SARS-CoV-2 antibody seroprevalence in children and workers from Belgian French-speaking primary schools

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Research Article

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Abstract

Background

During the COVID-19 pandemic in 2020, closing schools was discussed as a protective measure to limit the transmission of the virus in Belgium. There was however a lack of evidence on the role of young children in the spread of the virus. We undertook a study among Belgian primary schools in order to assess the seroprevalence of SARS-CoV-2 antibodies and its relationship with communal incidence, size of schools and socio-economic index.

Method

The prospective non-interventional study was conducted from January 14 to May 18, 2021, into 11 primary schools in Belgium during 6 weeks per school. Schools were purposively selected using extremes on 3 criteria: area with a low/high official COVID-19 incidence after the first wave, small/large size of the school, and low/high socio-economic index of the school. Out of 2488 children and 444 school staff invited to participate, 932 (38%) children and 242 (55%) school staff signed an informed consent. Each participant was tested for COVID-19 antibodies using a rapid finger prick test. Additional analysis was conducted to document the low participation rate.

Results

Participation of children was positively correlated with participation of school staff (r=+0.33;95%CI [-0.34;0.78]), but the correlation was much stronger with socio-economic index (r=+0.81;95%CI [0.40;0.95]). SARS-CoV-2 antibody seroprevalence was lower among children (191/922=21%;95%CI [18-23%]) than among school staff (61/240=25%;95%CI [20-31%]), and it was not correlated with communal cumulative incidence (r=+0.06;95%CI [-0.59;0.67] in children and r=+0.26;95%CI [-0.40;0.74] in school staff). In school staff, seroprevalence was increasing with socio-economic index (r=+0.37;95%CI [-0.29;0.79]), but not in children (r=-0.10;95%CI [-0.66;0.53]). Seroprevalence didn't present classroom clusters (intraclass correlation coefficient R^2=0.08 in children and R^2=0.12 in children with school staff).

Conclusion

In children, participation was low in schools with a low socio-economic index. Children had a lower seroprevalence than school staff and there were no classroom clusters, suggesting that they are not the transmitters.

Trial registration

The protocol, informed consent forms, and questionnaires were approved by the Hospital-Faculty Ethics Committee Saint-Luc ("Commission d'Ethique hospitalo -facultaire des Cliniques universitaires Saint-Luc") – UCLouvain, approval number: 2020/16NOV/552. It was registered on clinicaltrials.gov on

16/09/2021, identifier number: NCT05046470, and on ISRCTN on 20/04/2022, identifier number: ISRCTN16837012.

Introduction

In 2020, the rapid spread of a new coronavirus disease (COVID-19) due to a new virus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), led many countries to take preventive measures to limit the transmission of the virus. Because the transmission of the virus can occur before the first symptoms of the disease or even without symptoms, the control of this pandemic was particularly complex. Many countries decided to close schools, disrupting scholarship of about 1.57 billion of students (91%) worldwide.(1) However, there was a lack of evidence on the role of young children in schools in the spread of SARS-CoV-2.(2)

A first study in Iceland showed that the incidence of SARS-CoV-2 infection was lower in children under 10 years of age than in adolescents or adults.(3) Preliminary results within primary schools in France indicate that the transmission occurred mainly at home. The infection by SARS-CoV-2 was most often mild or asymptomatic in young children.(4) Severity of symptoms play an important role in the infectiousness degree and asymptomatic person appears to contribute lesser in the transmission of SARS-CoV-2.(5) As the majority of children appeared asymptomatic, the contribution of children to the virus transmission in society can be lower.(6) Some countries didn't close their schools, but maintained strict protection and distance measures. Their results pointed out that the transmission cases within primary schools were limited.(7–9)

Many consequences of the pandemic such as the lockdown or a school closures can have a significant impact on children's development, independently of SARS-CoV-2 risk and COVID-19 disease. An American study analyzed the effects of previous pandemics on children who experienced a quarantine or isolation, and nearly a third of them showed symptoms of post-traumatic stress disorder.(10) Previous closures of schools have shown that students who did not attend school for a long period of time are more likely not to return once schools reopen.(1) More recently, other studies showed that physical, mental, and social well-being of children, as well as their scholarship and development effects, are affected by schools closures and reactional activities, especially those with disadvantaged background.(11–13) In addition, interruption of social contact that results from school closures and other preventive measures toward the pandemic, has catastrophic consequences for children's well-being including domestic violence.(14)

We investigated whether seroprevalence of SARS-CoV-2 antibodies was as high in children as in school staff, whether it was related to the communal cumulative incidence of SARS-CoV-2, whether the seroprevalence was related to the size of the school, and whether seroprevalence was higher in disadvantaged background.

Method

Study design and population

A prospective, non-interventional study, named Dynamic transmission of coronavirus in schools (DYNAtracs), was conducted from January 14th 2021 to May 18th 2021 in primary schools of the Federation Wallonia Brussels in Belgium.

Schools were selected using a purposive sampling to build the sample according to three inclusion criteria (Table 1). These three criteria were based on three surrogate markers.

The first surrogate marker was for the local level of SARS-CoV-2. We wanted schools in areas with a low level of infection as well as in areas with a high level of infection. The local level of SARS-CoV-2 was reflected by cumulative incidence of SARS-CoV-2 during the first wave on May 6th 2020 in Belgium, based on data from the Belgian public health institute, Sciensano.(15) The median of data was used as a cut-off to define a high or low incidence area. A region/city with a high incidence of SARS-CoV-2 corresponded to an incidence equal to or greater than 5.0 per 1,000 persons. A region/city with a low incidence of SARS-CoV-2 corresponded to an incidence strictly below 5.0 per 1,000 persons.

The second surrogate marker was for the number of social contacts within schools. A low or high number of social contact in a school was substitute by the size of the school. The cut-off for a large/small school size was based on the estimated maximum total number of children in Belgian primary schools. A large school was defined as a school with a size above the first tertile that was 230 children. Schools with less than 230 children were considered as small.

The third surrogate marker was for the disadvantaged background of children. The disadvantaged background was substituted by a low socio-economic index of the school. In Belgium, all schools are classified on a 20-points scale index called ISE. This socio-economic index (ISE) aggregates the average data of all students of the school and is calculated with 7 variables of the child's household over 7 years: median of the household income, proportion of people in household with a superior education degree, proportion of people with a nursery or primary school degree, proportion of people with a job, proportion of persons with social assistance, proportion of people with a manual work and proportion of people working in the lowest level of tertiary sector. More specifically, individual values are collected for each child. Then, an aggregation of individual variables by school implantation, institution and statistical sector of residence is performed. The mean and standard deviation are computed and each variable is standardized in order to have a mean of 0 and a variance equal to 1. A principal component analysis is performed on the correlation matrix to extract loadings for each of the 7 variables for calculating the first principal component, that is ISE. The lower the ISE the lower the socio-economic index.(16)

$$ISE_i = \sum_{j=1}^{7} C_j \frac{(x_{ij} - A_j)}{B_j}$$

$$i = schoolimplantation, institutionorsector;$$

$$j = variablenumber;$$

$$C_j = loadingofthefirstprinicipalcomponent,$$

$$whichallowstoweightthecontributionofvariablenumberj;$$

$$A_j = meanofvariableacrossschools;$$

$$B_j = standarddeviationofthevariableaccrossschools$$

According to this socio-economic index ISE, a value greater or equal 13 (the upper tertile) was defined as a high ISE and a value lower or equal 7 (the first tertile) was defined as a low ISE.

