotypes of all fecal samples were classified using the 'Biotype' package on the R platform. In addition, the dominant species were selected based on the average abundances (higher than 0.01%), and the interactions between individual species were calculated using the Kendall correlation coefficient with the 'cor' package on the R platform.

Analysis of public datasets related to patients with COVID-19

To track the dynamic changes and patterns of the gut microbial communities of our cohort and patients with COVID-19, we downloaded the gut metagenome datasets of a cohort of COVID-19 patients from SRA databases (BioProject number: PRJNA624223). This cohort consisted of 73 fecal samples, which were divided into healthy Chinese individuals (15 samples), a critical group (8 samples), a mild group (5 samples), a moderate group (32 samples), a severe group (7 samples), and a pneumonia control group (6 samples), and provided evidence of the gut microbial alterations in COVID-19 patients. These 73 gut microbiome datasets were analyzed using the same strategy as that used for the datasets from our cohort, and the similarities among the microbial communities were estimated through linear discriminate analysis (LDA).

Statistical analysis

In the present study, the alpha diversities of the gut microbial communities, including Shannon and Simpson indices, were calculated with the 'vegan' package and compared among different time points during the SARS-CoV-2 vaccination process. ANOSIM and PERMANOVA were performed based on the Bray-Curtis distance matrix to estimate whether the taxonomic compositions of the gut microbial communities differed among different time points during the process of SARS-CoV-2 vaccination. In addition, LDA, which is a supervised learning approach, was applied to distinguish the gut microbial communities based on the taxonomic compositions. To evaluate the effects of body features and the gut microbiota and assess their contributions to the production of antibodies against SARS-CoV-2, a variation partitioning analysis (VPA) was performed using the R platform. Specifically, we utilized the interactive forward selection function in Canoco software (version: 5.0) to eliminate the collinearity between factors based on the contribution, *p* value and adjusted *p* value of each feature. Afterward, the features mean corpuscular volume (MCV), CD3+CD8+ T cells, CD3+CD4+CD8+ T cells, CD16+CD56+ cells, lymphocyte (LYM), and red blood cell volume distribution width-SD (RDW-SD) were selected and defined as body features, whereas a total of 25 taxa (**Supplementary Table S5**), including *Veillonella dispar*, *Lachnospiraceae bacterium*_3_1_46FAA, *Lachnospiraceae bacterium*_2_1_58FAA, *Lachnospiraceae bacterium*_8_1_57FAA, *Akkermansia muciniphila*, *Klebsiella*_ sp_MS_92_3, and *Lactobacillus ruminis*, were selected as representative species of the gut microbiota. Moreover, the contributions of body features and the gut microbiota to the production of SARS-CoV-2 antibodies were estimated using the 'varpart' function of the 'vegan' package on the R platform. The analyses were performed using SPSS version 22.0. The differences between groups were assessed by two-way ANOVA, and two-sided exact P-values are reported. A P-value < 0.05 was considered to indicate statistical significance. In the linear correlation analysis, a P-value < 0.05 was considered to indicate statistical significance.