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(i) *Title*: **Serosurveillance after a COVID-19 Vaccine Campaign in a Swiss Police Cohort**

(ii) *Short running title*: COVID-19 Serosuveillance in a Swiss Police Cohort

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Patient consent statement: All participants signed written informed consent prior to enrolment in the PoliCOV-19 study.

Permission to reproduce material from other sources: Not applicable. Figure 1 is adapted from an open resource website and referenced accordingly. The baseline study using the same cohort of study participants and using the same serology methods and questionnaires have been published elsewhere [1]. Here, the follow-up results after 3 and 6 months are presented.

Abstract

***Introduction*:** To assess the risk for COVID-19 of police officers, we are studying the seroprevalence in a cohort. The baseline cross-sectional investigation was performed prior to a vaccination campaign in January/February 2021, and demonstrated a seroprevalence of 12.9%. Here, we demonstrate serosurveillance results after a vaccination campaign.

Methods: The cohort consists of 1022 study participants. The 3-month and 6-month follow-up visits were performed in April/May and September 2021. Data on infection and vaccination rates were obtained via measuring antibodies to the nucleocapsid protein and spike protein and online questionnaires.

Results: The mean age of the population was 41 (SD 8.8) years, 72% were male and 76% had no comorbidity. Seroconversion was identified in 1.05% of the study population at the 3-month visit and in 0.73% at the 6-month visit, resulting in an infection rate of 1.8% over a time period of 6 months. In comparison, the infection rate in the general population over the same time period was higher (3.18%, P=0.018). At the 6-month visit, 77.8% of participants reported being vaccinated once and 70.5% twice; 81% had an anti-S antibody titer of >250 U/mL and 87.1% of ≥2 U/mL. No significant association between infection and job role within the department, working region, or years of experience in the job was found. Anti-spike antibody titers of vaccinated study participants showed a calculated decreasing trend 150 to 200 days after the second vaccine dose.

Conclusion: These data confirm the value of the vaccination campaign in an exposed group other than healthcare professionals.

Keywords

SARS-CoV-2; anti-S-antibodies; anti-NCP-antibodies; COVID-19 seroprevalence.

Introduction

The COVID-19 pandemic has ignited social unrest, including domestic violence, a surge in COVID-19 denials, and anti-masking and anti-vaccine protests worldwide [2-4]. It is reasonable to postulate that police officers, in particular those working in the field, are an exposure population. To assess the risk for SARS-CoV-2 infection in this group, since February 2021, we have been studying a cohort of individuals employed by the Cantonal Police Bern in Switzerland [5]. The seroprevalence of anti-nucleocapsid antibodies in the police cohort before initiating a vaccine program was 12.9% [1]. In March 2021, a vaccination campaign for their employees was promoted by the Cantonal Police Bern. Here, we present the COVID-19 infection and vaccination rate 3 and 6 months after initiating the cohort, and the dynamics of anti-spike antibody levels in vaccinated individuals. In addition, a comparison between the infection rates in the police cohort and the general population was made to estimate the success of the vaccine campaign.

Methods

Cohort: The study protocol is aligned with that of the WHO for population-based age-stratified seroepidemiological investigations [6], adapted for the specific population and geographic region in our study. The population involved in the PoliCOV-19 study has been published previously [1], and included after 6 months 1022 study participants (**Appendices, Figure S1**).

SARS-CoV-2 exposure: The series of COVID-19 waves in our region since the onset of the pandemic and the time points of cross-sectional analysis are shown in **Figure 1**. During the study period, there was no government-ordered lockdown. Wearing face masks for employees of the Cantonal Police Bern was made mandatory during working hours (indoor and outdoor) on October 13, 2020. On June 26, 2021, an exemption was introduced: Wearing

face masks was not mandatory for employees of the police within protected indoor rooms of the police departments, under the precondition that a physical distance of 1.5 meters was ascertained. For all other circumstances, mask-wearing remained mandatory.

SARS-CoV-2 variants: From mid-February to the end of June 2021, the SARS-CoV-2 Alpha variant (B.1.1.7) was dominant in Switzerland until its replacement by the Delta variant (B.1.617.2, all subvariants AY), which became predominant in late June 2021 [7].

Time points of cross-sectional analysis: The baseline investigation was performed in January/February and published elsewhere [1]. The 3-month follow-up visit was performed in April/May, and the 6-month follow-up in September 2021 (**Figure 1**).

Questionnaires: During every cross-sectional analysis of the cohort (i.e.; every 3 months), an online questionnaire was sent to study participants. The questionnaire aligned to the survey tools recommended by the WHO [8], and a questionnaire used by the Swiss Medical Association (FMH) to evaluate COVID-19 among physicians in Switzerland [9], and then adapted for police officers. It inquired job-related activity, possible COVID-19 contact, symptoms consistent with COVID-19, contact with presumed or confirmed cases, quarantine, and nasopharyngeal test results and vaccination status.

Antibody tests: SARS-CoV-2 antibodies to the nucleocapsid protein (NCP) and spike (S) protein were measured by using two commercially available immunoassays (Roche Diagnostics, Rotkreuz, Switzerland). To increase the specificity of anti-S antibody test results, we chose a cutoff value of ≥2 U/mL [10], instead of ≥0.8 U/mL, as recommended by the manufacturer.

COVID-19 infection definition in the cohort: COVID-19 infection was defined as seroconversion of anti-NCP antibodies or a self-reported PCR test from a nasopharyngeal swab in the questionnaire. To identify false-positive serological results, we contacted all individuals with anti-NCP antibody seroconversion and reinvestigated the cases. Samples