The two levels of each of the 3 criteria led to define eight strata for sampling schools within each stratum.

One to three schools were selected in each stratum, with the help of two administrations in charge of health at school, ONE ("Office de la Naissance et de l'Enfance") and PSE ("Promotion de la Santé à l'École"). School principals of selected schools were contacted to participate to the study.

Table 1
Schools according to 3 inclusion criteria

Cumulative incidence of SARS-CoV-2 **High ≥ 5.0** **Low < 5.0** **(per 1,000 persons)**	**Size of the School** **Large ≥ 230** **Small < 230**	**Socio-economic index** **High ≥ 13** **Low ≤ 7**	**School location**
High	Large	High	Angleur
		Low	Berchem-Ste-Agathe
		Low	Jette
		Low	Koekelberg
	Small	High	Herve
		Low	Seraing
Low	Large	High	Beauraing
		Low	Châtelineau 2
	Small	High	La Hulpe
		Low	Châtelineau 1
		Low	Farciennes

Cumulative incidence region/city of SARS-CoV-2 on May 6th 2020.

If they agreed to participate, they send us a list with the number of children per class and the number of workers in the school. A box per class was then prepared for parents with information, flyers and an informed consent to sign. All children from the school (6–12 years) were invited to participate as well as school staff. In order to help children of non-French speaking families, flyers were translated into languages requested by the principal: Arabic, Italian, Romanian, and Turkish. All school staff were also invited to participate and received a consent form to sign.

In parallel, school principals, teachers and parents were invited to participate to a videoconference to receive information and to ask questions.

A website was also created (https://www.sesa.ucl.ac.be/Dynatracs/) where parents could consult different information of the study, such as a video explaining the two testing procedures, the study protocol and flyers translated in different languages.

Participants were enrolled into the study if the consent was signed by both parents and the child or by the school staff.

In each school, the principal collected these signed forms within the week, and individual anonymized identification numbers were generated according to these lists of participants. The school location (Fig. 1), the school calendar, the protective measures at the time of the study, and the governmental measures to limit transmission of the virus were considered in the planning and field study organization (Fig. 2).

Each school was visited six times. We planned to return to the different schools each week, according to the school calendar. Each participant was tested by a rapid serological antibody test by finger prick only at inclusion. A saliva antigen test of SARS-CoV-2 was performed the first week and was repeated the following ones. Each week, the participant filled in a face-to-face questionnaire about possible exposure to COVID-19 and with demographic factors at inclusion. Each child received a notebook where he/she wrote down the risk of exposure during the entire period of the study and answered a well-being questionnaire during this pandemic of SARS-CoV-2. Teachers and school principals filled in different supplementary questionnaires with specific questions regarding protectives measures setting up in the school and the classrooms, class closure, etc. Each test and questionnaire were identified by the participant’s anonymized code during the entire study.

The Belgian concertation committee had provided some protective measures for schools when children showed symptoms or tested positive. When a child was tested positive, the parents were asked to warn the school and to isolate the child for a period of quarantine. When two children were tested positives within the same classroom, the classroom was closed and all the children were asked to stay at home for a quarantine period (see additional file 1).

Technical procedures

The presence of antibodies for SARS-CoV-2 was evaluated by using the Novel Coronavirus test, a lateral flow test antibody immunoglobulin M/G (IgM/IgG) assay (colloidal gold) (Avioq) (AVIOQ, Bio-Tech, Shandong, China) CE-labeled. Sensitivity for IgM/IgG was 68.8% (95% CI [60.3–76%]) and specificity was 95.8% (95% CI [88.5–98.6%]).(17) Two blind, and independent readings by two different experts were performed on the lateral flow test antibody. In case of discordance, a third reading was carried out by an expert supervisor and his reading was considered as the final result.

A saline mouth gargle sample was performed to collect the saliva from participants. This method showed a sensitivity of 98% to detect SARS-CoV-2 by Polymerase Chain Reaction (PCR) compared to nasopharyngeal swab.(18) Saliva was extracted by using the MagMAX Viral/pathogen Nucleid Acid Isolation kit on a KingFisher automated platform (ThermoFisher). An unbound MS-2-phage ribonucleic acid (RNA) sequence was added to each sample to show the efficiency of the process. Purified RNA was retro-transcribed and amplified on a QuantStudio5 real-time PCR platform with the TaqPath™ COVID-19 RT-PCR kit (ThermoFisher), that targeted the ORF1ab, N and S coding sequences by utilizing three different primers and probes sets. The different PCR assay findings are not published yet.

Data analysis

Participation of children and school staff are reported as number and proportion. Pearson's correlation (r, [95%CI]) were used to assess the relationship between participation or seroprevalence of children and participation of school staff, incidence level of SARS-CoV-2 within the school area at inclusion, size of the school, and the socio-economic index.

The SARS-CoV-2 seroprevalence was calculated for each school based on positive IgG. The communal cumulative incidence of SARS-CoV-2 was defined as the ratio between the cumulative cases reported by Sciensano for the area and the population number from national demography.(15) Seroprevalence among children and school staff, as well as the communal cumulative incidence of SARS-CoV-2 are reported per 1,000 persons. The cluster effect between classes within the schools was assessed using the intraclass Pearson's correlation coefficient (ICC).

Data analyses were performed with R 4.1.2.

Spatial distribution

The spatial distribution of participation and seroprevalence in children and school staff across Belgium has been performed using ArcGIS program 10.8 version.

Results

Among the 8 schools initially selected, 2 schools were excluded from the study because of a refusal from the school principal in one and a high refusal rate of children and parents (up to 40%) in the other one.

Five additional schools were then proposed, leading to 11 schools enrolled in the study (among the 13 invited schools). Additional analysis was conducted to document the low participation.

From these 11 schools, 1174 individuals participated to the study, including 932 children and 242 school staff.

Participation to the study

The global participation rate was about 37.5% with a total of 932 children (out of 2488 invited to participate) and 54.5% with a total of 242 school staff (out of 444 invited to participate).

The participation of children and of school staff within each school is illustrated on Fig. 3 (see Additional file 2 for more details). Participation of children (Fig. 3) was positively correlated (r = 0.33; CI 95% [-0.34;0.78]) with the participation of school staff.

The participation was higher in areas with a lower incidence level of SARS-CoV-2 at that time (in children r=-0.17; CI 95% [-0.70;0.48]; in school staff r=-0.52; CI 95% [-0.85;0.11]).

Participation in children and school staff was negatively correlated with the size of the school (children: r=-0.39; 95%CI [-0.80;0.27]; school staff: r=-0.50; 95%CI [-0.85;0.15]); the bigger the school the lower the participation rate.

Participation among children was lower (< 50%) in schools with a lower socio-economic index (ISE ≤ 7) (r = 0.81; CI 95% [0.40;0.95]), but among school staff there was no relationship between participation rate and ISE (r = 0.05; CI 95% [-0.56;0.63]), (Fig. 4).

Seroprevalence in children and school staff

There was 10.3% of discordance between the double-blind readings of SARS-CoV-2 lateral flow antibody test, and there were 12 cases with negative IgG but positive IgM that were considered as negative in our results.

