BMJ Paediatrics Open

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools

Journal:	*BMJ Paediatrics Open*
Manuscript ID	bmjpo-2024-002974
Article Type:	Original research
Date Submitted by the Author:	08-Aug-2024
Complete List of Authors:	Kimmig, Christian; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Langer, Thorsten; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Loy, Johanna K.; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Bender, Stephan; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Haddad, Anneke; Medical Center - University of Freiburg, Institute for Infection Prevention and Control
Keywords:	Health Policy, COVID-19, Child Health, Adolescent Health

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools

Authors

Christian Kimmig[1*], Thorsten Langer[1], Johanna Loy[2], Stephan Bender[2+], Anneke Haddad[3+]

[1] Medical Center - University of Freiburg, Center for Pediatrics, Mathildenstraße 1, D-79106 Freiburg, Germany
[2] Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, Robert-Koch-Str. 10, D-50935 Cologne, Germany
[3] Medical Center - University of Freiburg, Institute for Infection Prevention and Control, Breisacherstr. 115B, D-79106, Germany
*Corresponding Author
[+] These authors contributed equally to the manuscript.

Key messages

- Data on the experience of routine SARS-CoV-2 testing in asymptomatic children and adolescents is scarce. Moreover, factors associated with test appraisal are not sufficiently understood and there are no comparisons of different test types.
- We found that young people report give pooled PCR tests better ratings than rapid antigen tests. Additionally, children that are vaccine-willing, children without mental health difficulties and children that report better health-related quality of life give better overall test scores.
- This study provides data directly from children about their experiences of a mandatory public health measure; this could help policy-makers, practitioners and researchers to take young people's perspectives into account and better balance competing goals in implementing public health measures. Moreover, it demonstrates the feasibility and value of rapidly collecting direct data from large cohorts of children.

Abstract

Public health measures during the COVID-19 pandemic had dramatic consequences for children and adolescents. However, policy makers and health care researchers did not give sufficient weight to children's perspectives. One common public health measure was mandatory SARS-CoV-2 tests in schools. This study examines the evaluation of such mandatory testing. We investigated the effects of test type (pooled PCR tests vs. antigen rapid tests) and of demographic and psychological factors on evaluations of the experience of being tested testing. A total of 569 children (8-17 years) in two major German cities completed online questionnaires between October and December 2021. Participants answered questions addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties, and health-related quality of life. Results showed that overall test ratings were better for pooled PCR tests (p<.001). Vaccine-willing students evaluated SARS-CoV-2 tests more positively than vaccine-unwilling students, regardless of test type (p<.001). Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores (p<.001). Additionally, children who reported better health-related quality of life and children with less pandemic-related stress rated the tests more positively. These results suggest that there are differences in the appraisal of the test types and that specific subgroups' experiences of regular testing vary. Our study provides insights for policy makers in future pandemics and raises questions regarding parallels between testing and vaccination

hesitancy. Moreover, our study demonstrates the feasibility and value of collecting data directly from a large cohort of children in order to understand their experiences.

Introduction

Public health measures implemented during the COVID-19 pandemic had – and continue to have – dramatic consequences for children and adolescents. Decreased in-person social contact, isolation and increased screen time through home schooling are just some of many ways that young people's everyday lives were affected, regardless of whether or not they were infected[1].

Given that the medical risks of COVID-19 for most young people are low, the most significant and widespread risks of the pandemic for this age group therefore arose as a result of public health measures themselves. Thus one major challenge during the pandemic was to mitigate tensions between negative effects of public health measures on children and adolescents specifically and (high) medical risks for other demographic groups if such measures were not implemented. This consideration is critical, because childhood and adolescence are important and potentially vulnerable periods of sociocognitive development[2,3].Investing in children's health is critical not only for individual flourishing but also to ensure beneficial development of whole societies, as highlighted by the WHO-UNICEF-Lancet commission "*A future for the world's children*"[3]

Yet early in the pandemic, policy-makers did not give sufficient weight to children's rights, and children had no feasible opportunities to raise possible concerns regarding public health measures. Moreover, healthcare researchers investigating COVID-19 did not adequately consider children's and adolescents' experiences[4]. As a result, young people's perspectives on public health measures that directly and significantly affected them were neglected. To address this, Jörgensen et al. suggested adding the pillars "preparation (for future child health crisis)" and "power (authority of children's voices, which requires meaningful participation)"[5] to the existing 3P-Network (provision, protection and participation), anchored in the United Nations Convention on the Rights of the Child[6].

Although the SARS-CoV-2 pandemic is formally over, considering children's opinions on public health measures continues to be important. The frequency of pandemics has increased over the past century[7] and estimates for the lifetime risk of another pandemic range from 17% to 44%[8]. Consequently, we need to prepare for future situations where tensions arise between the need to prevent spread of infection and the desire to avoid subjecting children to mandatory public health measures. Data on perspectives from children themselves could yield new insights into how policy makers, public health authorities, schools and researchers could better balance such considerations.