143 with low titer results from individuals with no symptoms or negative nasopharyngeal PCR
144 test results were reanalyzed with a second and different anti-NCP antibody assay (Bio-Rad,
145 Marnes-la-Coquette, France). In the case of seronegative results with the second assay, the
146 serum test result was considered as a possible or likely false-positive result. Serological
147 results from individuals with a self-reported positive nasopharyngeal PCR test result and
148 without symptoms and without anti-NCP seroconversion were considered as possible or
149 likely false-negative cases if the time interval between PCR test result and serum sampling
150 was ≥14 days.
151 *The infection rate in the general population:* New infection cases in the general population
152 are defined as laboratory-confirmed cases (positive PCR test from nasopharyngeal or saliva
153 sample). The data were obtained from the Federal Office of Public Health [11]. The canton of
154 Bern consists of more than 1,043,000 inhabitants; the age-matched population for this study
155 consisted of 671'678 registered inhabitants at the 3 month-visit and 669'243 at the 6-month
156 visit.
157 *COVID-19 vaccine:* The messenger RNA vaccines from Pfizer-BioNTech and Moderna are
158 authorized and approved for use in Switzerland. The vaccination campaign of the police was
159 promoted from March 12th till June 11th, 2021 (**Figure 1**).
160 *Primary endpoint:* The primary endpoint was the infection rate in the police cohort at the 3-
161 month and 6-month visit.
162 *Secondary endpoints:* The secondary endpoints included the comparisons of the infection
163 rates between the police cohort and the general population at the 3-month and 6-month visits,
164 the association of age, comorbidity, job role (i.e.; mainly fieldwork or mainly office work),
165 working department, working region, and years of experience with the infection rate.
166 Secondary endpoints included further the proportions of vaccinated individuals and those
167 with anti-S antibody titers ≥2 U/mL in the cohort at the 6-month visit. In vaccinated

168 individuals, the time interval from vaccination to the calculated trend of anti-S antibody titers
169 falling below 250 U/mL was defined as a secondary endpoint.
170 *Statistical analysis:* To describe the characteristics of the study cohort, we used mean ±
171 standard deviation (SD) or median with interquartile range for summarizing continuous
172 variables, as appropriate. Comparisons were made by using the Student t-test or Mann-Whitney
173 test, respectively. Categorical data were shown as numbers with percentages and compared by
174 using Fisher's exact test for binary variables or the chi-squared test for more than two
175 categories. The Chi-squared test of homogeneity was used to compare new infection rates
176 between the police cohort and the Bernese general population (binary variables). The
177 comparisons included both the overall infection rates and were matched by age groups
178 according to the following categories: 20–29, 30–39, 40–49, 50–59, and 60–69 years. For
179 comparative analysis to identify groups at risk for infection, the variables comorbidity, working
180 department, and working region were combined with age groups and years of experience within
181 the police department. The latter was categorized as 0–9, 10–19, 20–29, and 30 or more years
182 of experience.
183 Generalized additive models were used to estimate the trend of the anti-S antibody titers over
184 time after vaccination. All analyses were performed with R (version 3.6.2).

Results

The mean age of the 1022 study participants was 41 (SD 8.8) years, 72% were male and 76% had no comorbidity; 58.3% (560) of study participants indicated that their main activity was fieldwork [1]. The numbers of samples analyzed at baseline, 3-month visit and 6-month visit were 978, 997, and 982, respectively. The presence or absence of seroconversion between the baseline and 3-month visit was investigated in 956 paired samples, and between the 3-month and 6-month visits in 955 paired samples. The seroprevalences of anti-NCP antibodies – without adjusting for paired sample results or false positive or false negative results – were 12.9% at baseline [1], 14.4% at the 3-month visit, and 15.3% at the 6-month visit (**Appendices, Figure S2**).

Primary endpoint – COVID-19 infection in the cohort: Seroconversion was identified in 1.05% (10/956) at the 3-month visit (**Table 1A**) and in 1.15% (11/955) at the 6-month visit (**Table 1B**). At the 3-month visit, no false-positive results were detected; at the 6-month-visit, 4 of the11 positive results were likely false-positive results (**Table 1B**). Therefore, the proportion of individuals with seroconversion at 6 months was adjusted from 1.15% (11/955) to 0.73% (7/955). The seroprevalence after excluding non-paired samples was adjusted to 13.95% at the 3-month-visit, and 14.7% at the 6-month visit.

No breakthrough infections were seen after two doses of vaccination. Six of ten infections at the 3-month visit (**Table 1A**), and three infections at the 6-month visit occurred in non-vaccinated individuals (**Table 1B**). The remaining infections occurred in vaccinated individuals between the first and the second dose of the vaccine.

Secondary endpoints:

COVID-19 infection proportions in the cohort in comparison to the ones in the general population: In the police cohort, the increase in seroprevalence at 6-month was 1.80% in comparison to the baseline (i.e., from 12.9% to 14.7%), and 0.73% in comparison to the 3-

month visit (i.e., from 13.95% to 14.7%). These values were significantly lower in comparison to the increase of the calculated infection rate of the general population (in comparison to the 6-month span: 1.8% versus 3.18%, *P*=0.018; in comparison to 3-month span: 0.73% versus 1.77%, *P*=0.021). After matching for age groups, the infection rate was lower in the police cohort than that in the general population, though not statistically significant (**Appendices, Figures S3-1 and S3-2**).

No statistically significant difference was seen in the subgroup analysis when comparing police officers involved in the fieldwork activity and the age-matched general population. No statistically significant association was found in the comparative analysis, including comorbidity, job role within the department, and years of experience (**Appendices, Table S1**).

Vaccination rate and anti-spike antibody titers in the cohort: At the 6-month visit, 77.8% of participants reported being vaccinated once and 70.5% twice; 81% had an anti-S antibody titer of >250 U/mL and 87.1% of ≥2 U/mL (**Figure 2**). The proportion of individuals with anti-S antibody titers >250 U/mL likely represented most of the the vaccinated group because it included responders and non-responders of questionnaires. The proportions of these parameters among police officers mainly involved in fieldwork and those mainly involved in office work were similar; 85.0% and 84.5% (*P*=0.9), respectively, reported being vaccinated once, 79.3% and 79.4%% (*P*=1.0) reported being vaccinated twice, 84.6% and 83.6% (*P*=0.748) had an anti-S antibody titer of >250 U/mL, and 90.2% and 88.1% (*P*=0.377), respectively, had an anti-S antibody titer ≥2 U/mL. The group with anti-S antibody titers of ≥2 U/mL consisted of the proportions of both, individuals who were vaccinated and those who had recovered from COVID-19 irrespective of vaccination status.

Two (0.3%) double-vaccinated and immunocompromised individuals did not show anti-S antibodies at the time of point serum sampling. Fifty-six (5.7%) of the study participants were seropositive and reported not being vaccinated.