Out of 1174 participants, 1162 serological tests (6 unreadable and 6 missing) were performed throughout all schools (see Additional files 3 and 4 for more details). 20.7% children (191/922; CI 95% [18.1;23.5]) and 25.4% school staff (61/240; CI 95% [20.0;31.4]) were positive for IgG.

Seroprevalence and participation in the study are represented geographically in Belgium specifically for children and school staff (Fig. 5). In the different schools (Fig. 5 and see Additional file 5 for more details), the rate of children with antibodies was highest around Brussels and Farciennes. But in school staff, the positivity rate was highest in Brussels, Herve, Beauraing and Farciennes.

Seroprevalence in children (Fig. 6) was higher in schools where the seroprevalence in school staff was high (r = 0.33; 95%CI [-0.34;0.77]).

Between schools, the seroprevalence was comparable (p-value = 0.17). We obtained a weak intraclass coefficient correlation: ICC = 0.08 in children and ICC = 0.12 in children with school staff.

Seroprevalence of antibodies SARS-CoV-2 in school staff (Fig. 7) was slightly associated with communal cumulative incidence (r = 0.26; CI 95% [-0.40;0.74]), but there was no correlation in children (r = 0.06; CI 95% [-0.59;0.67]). Seroprevalence in children and in school staff are generally above the dotted line, meaning that most of estimated seroprevalence were higher than communal cumulative incidence at the time of the study.

Seroprevalence in children and in school staff was lower in larger schools (≥ 230 children) (in children r=-0.63; 95%CI [-0.89; -0.04]); in school staff r=-0.28; 95%CI [-0.76;0.38]). Seroprevalence in school staff (Fig. 8) was higher in school with a high socio-economic index (ISE ≥ 13) (r = + 0.37; 95%CI [-0.29;0.79]), but it wasn't correlated in children (r=-0.10; 95%CI [-0.66;0.53]).

Discussion

Participation to the study

Children's participation in the study was lower than expected and may be partly explained by the problem of the recruitment period, which occurred during the lockdown. Reaching parents and children was difficult, resulting to misunderstandings and fears about the study. The two excluded schools because of a low participation rate had also a low socio-economic index. Some parents did not speak French, and even if we translated flyers into different languages, they refused to let their child participate. The consent form was the only way to inform parents in details about the study, but it was written in complicated terms as requested by our ethical committee, and led to some fears. For example, in the consent form, one of the possible side effects described for the finger prick test was a bruise, which was mentioned as an ecchymosis.

Most parents expressed their refusal to let their child participate, using arguments that showed a lack of understanding of how the study was being conducted (e.g. "we do not want our child to be vaccinated"). Investigators tried to explain the process of the study in simple terms, suitable for the general population, to reluctant parents. Some parents subsequently agreed to their child's participation, others did not.

Participation of children was higher in the schools where the participation staff was high. The only person available to explain the study simply and clearly was the teacher or the school principal. When the teacher was motivated to participate, children were perhaps more motivated to participate. School staff were mostly motivated to participate in every school. Not everyone who worked in the school could be present on the day we conducted the test, which may explain some refusals. Adherence to the study for the purpose of knowing the presence or absence of antibodies to the SARS-CoV-2 virus was one of the reasons that motivated staff members to participate. Contrarily, for those who had been infected by COVID-19, some did not wish to participate because they already knew the presence or absence of antibodies. Some school staff stated that they were interested in knowing the presence/absence of SARS-CoV-2 antibodies.

Motivation of school was not the only criterion for children to participate to the study.

In the protocol, we decided to establish 3 inclusion criteria to select schools. One was the incidence level of SARS-CoV-2 based on May 6th 2020. When we computed the participation according to the incidence level of SARS-CoV-2, we estimated the incidence based on the inclusion day. Participation of children and school staff was higher where the incidence level of SARS-CoV-2 level of SARS-CoV-2 was lower. The fear of the virus can explain the lower participation where the incidence level of SARS-CoV-2 was higher.

Participation of children and school staff was lower in large schools. Small schools are known to have more social contact and therefore, as children and school staff participated, others were more inclined to participate.

Children's participation was the lowest (< 50%) in schools with low socio-economic index (ISE ≤ 7), but it wasn't true for school staff. Socio-economic environment seems to have an influence on children's participation. Although we needed written consent from children and parents, the information should be more accessible and understandable, with simple terms suitable for children and parents. Every school staff didn't come from the same communal area. The Socio-economic index was calculated for every child within the school and children usually come from the same communal area as the school. As a result, the socio-economic index and the participation of school staff were not correlated.

A low socio-economic index shows that the different variables that decrease this index are more important in these schools. The different variables that decrease the socio-economic index of the schools are: proportion of people with a nursery or primary school degree, proportion of persons with social assistance, proportion of people with a manual work and proportion of people working in the lowest level of tertiary sector.(16)

One of the variable concerns the obtention of social assistance, in order to determine the socio-economic index. In Belgium, the CPAS ("Centre Public d'Action Sociale") is a social assistance that aims to ensure the right to social integration for people who do not have sufficient income and who meet the various legal conditions. In order to benefit from this social assistance, the person must meet the six legal conditions, which are: Belgian nationality, permanently living in Belgium, being of legal age, insufficient resources, willingness to work (unless health reasons prevent this) and having used up all the different social rights (the CPAS only operates as a last resort).(19) The ISE represents mainly the children and not the staff in a school.

Seroprevalence in children and in school staff

The seroprevalence of SARS-CoV-2 antibodies in school staff was higher than the seroprevalence in children, with 25.4% (95% CI [20.0;31.4]) and 20.7% (95% CI [18.1;23.5]) respectively. Seroprevalence among children was higher in schools with high seroprevalence among school staff. The weak intraclass coefficient correlation (ICC = 0.08 in children; ICC = 0.12 in children with school staff) suggests that seroprevalence didn't present classroom clusters. The classroom size did not appear to have an impact on the seroprevalence of SARS-CoV-2 among children in this study.

An initial study in Iceland showed that 6.7% of children under 10 years of age (38/564) were tested positive for SARS-CoV-2 by nasopharyngeal and oropharyngeal tests, compared to 13.7% (1,183/8,635) of individuals older than 10 years of age.(3)

In England, a study in primary schools reported a seroprevalence of 11.2% (91/816; 95% CI [7.9;15.1]) in children and 15.1% (209/1,381; 95% CI [11.9;18.9]) in staff. The weekly transmission of SARS-CoV-2 in children was 4.1 per 100,000 persons (12.5 in adults).(20) A prospective cross-sectional study analyzed infection clusters and outbreaks in staff and students. Staff had a higher incidence over children and the risk of an outbreak increased by 72% for every 5 cases per 100,000 in community incidence.(20) Children appear to be more likely mild or asymptomatic, and then are less being tested for the virus. (20, 21)

Another small study conducted in a Belgian primary school, 20.6% (13/63; 95% CI [10.6;30.6]) of children tested positive with throat washing sample, and the majority of them were asymptomatic. In that study, seropositivity in adults was 27.1% (32/118; 95% CI [19.1;35.7]), also higher, as in our own results.(22)

The course of COVID-19 was often milder with a better prognosis in children than in adults, and deaths were exceptionally rare in children.(23–25) The difference between adults and children to develop COVID-19 remains unexplained, even if immunity and innate responses may play a role.(26–28) Children can develop an immune response to the virus without virologic confirmation of SARS-CoV-2 infection, suggesting the possibility that immunity prevents the onset of SARS-CoV-2 infection.(29)

Children less than 10 years old were estimated to be significantly less infected by SARS-CoV-2 compared to teenagers or adults.(30) It seems important to make a distinction between children and adolescents, as the results do not appear to be entirely similar. Several studies have shown that seroprevalence in children and adolescents would differ.