Here, we present on data on children's perspectives regarding mandatory SARS-CoV-2 testing in schools. In Germany, schools were fully or partially closed for 38 weeks in total[9] (although evidence on the efficacy of school closures is equivocal[10]). To mitigate the risks of re-opening schools, many governments required children to undergo regular SARS-CoV-2 testing.

Although the medical risks of testing in schools were low, little is known about how children perceived this testing. Children's experience of being subjected to mandatory testing could influence their views and behavior regarding other public health measures, both now and in the future, particularly if their experiences were negative. People's thoughts and feelings play a critical role in their acceptance of public health measures[11] and low trust in such measures is associated with low compliance[12]. Although there was, overall, high acceptance of public health measures during the pandemic[13], most data is from adults. Regarding SARS-CoV-2 testing in particular, limited data from adults shows high acceptance [14–1617]. A large Norwegian cross-sectional study showed high compliance, especially among secondary school students. Regular testing in the aforementioned

study was voluntary[18]. Other than that, data on acceptance of routine testing in asymptomatic children is scarce and with small cohorts[19–21].

In line with Jörgensen et al.'s pillars "power" and "preparation"[5], our study aims to close this knowledge gap by investigating children's appraisals of routine SARS-CoV-2 testing in schools. We sought to address the following questions:

1. How do children appraise two different routine SARS-CoV-2 test types (rapid antigen tests and pooled PCR tests)? What are the effects of demographic factors? What emotions do children associate with the two different SARS-CoV-2 test types?
2. What is the relationship between test ratings and SARS-CoV-2 vaccine hesitancy?
3. How do test ratings relate to mental health difficulties, pandemic-related stress/difficulties, and health-related quality of life?

Methods

The public was not involved in the study design or the creation of the online questionnaire. Questionnaires and the recruitment strategy were developed by a multi professional team of different health care researchers. Data were collected between November and December 2021 using online questionnaires. Participants were recruited by distributing links and QR-codes in schools, day-care facilities, hospitals and parent organizations in two major German cities (Freiburg and Cologne) and inviting children aged 8-17 to complete the online questionnaires via REDCap[22,23]. Data from parents and caregivers of children aged 4-17 years were collected in parallel and have been reported separately[24].

During the data collection period, Sars-CoV-2 incidence in Germany was between 91 per 100,000 in October and >200 per 100,000 in November-December 2021[25]. The Delta variant was predominant during this period, which led to increased hospitalizations than other variants. Vaccination against SARS-CoV-2 was recommended and approved for children ≥12 years; the first vaccination for children ≥5 was approved after our data collection period. By Nov 20th 2021, 61.1% of children aged ≥12 years in Germany had been vaccinated at least once; 50.6% were fully vaccinated[26].

Participants provided demographic data and test information and completed a set of questionnaires addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties and health-related quality of life.

SARS-CoV-2 test type(s) and evaluation: Regular SARS-CoV-2 testing for pupils attending in-person lessons was mandatory in Germany during the data collection period. The most common test methods were rapid antigen tests and saliva-based pooled PCR tests ('pooled PCR tests pop-method')[27,28]. Both methods entailed multiple tests each week. If the school used both methods, participants reported on the test type they had most recently experienced. Participants rated the SARS-CoV-2 tests using a standard German school grading system (1=excellent to 6=fail). Additionally, participants received an Emotional Words List and reported on a 4-point Likert scale (0=*not at all* to 3=*very*) how strongly they experienced each of 22 emotions (e.g., *ängstlich* (fearful), *beruhigt* (reassured), *missgestimmt* (grumpy, ill-tempered), *fröhlich* (cheerful)) when performing the SARS-CoV-2 [29]. Item scores are summed to give scores on the Positive Domain and the Negative Domain, as well as Positive and Negative Subdomains. We focused on the Positive and Negative Domains and the three Negative Subdomains (A: Bad temperedness/Annoyance, B: Anxiety/Sadness, C: Deactivation).

Mental health difficulties: Participants completed the 25-item version of the Strength and Difficulties Questionnaire (SDQ)[30] to screen for emotional and behavioral difficulties. Here, we focused on the

total difficulties score, which was categorized as being within the normal range (≤14) or borderline/abnormal (>14).

Health-related quality of life (HRQoL): Participants completed the KIDSCREEN-10[31], a short questionnaire with 10 items on a 5-point Likert scale to asses general HRQoL. The KIDSCREEN-10 has good test-retest reliability (r = .73; ICC = .72) and internal consistency (Cronbach's alpha for the current study = 0.87).

Pandemic-related stress: To evaluate COVID-19 pandemic related stress, we used a questionnaire[32] which assesses quality of social interactions, educational burdens in school, leisure time activities and emotional responses to the pandemic. Responses are on a 5-point Likert scale ranging from "much worse" to "much better".