Dynamics of anti-S antibody levels: Anti-S antibody titers of vaccinated study participants showed a calculated decreasing trend after 150 to 200 days (**Figure 3**).

Discussion

In this cohort study, we noted a low infection rate and a relatively high vaccination rate among police officers. Despite a presumed higher exposure to SARS-CoV-2, in particular for police officers mainly involved in the fieldwork activity, the overall infection rate was not higher than in the general population. Finally, 150 to 200 days after vaccination, a decreasing trend in anti-S antibody titers was observed, underscoring the necessity of a booster vaccine four to six months after the second dose.

Law enforcement personnel face physical and psychological challenges during the COVID-19 pandemic [12, 13]. Their exposure to SARS-CoV-2 and possible risk of transmission during working hours (e.g.; in attendance of public protests) have been scarcely investigated. Seroprevalence studies are useful means to estimate the true extent of SARS-CoV-2 infection among a population [14, 15]. Few seroprevalence studies focused on public safety personnel [16-22]. Garbarino et al. [20] reported an overall seroprevalence of 4.8% in 10'535 police officers in Italy, with a higher seroprevalence in northern (9%) than in southern regions (1.6%).

In our cohort, the seroprevalence at the baseline was 12.9% in February 2021, similar to that reported in the general population [1]. The self-reported compliance with mask-wearing during working hours was very high. The results suggested that household contacts were the leading transmission venues. Regional differences in the seroprevalence were observed, and

police officers mainly working in the field were more frequently seropositive than those mainly working in the office [1]. In this study, the cohort was followed for 6 months. The regional and job-related differences in seroprevalence within the cohort waned over this time period. However, at the 6-month visit, the infection rate was lower in the cohort than the one in the general population (1.8% versus 3.18%, *P*=0.018). The true difference was likely more pronounced, considering that the observation in the police cohort was more precise than the one in the general population and that the numbers in the general population are likely underestimated. Although the difference in the proportion of the infection rate between the police cohort and the general population was minor, the calculated absolute number of individuals in the entire population is considerable.

In our view, the differences in COVID-19 infection rates are likely explained by the high compliance of police officers with hygiene precautions and mask-wearing with contacts, and by the relatively high vaccination rate. Previous studies have shown the efficacy of COVID-19 messenger RNA vaccines [23]. McLaughlin et al. [24] calculated in a negative binomial regression model that US counties with ≥80% of vaccine-eligible persons fully vaccinated had 30% lower rates of COVID-19 cases and 46% lower rates of COVID-19-related deaths compared to US counties with <50% vaccine coverage. The vaccination rate in the police cohort was more than 80% when considering the responses in the questionnaires and the proportions of individuals with anti-S antibody titers of >250 U/mL. A high proportion of study participants were vaccinated before the 4th wave of the pandemic. This proportion is higher than the one reported for the general population. For comparison, 54%-64% of the general population received at least 1 dose, and 58%-59% received 2 doses of COVID-19 vaccine in Switzerland in September 2021 [11]. These proportions include elderly individuals who were prioritized in the vaccine distribution. Thus, the age-matched differences in the vaccine rate between the police cohort and the general population were likely higher because

283 retired individuals were not included in the police cohort while they were included in the
284 vaccination registry of the general population. The lower proportion of vaccination in the
285 general population cannot be explained by the accessibility to the vaccine. In Switzerland, the
286 priority for receiving a vaccine depended on the risk of a severe course of COVID-19 and
287 immune status. Because vaccination is not mandatory, individuals who are skeptical about the
288 COVID-19 vaccine can refuse to be vaccinated.
289 The overall proportion of individuals with antibodies against SARS-CoV-2 in the police
290 cohort – defined as the proportion of individuals with anti-S antibody titer ≥2 U/mL – was
291 87.1% in September 2021. Similar to other studies [25], we observed a waning humoral
292 response after vaccination. In our previous baseline study [1], we demonstrated that the
293 neutralization capacity of naturally acquired antibodies decreased with emerging of new
294 variants of SARS-CoV-2, and that neutralization correlated with the extent of antibody titer.
295 Vaccine efficacy decreases over time [26, 27]. A vaccine booster dose increases the antibody
296 neutralization level and leads to increased protection against infection of the delta variant and
297 severe illness [28, 29]. However, this effect is likely not durable. In the police cohort, the
298 calculated population curve of the sample results indicated a decrease in anti-S antibody titers
299 below 250 U/mL approximately 150 to 200 days after vaccination. The aforementioned
300 arguments together with these results justified promoting a booster vaccination (third dose)
301 campaign.
302 Our study has limitations. The statistically significant difference in infection rate between the
303 police cohort and the general population is arguable because it was only seen in the overall
304 analysis but not in the age-matched comparison. We were unable to exclude the infection rate
305 in risk groups within the general population, considering that the police cohort consists of
306 predominantly healthy individuals. However, the true infection rate in the general population
307 is likely underestimated. We were unable to identify an infection in individuals without self-

reported nasopharyngeal sample test results and at least two serum (paired) samples over the 6 months (i.e.; to detect seroconversion). We believe that our results are representative, considering that in more than 95% of study participants two or three serum samples were available. The time points for blood sampling and sending out questionnaires were predefined in the study protocol. Hence, the dynamics of antibody titers over time are biased by these sampling time points. The COVID-19 infection rate in the police cohort was evaluated by self-reported PCR test results and seroconversion in serum samples. The infection rate in the general population was evaluated by analyzing laboratory-confirmed cases that were reported daily by the Federal Office of Public Health. Despite using two different methodologies, we were able to statistically homogenize these results for comparison. We are unable to perform antibody titer dynamic analysis at very high titer levels, because of the upper quantification limit of the anti-S antibody assay (i.e.; >250 U/mL).

In conclusion, our COVID-19 cross-sectional surveys among police officers demonstrated an increase in seroprevalence from 12.9% to 14.7% in 6 months. The increase was lower than the laboratory confirmed SARS-CoV-2 infection rate observed in the general population. During the same period, we observed a relatively high vaccination rate of approximately 80%. In contrast to the pre-vaccination analysis at baseline, no significant association with the job role within the department or working regions was observed. The observed waning humoral response 150 to 200 days after vaccination together with results from other studies showing the efficacy of a third dose, supported a further campaign for a booster vaccination. The results of the cross-sectional surveys at the 9- and 12-months visit are currently being analyzed.