Two Belgian studies compared seroprevalence in Belgian primary schools to secondary schools. Both studies reported similar antibody seroprevalence in children, but it was lower than seroprevalence in adolescents. In the first study, 6.6% (95% CI [1.2;12.1]) were seropositive in primary schools compared to 12.2% (95% CI [7.2;17.1]) in secondary schools.(31) The second study performed this comparison over 3 periods: from December 2020 to January 2021, in March 2021, and from May to June 2021. Seroprevalence was comparable in both groups but lower in primary schools. Seroprevalence was: 11.0% (95% CI [7.6;15.9]) in primary schools versus 13.6 (95% CI [9.9;18.5]) in secondary schools, 17.1% (95% CI [13.3;21. 9]) in primary schools versus 18.0% (95% CI [13.6;23.8]) in secondary schools for the second period; 15.4% (95% CI [12.2;19.6]) in primary schools versus 17.2% (95% CI [13.1;22.7]) in secondary schools for the third period.(32)

Seroprevalence and communal cumulative incidence

Throughout the lockdown period, investigators worked closely with the local health promotion teams and schools. Before, during and after the study, the local physicians provided data concerning infected children and school staff. Specifics measures against COVID-19 were set up for primary schools (see Additional file 1 for more details).(33, 34)

Previous studies reported that children do not appear to play a major role in the transmission of SARS-CoV-2.(3–9) Results of our study show that the seroprevalence among children and school staff within schools was higher than the incidence of COVID-19 positive cases in the communal area, because the communal cumulative incidence was underestimated. At the beginning of the pandemic in Belgium, only people with severe symptoms (e.g. temperature ≥ 38°C) were tested. All possible contacts in adults were tested after mid-June 2020.(33)

The lateral flow test that we used during our study had a sensitivity of 68.8% and a specificity of 95.8%.(17) The positive predictive value is expected to be high, but we have no way to estimate the seroprevalence itself.

The lateral flow test in children and school staff was operated at inclusion but a second test one week after was not allowed per protocol, so positive IgM with negative IgG could not be assessed for new infections.

Presence of antibodies, reflects a previous infection/contact with the virus. It doesn't show the actual number of persons with SARS-CoV-2 infection at that time. This might also explain why our seroprevalence of antibodies in children wasn't correlated to the communal cumulative incidence.

Seroprevalence and size of the school

Size of the school was considered as a way to evaluate social contact in children, which is an important factor in the virus transmission.(6) The findings suggest that the seroprevalence of SARS-CoV-2 antibodies was lower in larger schools, both in children and in school staff. These results suggest that close contacts are maybe more important in small schools, even if number of contacts is expected to be higher in larger schools.

Seroprevalence and socio-economic index

Seroprevalence in school staff was higher in schools with a high socio-economic index, and seroprevalence wasn't correlated with ISE in children. A first reason is that the socio-economic index is calculated from children data and not from staff data. Another reason is that most teachers and school staff live outside the communal area. For children, seroprevalence didn't correlate with socio-economic index as opposed to participation rates that were highly correlated with ISE.

Limitation

Our study has some limitations. Information about the study was only provided in paper forms with complicated terms and maybe not adapted to the general population, leading to low participation. Recruitment was made thanks to school principals because of the restriction distance measures at that time. Distance recruitment increased misunderstanding of parents and children about the purpose of the study.

Seroprevalence was not analyzed two times but only at the beginning of the study, based on the protocol. A comparison between the beginning and another time point during the study would allow to analyze the evolution of the situation during the study, but also during the different measures taken at that time against COVID-19.

Another limitation is that the ISE is linked to a school and not a child; we don't know if all participant children from low-ISE schools are living in poverty or not.

Nevertheless, our results are consistent with other studies. Our main findings are that children from schools with a low socio-economic index were less allowed to participate. Children had a lower seroprevalence than school staff and there were no classroom clusters, suggesting that they are not the transmitters of SARS-CoV-2. Our results strongly suggest that information strategies have to be more oriented to low socio-economic index in order to increase their participation in the disease control. Well-being and mental health of children should be at the center of our decisions in order to limit further consequences in their development and scholarship. Data on the virus infection and transmission are important for decision-making to control the disease, while considering the numerous consequences that may result from these decisions.

Children have been and are still being strongly affected by the COVID-19 pandemic. Understanding the transmission of SARS-CoV-2 in schools could limit the long-term consequences on children's scholarship, development and well-being. Taking socio-economic index into consideration is an important notion to analyze the virus transmission as the pandemic has reinforced social inequalities. By integrating all the lessons learned from this pandemic, we will be better prepared to deal with future health problems.

Abbreviations

COVID-19
coronavirus disease
CPAS
"Centre Public d'Action Sociale"
ICC
the intraclass correlation coefficient
IgM/IgG
immunoglobulin M/G
ISE
socio-economic index

ONE
“Office de la Naissance et de l’Enfance”
PSE
“Promotion de la Santé à l’École”
PCR
polymerase chain reaction
RNA
ribonucleic acid
SARS-CoV-2
severe acute respiratory syndrome coronavirus 2

Declarations

Ethics declarations

Ethics approval and consent to participate

This study was carried out in accordance with relevant guidelines and regulations (e.g. the Declaration of Helsinki). The protocol, informed consent forms, and questionnaires were approved by the Hospital-Faculty Ethics Committee Saint-Luc (“Commission d’Ethique hospitalo -facultaire des Cliniques universitaires Saint-Luc”) – UCLouvain, in Brussels, approval number: 2020/16NOV/552. It was registered on clinicaltrials.gov on 16/09/2021, identifier number: NCT05046470, and on ISRCTN on 20/04/2022, identifier number: ISRCTN16837012. Written informed consent was obtained from all participants prior to participation and/or their legal guardian.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors contribution's

KC collected, analyzed, and interpreted data, drafted, edited, and prepared the final manuscript, tables and figures. JF, OC, BK, FR, MDK and DVL participated to the design of the study. JF, OC and DVL helped collecting data and supported manuscript writing. RDM, FM, and BK conducted the laboratory analyses. MDK collected, contributed to the analysis and interpretation of the data, supported and edited the final manuscript. AR designed and supervised the project, supported data analyses and interpretation, and edited the final manuscript. All authors read and approved the final manuscript.