Statistical analyses were performed in SPSS 29.0 (IBM). To examine effects of gender, school type, age (within the sub-group who attended secondary grammar school), vaccination status and mental health difficulties on ratings of the two different SARS-CoV-2 test types, we used ordinary multiway ANOVA. For vaccination status, we conducted separate analyses for 12-17 year olds and under 12 year olds, since at the time of the data collection, vaccination was recommended for children aged ≥12 but not for younger children. We also used multiway ANOVA to examine effects of test type on Positive Domain emotions on the Emotional Words Test. Scores on the Negative Domain and its three Subdomains were strongly right-skewed; we therefore used non-parametric (Mann-Whitney) tests to analyze effects of test type on these scores. We examined associations between test ratings and health-related quality of life and pandemic-related stress using Pearson correlations. Some children experienced both test types and reported on their experience of their most recent test. Mixed test types may have influenced results; we therefore conducted sensitivity analyses by repeating each analysis with data only from children who had only experienced one test type or the other. Since analyses were exploratory, all tests were two-tailed and we did not attempt to replace missing values; rather, we excluded missing values from statistical analyses.

The study funder had no role in study design, in the collection, analysis, and interpretation of data, in writing of the report, or in the decision to submit the paper for publication.

Results

Full data sets were available for 589 children. Due to low numbers, we excluded gender-diverse participants (n=4), those whose most recent test was an antigen spit test (n=8), and those whose last test was >7 days prior to the survey (n=8). The final sample therefore included 569 children. Data regarding demographics, SARS-CoV-2 testing and vaccination status are summarized in *Table 1.*

Children's **overall ratings** of the two test types and differences based on gender or school level (primary/secondary) showed that pooled PCR tests received better ratings than rapid antigen tests (main effect of test type, $F(1, 549)=28.400$, $p<.001$, partial $\eta^2=0.049$; estimated mean difference 0.95, 95% CI [0.60, 1.30]). The sensitivity analysis showed the same pattern of results. We found no statistically significant effects of age amongst secondary grammar school students (see Supplementary Results for details). Participants with unclear (e.g., Steiner school) or missing school type were excluded (n=13).

Regarding **emotions associated with SARS-CoV-2 testing,** the Pooled PCR -test group reported higher mean Positive Domain scores associated with testing than the antigen rapid antigen test group (main effect of test type, $F(1, 565)=36.524$, $p<.001$, partial $\eta^2=.061$; estimated mean difference 2.17, 95% CI [1.46, 2.87]). The sensitivity analysis yielded the same pattern of effects. The pooled PCR-test group also reported had lower scores for the negative domain (mean rank 274.61) than the antigen test

group (mean rank 308.0; Mann-Whitney U-test Z=-.261, *p*=.024). The same held for negative subdomain A (Bad temperedness/Annoyance), Z=-3.394, *p* <.001 and negative subdomain B (Anxiety/Sadness), Z=-3.987, p<.001. For negative subdomain C (Deactivation), the Pooled PCR test group associated testing with higher deactivation levels (mean rank 295.8) than the antigen test group (mean rank 261.1 Mann-Whitney U, Z=-2.505, *p*=.012). The sensitivity analysis showed the same pattern of results for the Negative Domain and for Negative Subdomains A and B. For Negative Subdomain C, the difference was no longer statistically significant in the sensitivity analysis (*p*=.061).

We also examined effects of **vaccination status**. Amongst 12-17 year olds, vaccinated/vaccine-willing adolescents gave the tests significantly better ratings than unvaccinated and vaccine-unwilling adolescents (main effect of vaccination status, F(1,367)=110.650, p<.001, partial η^2=0.232; estimated mean difference 1.69, 95% CI [1.38, 2.01]). The pooled PCR tests received significantly better ratings than the antigen tests (main effect of test type, F(1,367)=29.088, p<.001, partial η^2 =0.073; estimated mean difference 0.87, 95% CI [0.55, 1.18]). The interaction was not significant. In the sensitivity analysis, the two main effects remained significant; in addition, a significant interaction (F(1, 265)=4.211, *p*=.041, partial η^2=0.016) arose because the difference between the two test types was significantly larger for unvaccinated/unwilling participants (mean difference 1.68, 95% CI [0.89, 2.47]) than for vaccinated/willing participants (mean difference 0.80, 95% CI for difference [0.49, 1.10]). However some subgroups in this analysis were extremely small.

Amongst under-12 year olds, vaccine-willing children rated the tests statistically significantly better than those who were vaccine-unwilling (main effect of vaccination status, F(1, 146)=36.786, p<.001, partial η^2=0.201; estimated mean difference 1.40, 95% CI [0.94, 1.86]). The effect of test type and the interaction were not statistically significant. In the sensitivity analysis, both main effects were statistically significant: not only did vaccine-willing children give the tests significantly better ratings than vaccine-unwilling children (as in the main analysis), but also the pooled PCR tests received better ratings than the antigen tests (F(1, 126)=5.175, *p*=.025, partial η^2=0.002, as seen in earlier). The interaction was not statistically significant.