References

1. Sendi P, Baldan R, Thierstein M, et al. A Multidimensional Cross-Sectional Analysis of Coronavirus Disease 2019 Seroprevalence Among a Police Officer Cohort: The PoliCOV-19 Study. Open Forum Infect Dis. 2021;8(12):ofab524. https://doi.org/10.1093/ofid/ofab524.
2. Paterlini M. Covid-19: Italy sees protests against mandatory health passports for workplaces. Bmj. 2021;375:n2575. https://doi.org/10.1136/bmj.n2575.
3. Ran J, Zhao S, Han L, et al. The changing patterns of COVID-19 transmissibility during the social unrest in the United States: A nationwide ecological study with a before-and-after comparison. One Health. 2021;12:100201. https://doi.org/10.1016/j.onehlt.2020.100201.
4. Boserup B, McKenney M, Elkbuli A. Alarming trends in US domestic violence during the COVID-19 pandemic. Am J Emerg Med. 2020;38(12):2753-5. https://doi.org/10.1016/j.ajem.2020.04.077.
5. Sendi P. Police Officer COVID-19 Seroprevalence Survey in the Canton of Bern, Switzerland. https://clinicaltrials.gov/ct2/show/NCT04643444. 2021.
6. WHO. Population-based age-stratified seroepidemiological investigation protocol for COVID-19 virus infection. https://www.who.int/publications-detail/population-based-age-stratified-seroepidemiological-investigation-protocol-for-covid-19-virus-infection. Accessed March 17 2020.
7. Health FOoP. COVID-19 Switzerland Information on the current situation. https://www.covid19.admin.ch/en/epidemiologic/virus-variants/d/overview. Accessed 2021 2021.
8. WHO. SURVEY TOOL AND GUIDANCE, Rapid, simple, flexible behavioral insights on COVID-19. http://www.euro.who.int/data/assets/pdf_file/0007/436705/COVID-19-survey-tool-and-guidance.pdf?ua=1. Accessed March 17 2020.
9. Wille N, Schlup J. Corona-Pandemie: Situation der Ärztinnen und Ärzte in der Schweiz. SCHWEIZERISCHE ÄRZTEZEITUNG – BULLETIN DES MÉDECINS SUISSES – BOLLETTINO DEI MEDICI SVIZZERI. 2020;10(29-30):882–4.
10. Riester E, Findeisen P, Hegel JK, et al. Performance evaluation of the Roche Elecsys Anti-SARS-CoV-2 S immunoassay. J Virol Methods. 2021;297:114271. https://doi.org/10.1016/j.jviromet.2021.114271.
11. Health FOoP. COVID-19 Switzerland. https://www.covid19.admin.ch/en/overview.
12. Hernández-Vásquez A, Azañedo D. COVID-19 in Peru: the need to pay attention to the high number of police deaths due to the pandemic. J Public Health (Oxf). 2020;42(3):640-1. https://doi.org/10.1093/pubmed/fdaa079.
13. Lázaro-Pérez C, Martínez-López J, Gómez-Galán J, Fernández-Martínez MDM. COVID-19 Pandemic and Death Anxiety in Security Forces in Spain. Int J Environ Res Public Health. 2020;17(21). https://doi.org/10.3390/ijerph17217760.
14. WHO. True extent of SARS-CoV-2 Infection through seroprevalence studies. https://www.who.int/news/item/03-02-2022-true-extent-of-sars-cov-2-infection-through-seroprevalence-studies.
15. Bergeri I, Whelan M, Ware H, et al. Global epidemiology of SARS-CoV-2 infection: a systematic review and meta-analysis of standardized population-based seroprevalence studies, Jan 2020-Oct 2021. medRxiv. 2021:2021.12.14.21267791. https://doi.org/10.1101/2021.12.14.21267791.
16. Sami S, Akinbami LJ, Petersen LR, et al. Prevalence of SARS-CoV-2 Antibodies in First Responders and Public Safety Personnel, New York City, New York, USA, May-July 2020. Emerg Infect Dis. 2021;27(3):796-804. https://doi.org/10.3201/eid2703.204340.
17. Gujski M, Jankowski M, Pinkas J, et al. Prevalence of Current and Past SARS-CoV-2 Infections among Police Employees in Poland, June-July 2020. J Clin Med. 2020;9(10). https://doi.org/10.3390/jcm9103245.

18. Halatoko WA, Konu YR, Gbeasor-Komlanvi FA, et al. Prevalence of SARS-CoV-2 among high-risk populations in Lomé (Togo) in 2020. PLoS One. 2020;15(11):e0242124. https://doi.org/10.1371/journal.pone.0242124.
19. Chughtai OR, Batool H, Khan MD, Chughtai AS. Frequency of COVID-19 IgG Antibodies among Special Police Squad Lahore, Pakistan. J Coll Physicians Surg Pak. 2020;30(7):735-9. https://doi.org/10.29271/jcpsp.2020.07.735.
20. Garbarino S, Domnich A, Costa E, et al. Seroprevalence of SARS-CoV-2 in a Large Cohort of Italian Police Officers. Int J Environ Res Public Health. 2021;18(22). https://doi.org/10.3390/ijerph182212201.
21. Pasqualotto AC, Pereira PC, Lana DFD, et al. COVID-19 seroprevalence in military police force, Southern Brazil. PLoS One. 2021;16(4):e0249672. https://doi.org/10.1371/journal.pone.0249672.
22. Decker S, Dambros E, Reis ROD, Nedel CE, Plotzki R, Bertoldi EG. Prospective study on COVID-19 seroprevalence and behavioural patterns in military personnel from the Southern Brazil. Infect Dis (Lond). 2022;54(3):228-31. https://doi.org/10.1080/23744235.2021.1995039.
23. El Sahly HM, Baden LR, Essink B, et al. Efficacy of the mRNA-1273 SARS-CoV-2 Vaccine at Completion of Blinded Phase. N Engl J Med. 2021;385(19):1774-85. https://doi.org/10.1056/NEJMoa2113017.
24. McLaughlin JM, Khan F, Pugh S, Swerdlow DL, Jodar L. County-level vaccination coverage and rates of COVID-19 cases and deaths in the United States: An ecological analysis. Lancet Reg Health Am. 2022;9:100191. https://doi.org/10.1016/j.lana.2022.100191.
25. Levin EG, Lustig Y, Cohen C, et al. Waning Immune Humoral Response to BNT162b2 Covid-19 Vaccine over 6 Months. N Engl J Med. 2021;385(24):e84. https://doi.org/10.1056/NEJMoa2114583.
26. Goldberg Y, Mandel M, Bar-On YM, et al. Waning Immunity after the BNT162b2 Vaccine in Israel. N Engl J Med. 2021;385(24):e85. https://doi.org/10.1056/NEJMoa2114228.
27. Chemaitelly H, Tang P, Hasan MR, et al. Waning of BNT162b2 Vaccine Protection against SARS-CoV-2 Infection in Qatar. N Engl J Med. 2021;385(24):e83. https://doi.org/10.1056/NEJMoa2114114.
28. Bar-On YM, Goldberg Y, Mandel M, et al. Protection against Covid-19 by BNT162b2 Booster across Age Groups. N Engl J Med. 2021;385(26):2421-30. https://doi.org/10.1056/NEJMoa2115926.
29. Andrews N, Stowe J, Kirsebom F, et al. Effectiveness of COVID-19 booster vaccines against covid-19 related symptoms, hospitalisation and death in England. Nat Med. 2022. https://doi.org/10.1038/s41591-022-01699-1.