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Figures

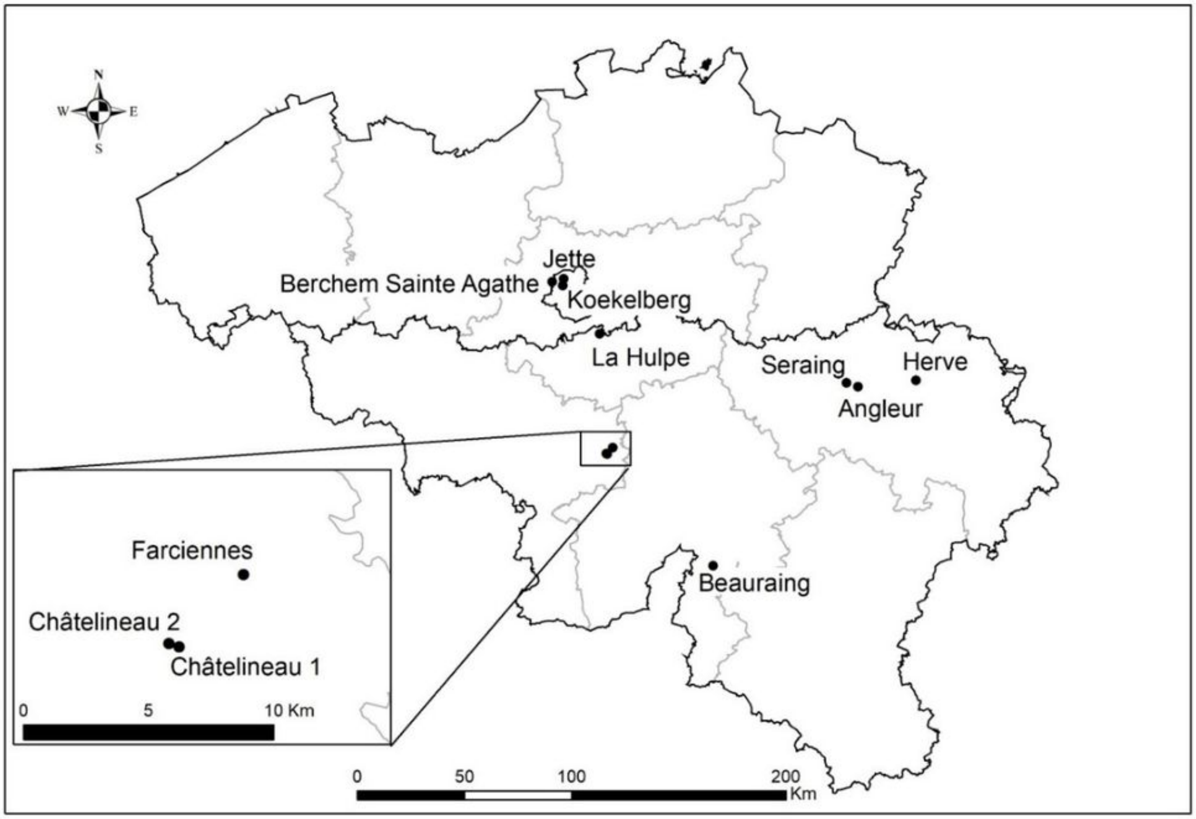

Figure 1

Geographic distribution of the schools participating in the study in Belgium

Schools are geographically represented by a black circle.

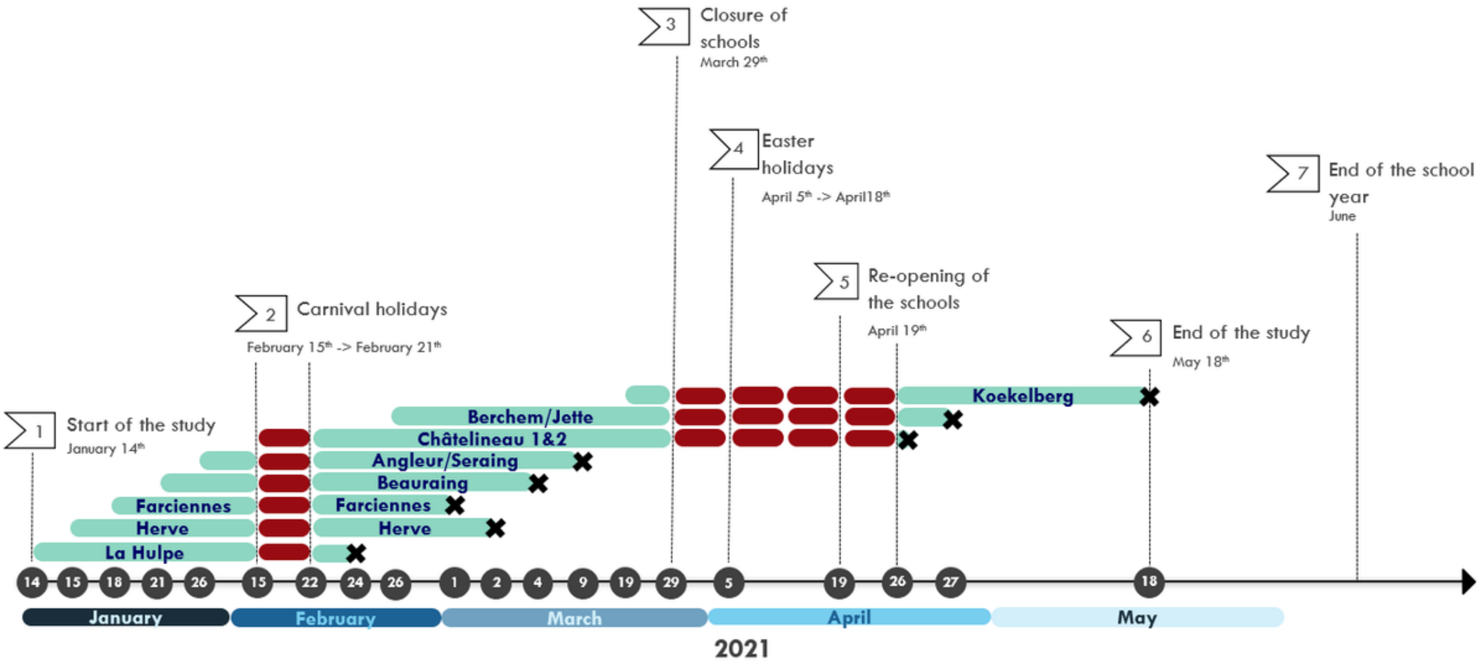

Figure 2

Calendar for the organization of the tests in the different schools

Green zone: study period within the school; red zone: school vacations, closing period or study break; black cross: end of the study for the school.