Applying an ANOVA to examine the influence **mental health difficulties on testing experiences** yielded three significant main effects: test type: F(1, 561)=51.108, *p*<.001, partial η^2=.083; SDQ category: F(1, 561)=38.830, *p*<.001, partial η^2=.065; gender: F(1, 561)=11.204, *p*<.001, partial η^2<.020. In addition, the interaction between gender and SDQ category was significant, F(1, 561)=5.401, *p* =.020, partial η^2=.010. This arose because the gender difference in test ratings was statistically significant amongst those with borderline/abnormal SDQ scores (estimated mean difference 0.75, 95% CI [0.28, 1.22],) but not amongst those with normal SDQ scores (estimated mean difference 0.14, 95% CI [-0.08, 0.35]); see Figure 2. In the sensitivity analysis, the main effects SDQ category and test method remained statistically significant, ps<.001, but the main effect of gender and the interaction were no longer statistically significant.

Better **health-related quality of life**, as measured by KIDSCREEN scores, was statistically significantly correlated with better test ratings, r(567)=-.283, 95% CI [-.357, -.206]. Similarly, children who reported lower levels of **pandemic-related stress/difficulties**, as indicated by CBB scores, gave the tests better ratings, r(567)=.308, 95% CI [.232, .380]. For both correlations, there was no statistically significant difference between test types and the sensitivity analyses yielded similar patterns of effects.

Discussion

Our data, gathered directly from a large cohort of children, helps to narrow a knowledge gap in understanding children's experiences of being subjected to a regular, mandatory public health measure in school. In summary, our main findings were as follows:

1. Overall test ratings were better for pooled PCR tests. We found no significant effects of school type or age on test ratings. Children in the pooled PCR group reported more positive test-related emotions and less negative emotions (e.g., anxiety, annoyance). Interestingly, however, children in the pooled PCR group also reported more *Deactivation* emotions (e.g., tiredness, sleepiness, listlessness).
2. COVID-19 vaccinated or vaccine-willing students evaluated SARS-CoV-2 tests more positively than unvaccinated or vaccine-unwilling students, regardless of test type.
3. Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores. Similarly, children who reported better health-related quality of life and children with less pandemic-related stress also gave the tests better scores. These results were independent of the test type.

One strength of our study is the large sample size, which includes participants from two different areas in Germany (Cologne and Freiburg). Another major strength is that the reported data is directly from children and adolescents, which allows us to explore their emotional experience directly rather than via proxy report through caregivers.

An important limitation is that the sample was not representative; this is evident from the fact that 80% of our data was collected from secondary grammar school students, whose experiences may not reflect those of other groups. Further, we could not differentiate between nasal and oral rapid antigen swabs but solely differentiated between test types (PCR vs antigen) Swab location might influence test experience; however, most rapid antigen tests used at the time were nasal.

Overall, however, our study adds to existing data on acceptance of SARS-CoV-2 tests in general and the comparison of different sampling techniques. Schuster et al. found that students report a preference for nasal swabs over saliva tests[19]. However, they did not compare different test types (PCR vs antigen) and their sample size was rather small (67 students). Our study adds to their data with data from a large cohort considering different test types (not just test location). Franconeri et al. found good compliance and high satisfaction with regular voluntary testing among primary and secondary students. They focused on the satisfaction on the implementation of regular testing rather than the emotional experience during testing[18]. Adding to this study, our data expands the knowledge on testing acceptance considering mandatory tests and the actual experience when being tested. Moreover, we collected data from a wide age spectrum, which adds to Unger et al. who explored the acceptance of regular testing in focus group discussion found that students were in favor of testing at schools because it facilitated the return to in-person class. However they only interviewed high school students (Grade 10-12)[21].

In a parallel project[33], we investigated how parents evaluated the testing experience for their children and parents' reports on their children's responses and attitudes towards SARS-CoV-2 tests. The results were mostly in line with the data reported here: Parents also preferred pooled PCR tests for their children, parents of unvaccinated children tended to give tests worse ratings in general and parents of children with mental health difficulties gave worse ratings.

Considering our analysis, existing literature and the likelihood of future pandemics, our study aims to help prepare policy makers for "the next pandemic".

First, pooled PCR tests seem to be the preferred test option among children and adolescence. A recommendation for a specific test should always be given in light of current pandemic epidemiology and infection rates. Fear of infection can play an important role in how tests are perceived. SARS-CoV-2 incidence during our data collection period was high, which may have resulted in higher fear of COVID-19. Second, we advocate for age-specific support weighing the specific needs of elementary school students vs. adolescents. Third, children with mental health issues should be specifically prepared and supported in order to ensure a comfortable testing experience.

Our suggestions for "the next pandemic" stem from the direct insight of children's and adolescents experiences. Our study demonstrates the feasibility of collecting data directly from a large cohort of children rapidly to obtain insights into their experiences with a public health measure that influences their everyday life. For future pandemics, when public health measures might be necessary again, those measures could be adapted in real time to children's needs. Our study could serve as an example to prepare (→ "preparation") and give "power" to children and the chance to make a change[5]. Our study demonstrated that it is possible and necessary to involve large cohorts of children in research about public health measures. Children's rights are not a luxury and their right of participation[6] should not be disregarded, not even in light of a worldwide pandemic.