Table 1A: Newly identified COVID-19 cases between baseline (February/March 2021) and the 3-month visit (April/May 2021).

3-month visit: 10 (1.05%) newly identified COVID-19 infections in 956 study participants with samples at baseline and 3-month visits.								
Record ID	**Symptoms consistent with COVID-19**	**NSP swab**	**Seroconversion Dates of sampling[1]**	**Anti-NCP (COI)[2]**	**Anti-S (U/mL)[2]**	**Vaccinated**	**1st Dose**	**2nd Dose**
43¥	Yes (Onset: April 10)	Negative	March 4 / May 4	176	>250	Yes	March 26	May 4
118	Yes (Onset: February 14)	Negative	March 4 / May 4	45.1	>250	Yes	April 10	May 10
123	No, and no known or traceable contacts	Not tested	Feb 16 / May 4	104	>250	Yes	March 10	May 14
130	No	Positive March 20	Feb 16 / May 11	106	104	No	-	-
291	Yes	Positive April 21	Feb 26 / June 11	123	154	No	-	-
702	Yes	Positive February 27	March 9 / April 27	4.2	74.4	No	-	-
739	Yes (Onset: March 22)	Negative	Feb 23 / April 26	93.2	25.7	No	-	-
771	Yes (Onset: End of February)	Negative	March 4 / May 12	12.5	>250	Yes	May 5	-
813	Yes	Positive March 30	Feb 25 / April 26	135	>250	No	-	-
979	Yes	Positive April 12	March 4 / April 27	128	18.1	No	-	-

Abbreviations: Anti-NCP, anti-nucleocapsid antibodies; Anti-S, anti-spike protein antibodies; NSP, nasopharyngeal swab testing (PCR in case of a positive result; antigen test or PCR in case of a negative result, self-reported results); COI, cut-off index.

[1] The first date is the date of sampling at baseline (seronegative); the second date is the date of sampling at the 3-month visit (seropositive).

[2] Results at the 3-month visit; results at baseline are not shown because they are seronegative.

¥ COVID-19 disease between the first and second vaccination dose.

Table 1B: Newly identified COVID-19 cases between the 3-month (April/May) and the 6-month visit (September 2021).

6-month visit: 11 (1.15%) newly identified COVID-19 infections in 955 study participants with samples at 3-month and 6-month visits. Four results are possibly or likely false positive (i.e., 7 [0.73%] newly identified COVID-19 infections).								
Record ID	**Symptoms consistent with COVID-19**	**NSP swab**	**Seroconversion Dates of sampling[1]**	**Anti-NCP (COI)[2]**	**Anti-S (U/mL)**	**Vaccinated**	**1st Dose**	**2nd Dose**
31[¥]	Yes (Onset: April 22)	Negative	April 27 / Sept 8	16.4	>250	Yes	March 29	April 30
195	No, and no known or traceable contacts	Not tested	April 27 / Sept 8	14.4	>250	Yes	April 27	May 25
220[±]	Yes (Onset: August 27)	Negative	May 7 / Sept 8	2.1[±]	>250	Yes	April 19	May 17
245[±]	No, and no known or traceable contacts	Not tested	April 28 / Sept 10	1.0[±]	0.4	No	-	-
322[±]	No, and no known or traceable contacts	Not tested	April 27 / Sept 9	1.3[±]	>250	Yes	April 27	May 24
380[¥]	Yes (Onset: Mid-May)	Positive May 10	May 7 / Sept 20	29.2	>250	Yes	April 20	Sept 27
465	No, and no known or traceable contacts	Not tested	April 30 / Sept 9	23.7	>250	Yes	April 20	May 20
610	Yes	Positive August 21	May 6 / Oct 26	135	30	No	-	-
717	Yes (Onset: September)	Negative	April 26 / Oct 29	23.2	>250	No	-	-
841	Yes	Positive Sept 14	April 9 / Sept 27	11.2	>250	Yes	April 9	May 27
933[±]	No, and no known or traceable contacts	Not tested	April 26 / Sept 21	3.3[±]	>250	Yes	April 23	May 21

Abbreviations: Anti-NCP, anti-nucleocapsid antibodies; Anti-S, anti-spike protein antibodies; NSP, nasopharyngeal swab testing (PCR in case of a positive result; antigen test or PCR in case of a negative result, self-reported results), COI, cut-off index.

[1] The first date is the date of sampling at the 3-month visit (seronegative); the second date is the date of sampling at the 6-month visit (seropositive).

[2] Results at the 6-month visit; results at the 3-month visit are not shown because they are seronegative.

[¥] COVID-19 disease between the first and second vaccination dose.

[¥¥] SARS-CoV-2 infection after the second possible vaccination dose (vaccine breakthrough infection).

[±] False-positive anti-NCP result possible or likely

Figure legends

Figure 1: Series of COVID-19 waves in the canton of Bern (Switzerland) since the onset of the pandemic and the time points of cross-sectional analysis of the PoliCOV-19 study. Figure obtained and adapted from open-source data, available at https://covid-kennzahlen.apps.be.ch/#/de/cockpit (last accessed Dec 29, 2021).