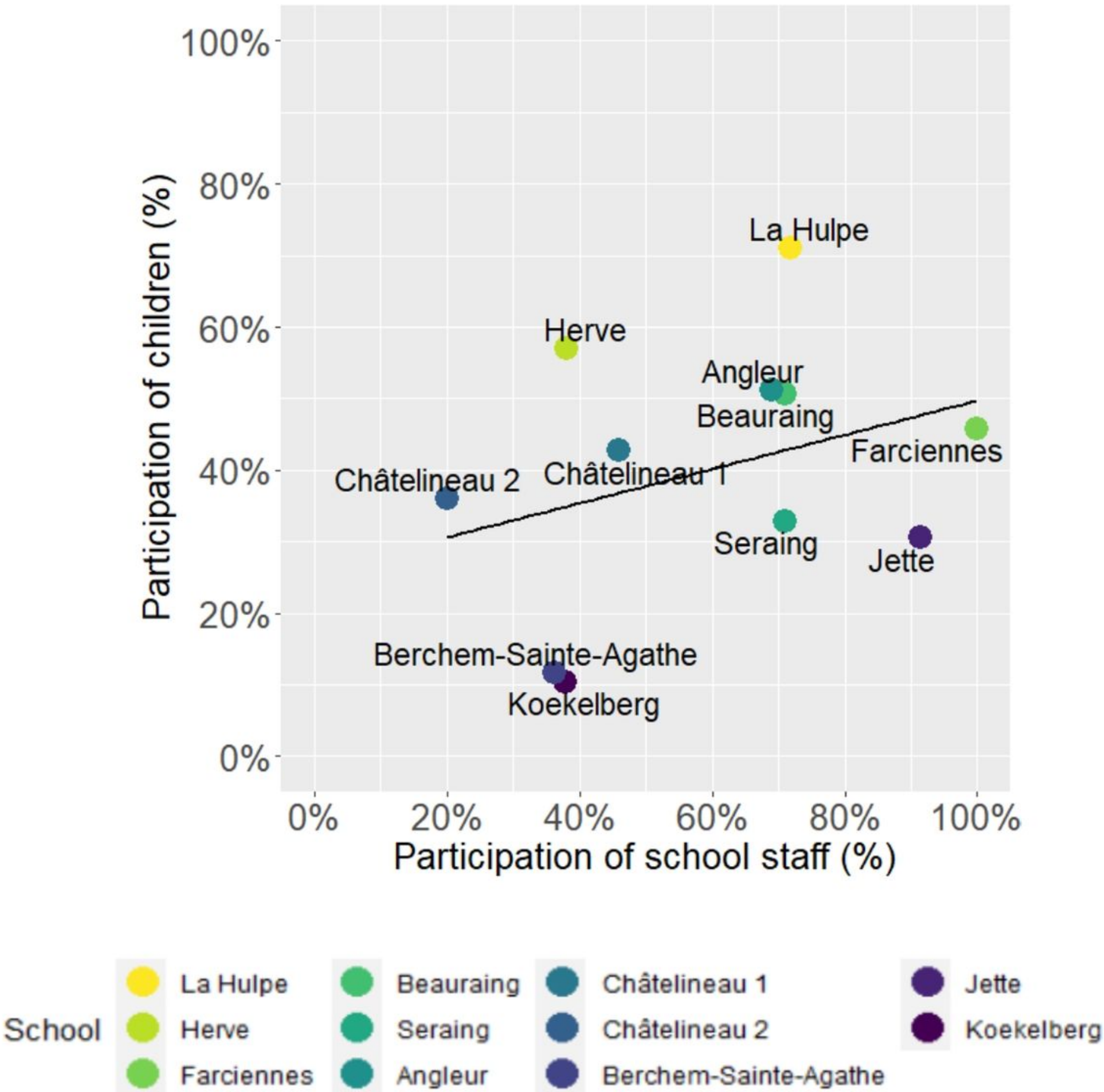

Figure 3

Participation of children according to the participation of school staff in the study

Participation of children and school staff are represented by percentages (%). The correlation between children and school staff participation is represented by a black line. Schools are represented by a colored dot.

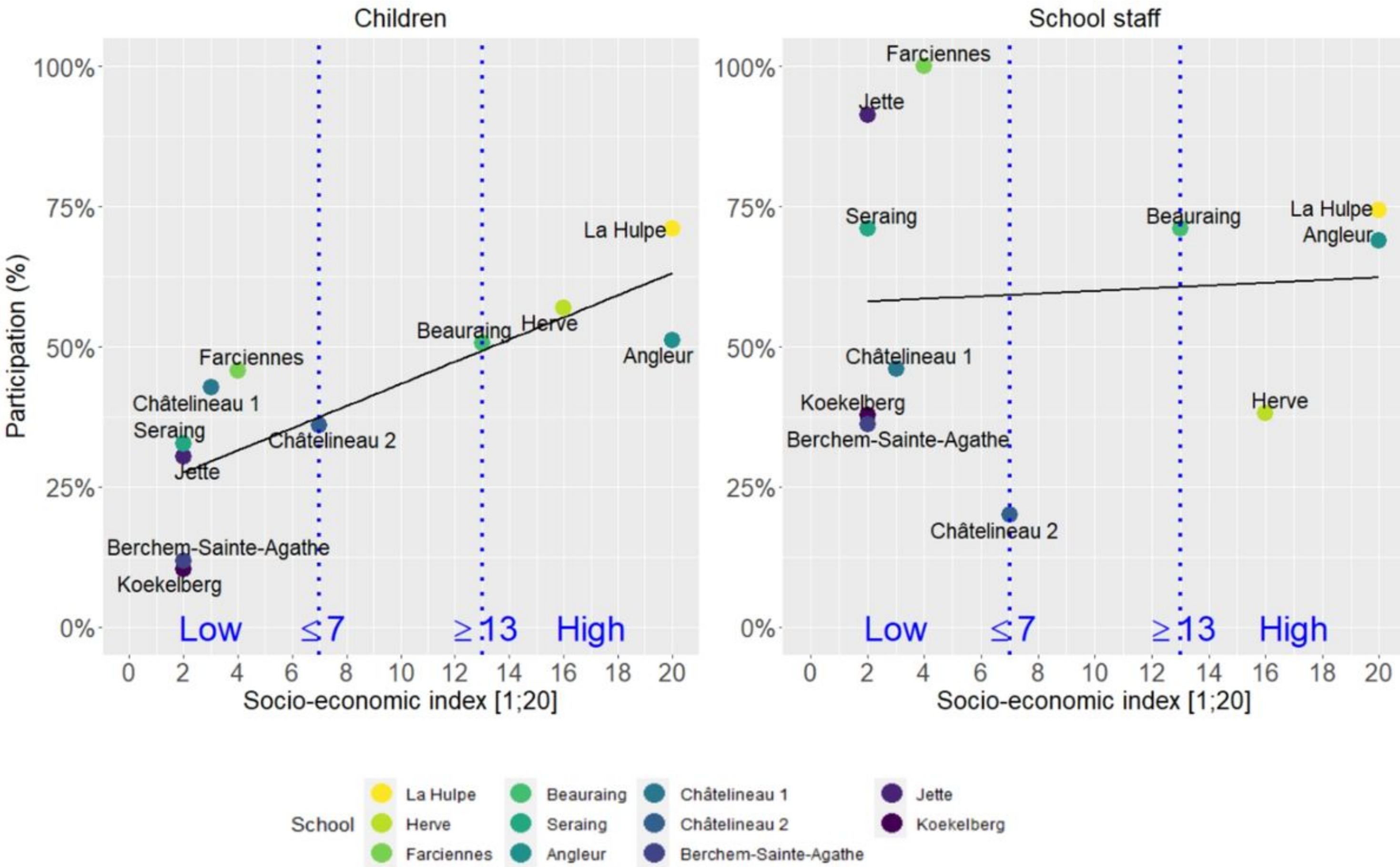

Figure 4

Participation of children and school staff according to the socio-economic index

The participation of children and school staff is represented by percentages (%). Socio-economic index (Belgian 20-point-scale ISE index) is represented between 1 to 20. The two extremes value, ≤7 and ≥13 are represented by the two blue dashed lines. The correlation between participation and the socio-economic index of the school is represented by the black lines. Schools are represented by a colored dot.