Finally, our study gives room to relevant questions and ideas about future research. As one example, we found an association between vaccination and testing acceptance. There is plenty of research regarding vaccine acceptance/hesitancy and associated factors[11,34]. We argue that parallels between vaccine acceptance and testing acceptance should be investigated. For example, what is the relationship between those "acceptances"? Are there common factors? Does this have implications for the implementation of public health measures? We consider this to be an important area for future research, with the goal of understanding children's experiences and motivations to comply with public health measures.

Funding statement: This work was supported by grant number ZMI1-2521COR004 by the Federal Ministry for Health.

Competing interest statement: The authors have no competing interests regarding this research article.

Authors contributions:

- Christian Kimmig: Manuscript writing, recruitment, data collection, literature research
- Anneke Haddad: Manuscript writing, data analysis, literature research
- Stephan Bender: Study design and planning, data collection, data analysis, funding acquisition
- Thorsten Langer: Study design and planning, recruitment, reviewing and editing of manuscript
- Johanna Loy: Data preparation, reviewing and editing the manuscript

Bibliography

1. Mulkey, S. B., Bearer, C. F. & Molloy, E. J. Indirect effects of the COVID-19 pandemic on children relate to the child's age and experience. *Pediatr. Res.* **94**, 1586–1587 (2023).
2. Calvin, C. M. *et al.* Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. *Int. J. Epidemiol.* **40**, 626–644 (2011).
3. Clark, H. *et al.* A future for the world's children? A WHO–UNICEF–Lancet Commission. *The Lancet* **395**, 605–658 (2020).
4. Jörgensen, E. *et al.* The voices of children and young people during COVID-19: A critical review of methods. *Acta Paediatr. Oslo Nor. 1992* **111**, 1670–1681 (2022).
5. Jörgensen, E., Wood, L., Lynch, M. A., Spencer, N. & Gunnlaugsson, G. Child Rights during the COVID-19 Pandemic: Learning from Child Health-and-Rights Professionals across the World. *Child. Basel Switz.* **10**, 1670 (2023).
6. UN General Assembly Convention on the Rights of the Child. 1989. [(accessed on 08 April 2024)]. Available online: https://www.unicef.org/media/52626/file.
7. Jones, K. E. *et al.* Global trends in emerging infectious diseases. *Nature* **451**, 990–993 (2008).
8. Marani, M., Katul, G. G., Pan, W. K. & Parolari, A. J. Intensity and frequency of extreme novel epidemics. *Proc. Natl. Acad. Sci.* **118**, e2105482118 (2021).
9. Fuchs-Schündeln, N. Covid-induced school closures in the United States and Germany: long-term distributional effects. *Econ. Policy* **37**, 609–639 (2022).
10. Viner, R. M. *et al.* School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child Adolesc. Health* **4**, 397–404 (2020).
11. Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J. & Kempe, A. Increasing Vaccination: Putting Psychological Science Into Action. *Psychol. Sci. Public Interest J. Am. Psychol. Soc.* **18**, 149–207 (2017).

12. Nivette, A. *et al.* Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. *Soc. Sci. Med.* **268**, 113370 (2021).

13. Fiordelli, M., Rubinelli, S. & Diviani, N. Acceptance of Public Health Measures During the COVID-19 Pandemic: A Cross-Sectional Study of the Swiss Population's Beliefs, Attitudes, Trust, and Information-Seeking Behavior. *Int. J. Public Health* **68**, 1605982 (2023).

14. Wu, F. *et al.* The acceptance of SARS-CoV-2 rapid antigen self-testing: A cross-sectional study in China. *J. Med. Virol.* jmv.28227 (2022) doi:10.1002/jmv.28227.

15. Bevan, I., Stage Baxter, M., Stagg, H. R. & Street, A. Knowledge, Attitudes, and Behavior Related to COVID-19 Testing: A Rapid Scoping Review. *Diagnostics* **11**, 1685 (2021).

16. Nguyen, N. *et al.* A mixed methods study evaluating acceptability of a daily COVID-19 testing regimen with a mobile-app connected, at-home, rapid antigen test: Implications for current and future pandemics. *PloS One* **17**, e0267766 (2022).

17. Fallucchi, F., Görges, L., Machado, J., Pieters, A. & Suhrcke, M. How to make universal, voluntary testing for COVID-19 work? A behavioural economics perspective. *Health Policy* **125**, 972–980 (2021).

18. Franconeri, L. *et al.* Experiences with regular testing of students for SARS-CoV-2 in primary and secondary schools: results from a cross-sectional study in two Norwegian counties, autumn 2021. *BMC Public Health* **23**, 1548 (2023).

19. Schuster, J. E. *et al.* A COVID-19 Testing Preference Study in Schools. *Pediatrics* **152**, e2022060352H (2023).

20. Denford, S. *et al.* Feasibility and acceptability of daily testing at school as an alternative to self-isolation following close contact with a confirmed case of COVID-19: a qualitative analysis. *BMC Public Health* **22**, 742 (2022).

21. Unger, J. B. *et al.* COVID-19 Testing in Schools: Perspectives of School Administrators, Teachers, Parents, and Students in Southern California. *Health Promot. Pract.* **24**, 350–359 (2023).