Figure 2: Cumulative proportion of vaccinated individuals in the police cohort who were vaccinated or recovered from COVID-19. The proportion of individuals with anti-S antibody titers >250 U/mL likely represented the vaccinated group because it included responders and non-responders of questionnaires. The group with anti-S antibody titers of ≥2 U/mL consisted of the proportions of both, individuals who were vaccinated and those who had recovered from COVID-19 irrespective of vaccination status. The timeline is biased by the time point of serum sampling and filling out questionnaires.

Figure 3: Calculated trend of anti-S antibody titer curve over time in vaccinated study participants. Each dot reflects the sampling time point. The dynamics of antibody titers over time are biased by the sampling time points.

SUPPLEMENTARY MATERIAL to Original Article –Version 24-March-2022

High Vaccination and Low SARS-CoV-2 Infection Rate in a Swiss Police Cohort During the Delta Wave.

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Keywords: SARS-CoV-2; anti-S-antibodies; anti-NCP-antibodies; COVID-19 seroprevalence.

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Content

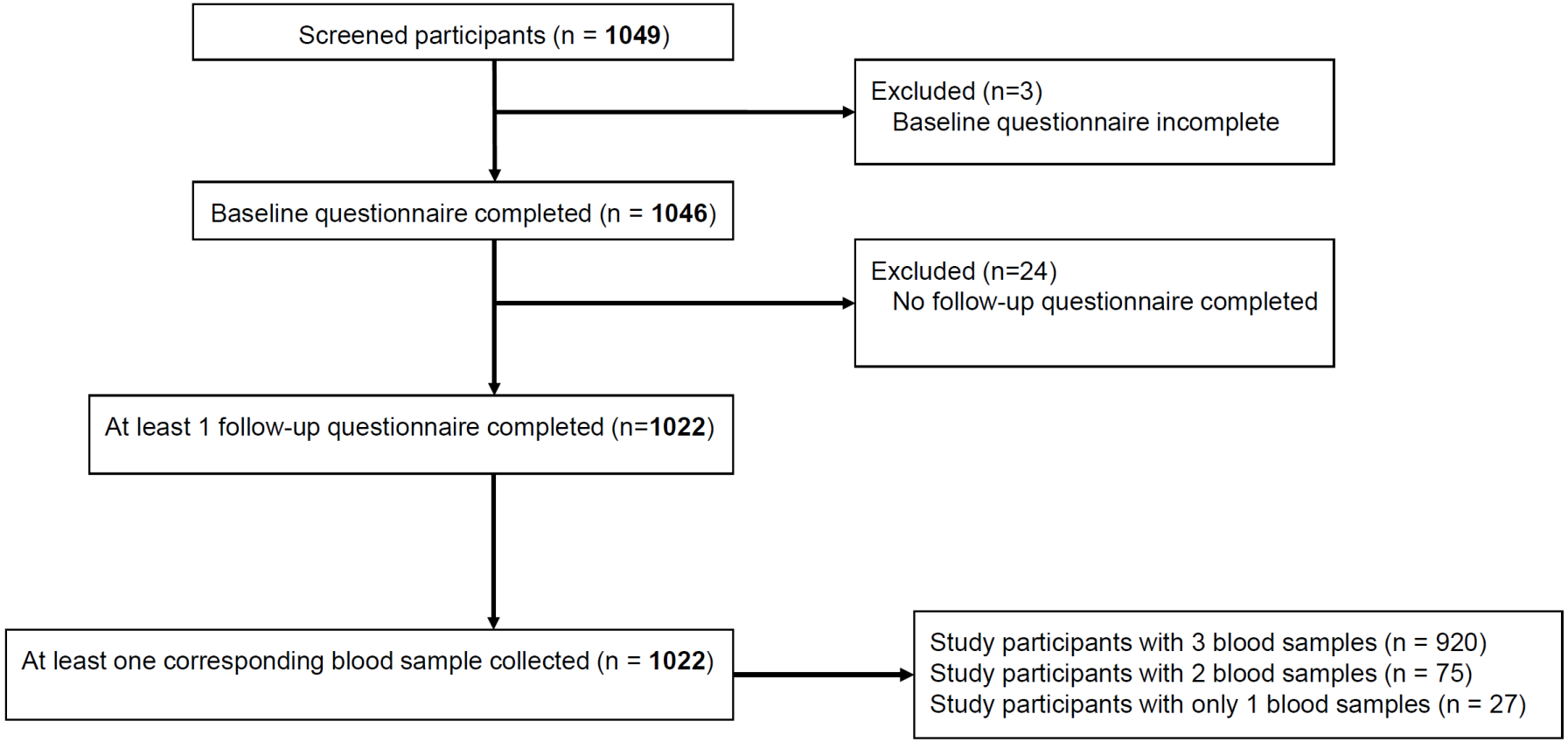
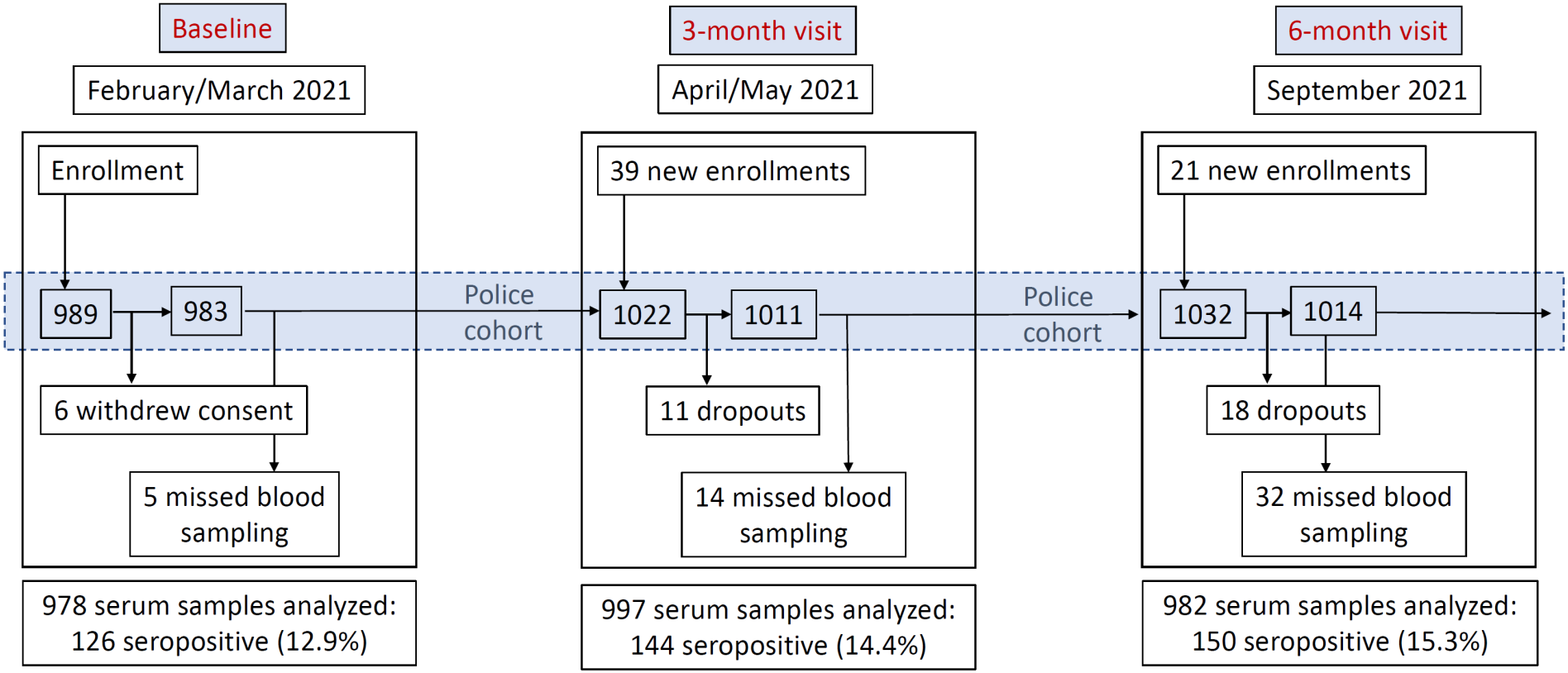
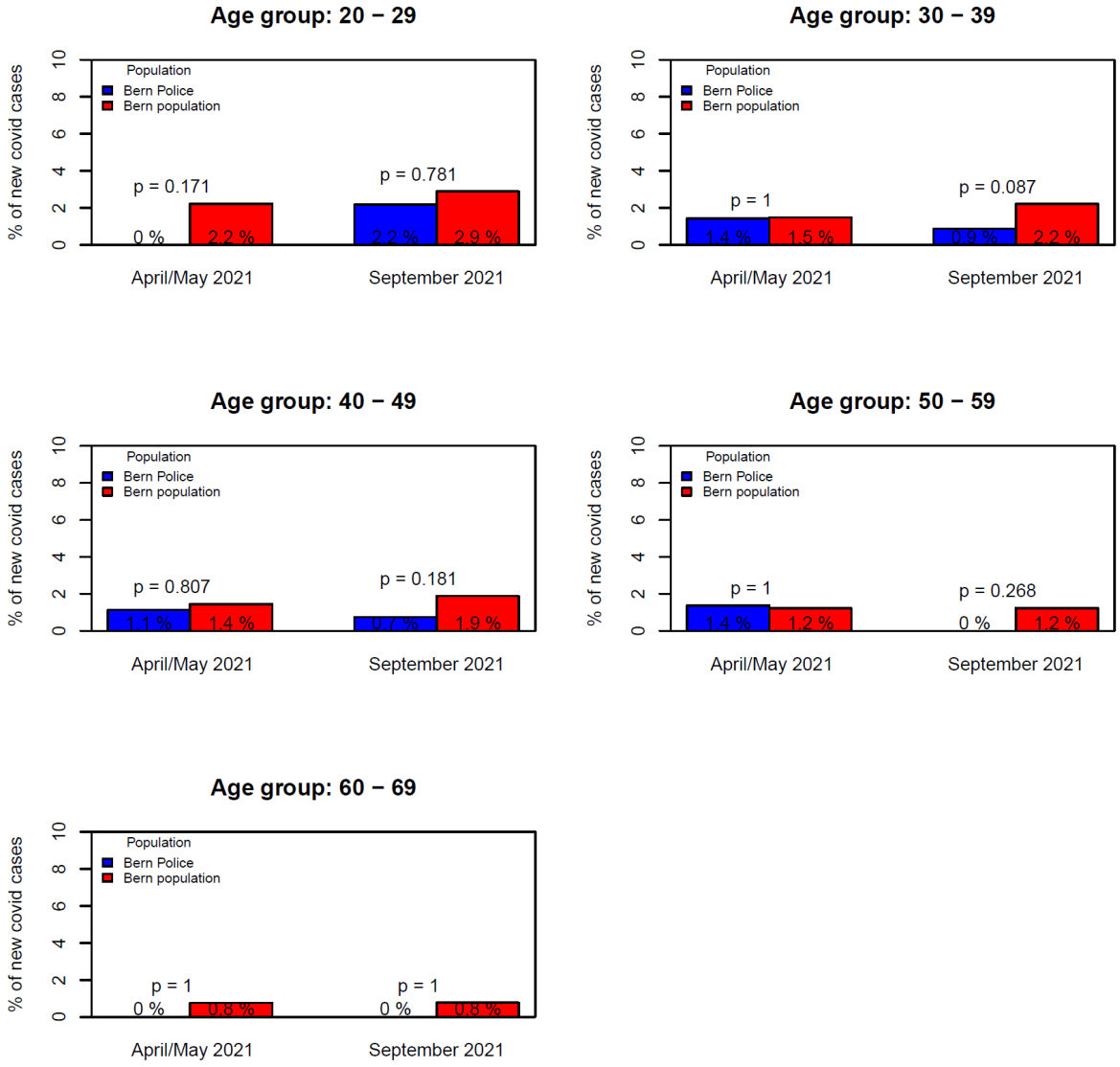


Figure S1: Number of individuals included in the cohort analysis between January/February and September 2021 **(n = 1022)**