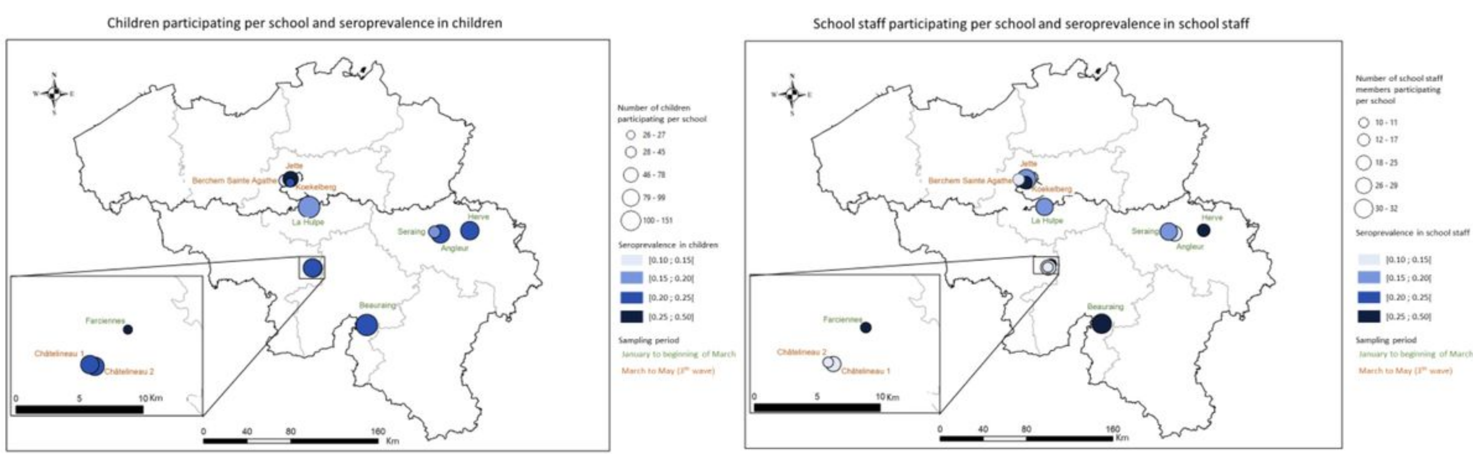

Figure 5

Geographic representation of participation and seroprevalence of children and school staff in Belgium

Participation (n total) is represented by the circle size. Seroprevalence (n IgG+/n total) in children and school staff is represented by the blue color scale.

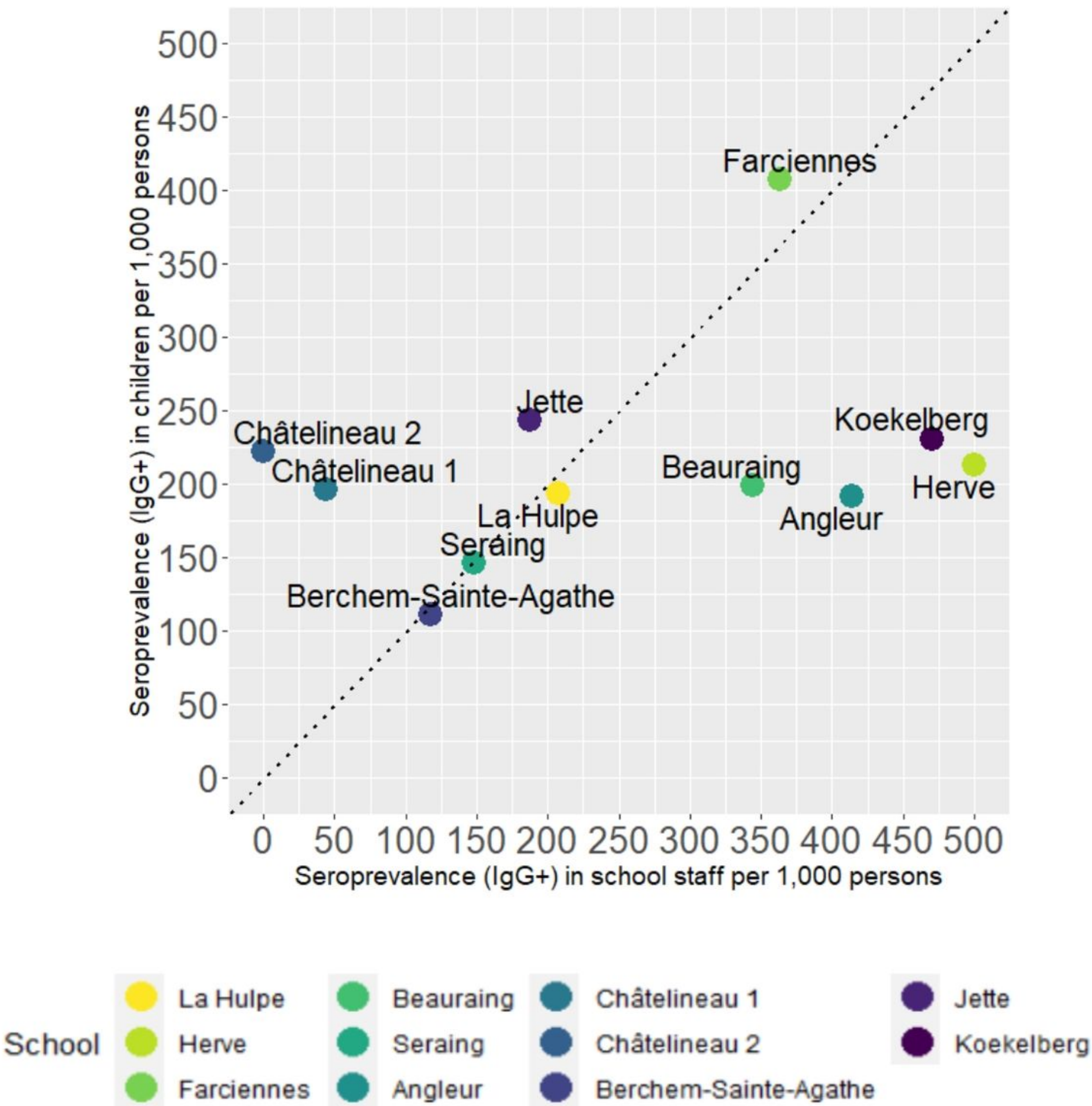

Figure 6

Seroprevalence in children according to the seroprevalence in school staff

Seroprevalence (IgG+) in children and school staff are represented by 1,000 per inhabitants. The identity line is represented by the black dashed line. Schools are represented by a colored dot.