22. Harris, P. A. *et al.* The REDCap consortium: Building an international community of software platform partners. *J. Biomed. Inform.* **95**, 103208 (2019).

23. Harris, P. A. *et al.* Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J. Biomed. Inform.* **42**, 377–381 (2009).

24. Loy, J. K. *et al.* Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. *Front. Public Health* **12**, 1264019 (2024).

25. Robert Koch Institute. Coronavirus Disease 2019 (COVID-19). Daily Situation Report [cited 2024 04/15]. Available from: 707 https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Situationsberichte/Archiv_Sit 708 uationsberichte.html?nn=13490888.

26. Robert Koch-Institut. COVID-19-Impfungen in Deutschland. [object Object] https://doi.org/10.5281/ZENODO.10516840 (2024).

27. Polechová, J. *et al.* SARS-CoV-2 rapid antigen tests provide benefits for epidemic control – observations from Austrian schools. *J. Clin. Epidemiol.* **145**, 14–19 (2022).

28. Joachim, A. *et al.* Pooled RT-qPCR testing for SARS-CoV-2 surveillance in schools - a cluster randomised trial. *EClinicalMedicine* **39**, 101082 (2021).

29. Janke, B. & Janke, W. Untersuchungen zur Erfassung des Befindens von Kindern: Entwicklung einer Selbstbeurteilungsmethode (EWL40-KJ). *Diagnostica* **51**, 29–39 (2005).

30. Goodman, R. Psychometric Properties of the Strengths and Difficulties Questionnaire. *J. Am. Acad. Child Adolesc. Psychiatry* **40**, 1337–1345 (2001).

31. the European KIDSCREEN Group *et al.* Reliability, construct and criterion validity of the KIDSCREEN-10 score: a short measure for children and adolescents' well-being and health-related quality of life. *Qual. Life Res.* **19**, 1487–1500 (2010).

32. Döpfner, M. *et al.* Die psychische Belastung von Kindern, Jugendlichen und ihren Familien während der COVID-19-Pandemie und der Zusammenhang mit emotionalen und

Verhaltensauffälligkeiten. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz* **64**, 1522–1532 (2021).

33. Loy JK, Kimmig C, Klos S, Wunram HL, Langer T, Breitinger E and Bender S (2024) Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. Front. Public Health 12:1264019. doi: 10.3389/fpubh.2024.1264019, accepted 26 June 2024.

34. Pourrazavi, S., Fathifar, Z., Sharma, M. & Allahverdipour, H. COVID-19 vaccine hesitancy: A Systematic review of cognitive determinants. *Health Promot. Perspect.* **13**, 21–35 (2023).

Table 1:

DEMOGRAPHICS: SARS-COV-2 TESTING DATA AND VACCINATION STATUS	
Male, n	202 (35.5%)
Age in years, mean (SD)	13.1 (2.6)
School type, n	
- **Elementary school**	73 (12.8%)
- **Secondary school**	
○ **Secondary grammar school**	455 (80.0%)
○ **Non-acadamic-track secondary schools**	19 (3.4%)
○ **other**	22 (3,9%)
City, n	
- **Freiburg city**	326 (57.3%)
- **Freiburg region**	35 (6.2%)
- **Cologne city**	182 (32.0%)
- **Cologne region**	14 (2.5%)
- **Other**	12 (2.1%)
SARS-CoV-2 test type, n	
- **Only pooled PCR tests**	334 (58.7%)
- **Only rapid antigen tests (oral/nasal)**	102 (17.9%)
- **Mixed tests, most recent test Pooled PCR test**	58 (10.2%)
- **Mixed tests, most recent test rapid antigen (oral/nasal)**	75 (13.2%)
Vaccination status (12 years and over), n	
- vaccinated	300 (75.4%)
- unvaccinated, vaccine-willing	33 (8.3%)
- unvaccinated, vaccine-unwilling	38 (9.5%)
- missing data regarding vaccination/vaccine-willingness	27 (6.8%)
Vaccination status (under 12 years), n	
- vaccine-willing	119 (69.6%)
- vaccine-unwilling	31 (18.1%)
- missing data regarding vaccine-willingness	20 (11.7%)
SDQ scores	
- **NORMAL**	452
- **BORDERLINE/ABNORMAL**	117