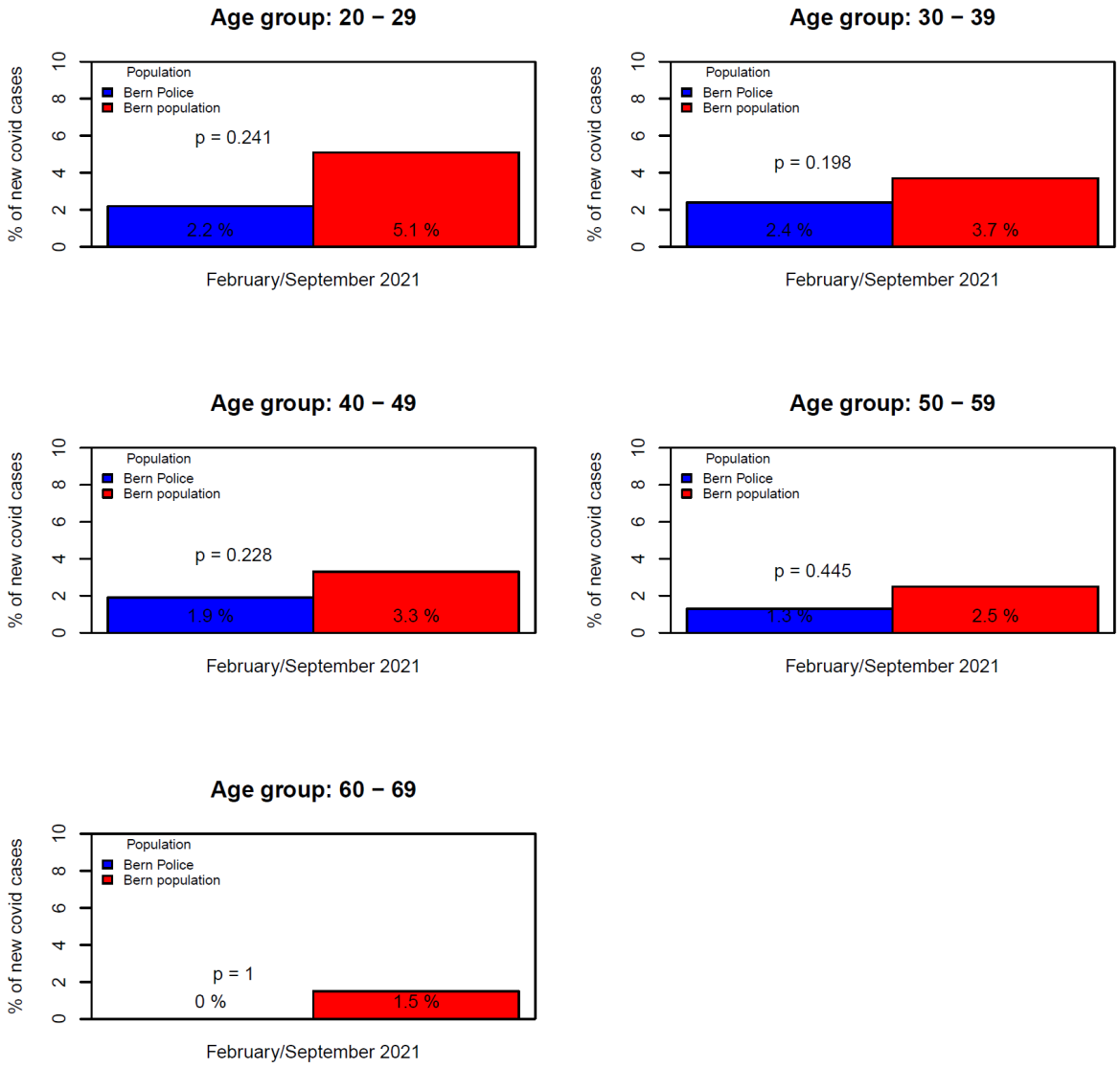
Appendices Figure S2 : Anti-NCP antibody seroprevalence of the police cohort at baseline and 3- and 6-month visits.



Anti-NCP antibody seroprevalence of the police cohort at the baseline, 3-month and 6 month-visits. Results are displayed without correcting for the sensitivity and specificity of the anti-NCP antibody assay (i.e.; unadjusted seroprevalence).



Appendices Figure S3-1: Comparison of the SARS-CoV-2 infection rate between the police cohort and the general population of the canton of Bern. Comparisons between the infection rates at the 3-month (April/May 2021) and 6-month visits (September 2021).



Appendices Figure S3-2: Comparison of the SARS-CoV-2 infection rate between the police cohort and the general population of the canton of Bern over a time period of 6 months (i.e., from February to September 2021).

Appendices Table S1: Association of comorbidity and work-related factors with the infection rate:

	Comorbidity					
	Yes			**No**		
Age group	beta	Odds ratio	p-value	beta	Odds ratio	p-value
20 - 29	ref			ref		
30 - 39	17.168	28578730	0.999	0.025	1.025	0.938
40 - 49	0	1	1	-0.161	0.851	0.629
50 - 59	18.131	74849054	0.999	-0.092	0.912	0.805
60 - 69	0	1	1	-0.297	0.743	0.788
Intercept	-19.566	0	0.999	-1.649	0.192	<0.001
	Department					
	Regional police			**Others**		
Years of experience	beta	Odds ratio	p-value	beta	Odds ratio	p-value
0 - 9	ref			ref		
10 - 19	-0.266	0.766	0.285	0.491	1.634	0.297
20 - 29	0.144	1.155	0.653	0.498	1.645	0.32
> 30	0.175	1.191	0.739	-0.954	0.385	0.384
Intercept	-1.561	0.21	<0.001	-2.181	0.113	<0.001
	Work region					
	Bern City, Region Bern			**Bernese Oberland; Mittelland, Emmental, Oberaargau; Seeland, Bernese Jura**		
Years of experience	beta	Odds ratio	p-value	beta	Odds ratio	p-value
0 - 9	ref			ref		
10 - 19	-0.037	0.963	0.912	-0.167	0.846	0.541
20 - 29	0.229	1.257	0.54	0.094	1.098	0.791
> 30	-0.436	0.647	0.576	-0.196	0.822	0.734
Intercept	-1.915	0.147	<0.001	-1.462	0.232	<0.001