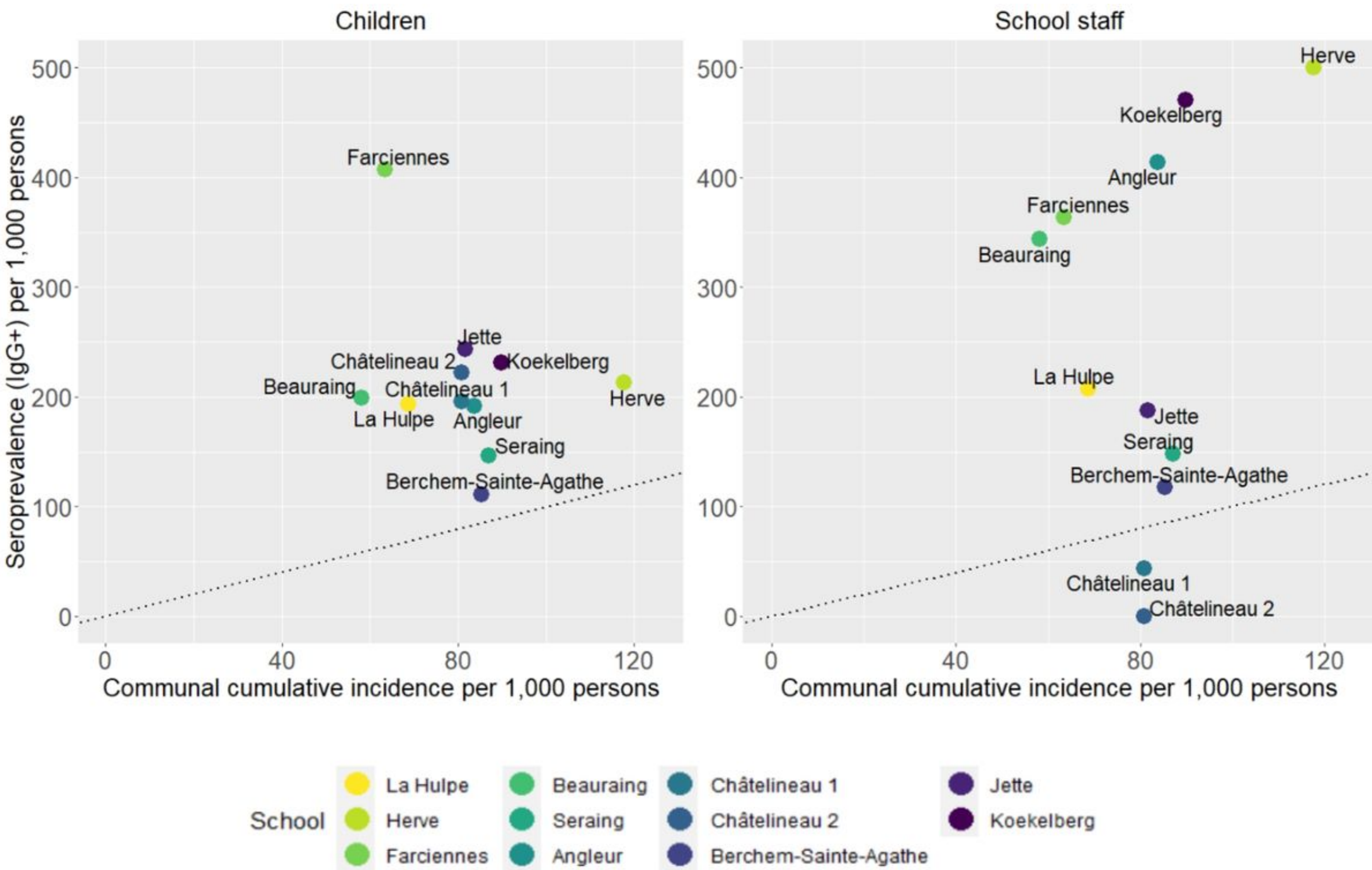

Figure 7

Seroprevalence in children and school staff according to communal cumulative incidence

Seroprevalence (IgG+) in children, in school staff and communal cumulative incidence are represented by incidence per 1,000 inhabitants. The identity line is represented by the black dashed line. Schools are represented by a colored dot.

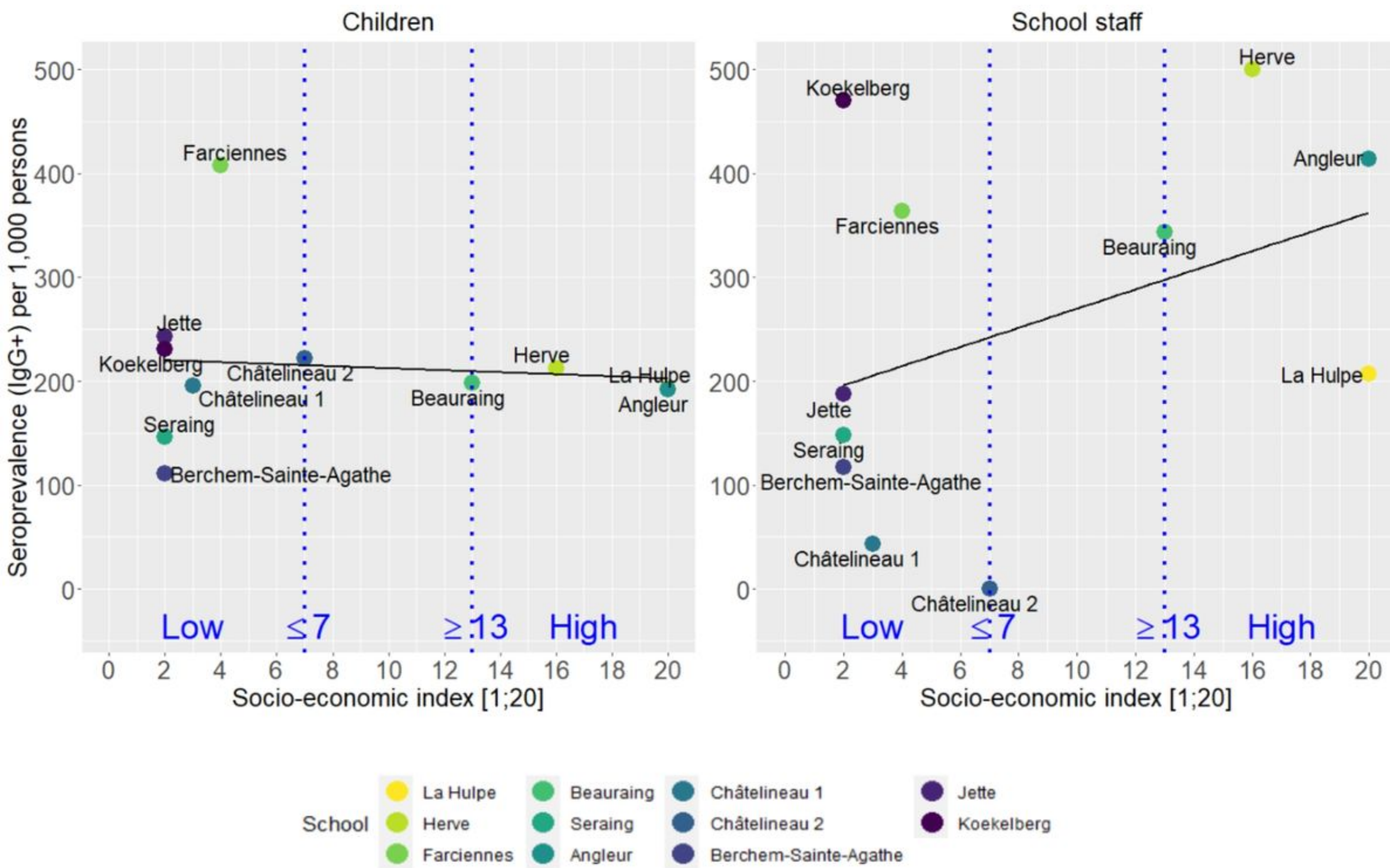

Figure 8

Seroprevalence in children and school staff according to the socio-economic index

Seroprevalence (IgG+) in children and school staff are represented by 1,000 per inhabitants. Socio-economic index (Belgian 20-point-scale ISE index) is represented between 0 to 20. The two extremes value, ≤7 and ≥13 are represented by the two blue dashed lines. The correlation between seroprevalence and socio-economic index is represented by a black line. Schools are represented by a colored dot.

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