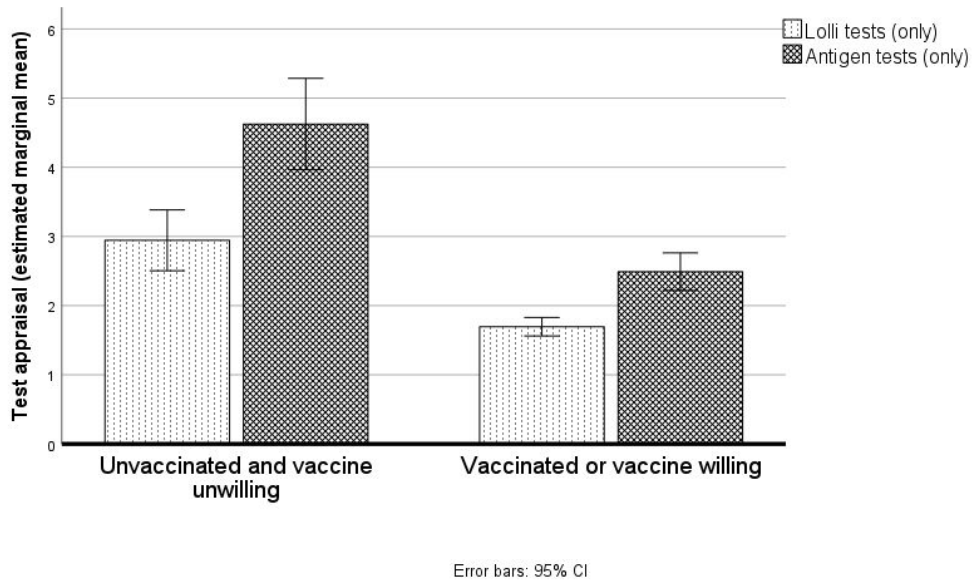

Figure 1: Test ratings for the two test types by vaccination status.

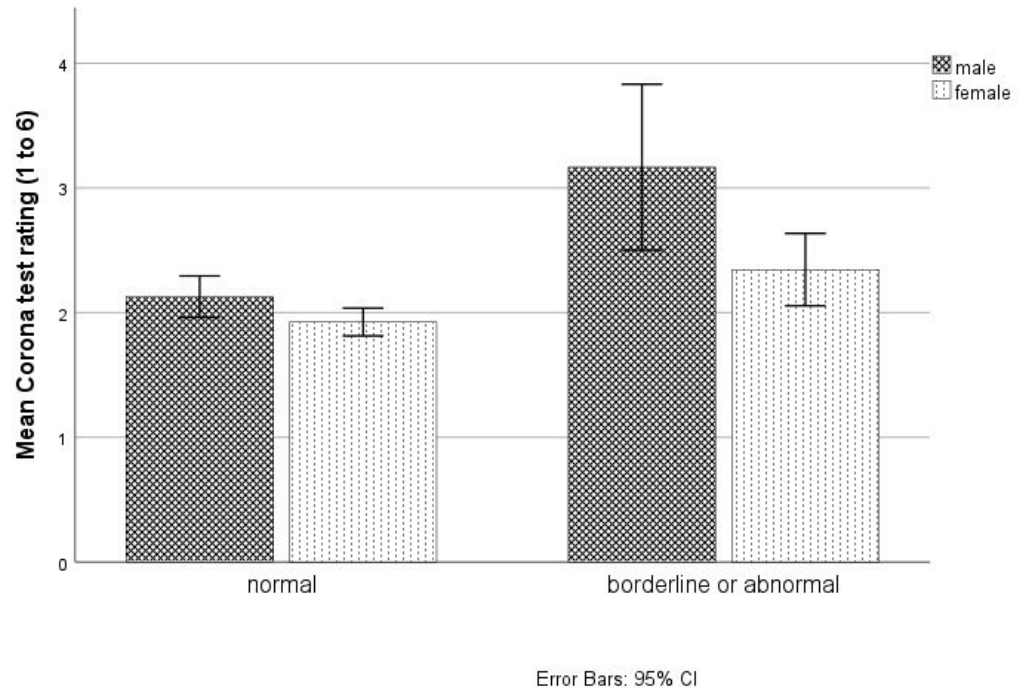

Figure 2: mean Corona test rating (1=best possible rating, 6=worst possible rating) for boys and girls by SDQ score category (normal or borderline/abnormal).

Supplementary:

Effect of age:

We restricted our analysis of effects of **age** on test ratings this analysis to secondary grammar school students, since school type may have been confounded with age; secondary grammar school was the best represented school type in our cohort (n=455) and this subgroup included children aged between 10 and 17. The 2 (test type) x 2 (gender) ANCOVA with age as a covariate revealed significant main effects of test method, $F(1, 450)=40.946$, $p<.001$, partial $\eta^2=.083$, and gender, $F(1, 450)=5.974$, $p=.015$, partial $\eta^2=.013$. The main effects of age and the interactions were not significant ($p>.224$). Pooled PCR tests received better ratings than antigen tests (estimated mean difference 0.72, 95% CI [0.48, 0.94]) and girls gave better ratings than boys (estimated mean difference 0.28, 95% CI [0.05, 0.50]). In the sensitivity analysis, the effect of gender was no longer significant ($p=.136$), though the Pooled PCR tests still received significantly better ratings than antigen tests ($p<.001$).

BMJ Paediatrics Open

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools: A cross-sectional survey

Journal:	*BMJ Paediatrics Open*
Manuscript ID	bmjpo-2024-002974.R1
Article Type:	Original research
Date Submitted by the Author:	28-Sep-2024
Complete List of Authors:	Kimmig, Christian; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Langer, Thorsten; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Loy, Johanna K.; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Bender, Stephan; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Haddad, Anneke; Medical Center - University of Freiburg, Institute for Infection Prevention and Control
Keywords:	Health Policy, COVID-19, Child Health, Adolescent Health

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools: A cross-sectional survey

Authors

Christian Kimmig[1*], Thorsten Langer[1], Johanna Loy[2], Stephan Bender[2+], Anneke Haddad[3+]

[1] Medical Center - University of Freiburg, Center for Pediatrics, Mathildenstraße 1, D-79106 Freiburg, Germany
[2] Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, Robert-Koch-Str. 10, D-50935 Cologne, Germany
[3] Medical Center - University of Freiburg, Institute for Infection Prevention and Control, Breisacherstr. 115B, D-79106, Germany
*Corresponding Author
[+] These authors contributed equally to the manuscript.

Correspondence to:
Christian Kimmig
Address: Breisacher Straße 62, 79106 Freiburg, Germany
Email: christian.kimmig@uniklinik-freiburg.de
Phone: +49 761 270 43761

Keywords:
Health Policy, COVID-19, Child Health, Adolescent Health

Word count:
Manuscript: 3595 (including abstract and key messages)
Abstract: 256
Key messages: 134

Abstract

Background:

Public health measures during the COVID-19 pandemic had dramatic consequences for children and adolescents. However, policy makers and health care researchers did not give sufficient weight to children's perspectives. One common public health measure was mandatory SARS-CoV-2 tests in schools. This study examines the evaluation of such mandatory testing.

Methods:

We investigated the effects of test type (pooled PCR tests vs. antigen rapid tests) and of demographic and psychological factors on evaluations of the experience of being tested testing. A total of 569 children (8-17 years) in two major German cities completed online questionnaires between October and December 2021. Participants answered questions addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties, and health-related quality of life.

Results:

Our results showed that overall test ratings were better for pooled PCR tests (p<.001). Vaccine-willing students evaluated SARS-CoV-2 tests more positively than vaccine-unwilling students, regardless of test type (p<.001). Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores (p<.001). Additionally, children who reported better health-related quality of life and children with less pandemic-related stress rated the tests more positively.

Conclusions:

Our results suggest that there are differences in the appraisal of the test types and that specific subgroups' experiences of regular testing vary. Our study provides insights for policy makers in future pandemics and raises questions regarding parallels between testing and vaccination hesitancy. Moreover, our study demonstrates the feasibility and value of collecting data directly from a large cohort of children in order to understand their experiences.

Key messages

- Data on the experience of routine SARS-CoV-2 testing in asymptomatic children and adolescents is scarce. Moreover, factors associated with test appraisal are not sufficiently understood and there are no comparisons of different test types.
- We found that young people report give pooled PCR tests better ratings than rapid antigen tests. Additionally, children that are vaccine-willing, children without mental health difficulties and children that report better health-related quality of life give better overall test scores.
- This study provides data directly from children about their experiences of a mandatory public health measure; this could help policy-makers, practitioners and researchers to take young people's perspectives into account and better balance competing goals in implementing public health measures. Moreover, it demonstrates the feasibility and value of rapidly collecting direct data from large cohorts of children.

Introduction

Public health measures implemented during the COVID-19 pandemic had – and continue to have – dramatic consequences for children and adolescents. Decreased in-person social contact, isolation and increased screen time through home schooling are just some of many ways that young people's everyday lives were affected, regardless of whether or not they were infected[1].

Given that the medical risks of COVID-19 for most young people are low, the most significant and widespread risks of the pandemic for this age group therefore arose as a result of public health measures themselves. Thus one major challenge during the pandemic was to mitigate tensions between negative effects of public health measures on children and adolescents specifically and (high) medical risks for other demographic groups if such measures were not implemented. This consideration is critical, because childhood and adolescence are important and potentially vulnerable periods of sociocognitive development[2,3].Investing in children's health is critical not only for individual flourishing but also to ensure beneficial development of whole societies, as highlighted by the WHO-UNICEF-Lancet commission "*A future for the world's children*"[3]

Yet early in the pandemic, policy-makers did not give sufficient weight to children's rights, and children had no feasible opportunities to raise possible concerns regarding public health measures. Moreover, healthcare researchers investigating COVID-19 did not adequately consider children's and adolescents' experiences[4]. As a result, young people's perspectives on public health measures that directly and significantly affected them were neglected. To address this, Jörgensen et al. suggested adding the pillars "preparation (for future child health crisis)" and "power (authority of children's voices, which requires meaningful participation)"[5] to the existing 3P-Network (provision, protection and participation), anchored in the United Nations Convention on the Rights of the Child[6].

Although the SARS-CoV-2 pandemic is formally over, considering children's opinions on public health measures continues to be important. The frequency of pandemics has increased over the past century[7] and estimates for the lifetime risk of another pandemic range from 17% to 44%[8]. Consequently, we need to prepare for future situations where tensions arise between the need to prevent spread of infection and the desire to avoid subjecting children to mandatory public health measures. Data on perspectives from children themselves could yield new insights into how policy makers, public health authorities, schools and researchers could better balance such considerations.

Here, we present on data on children's perspectives regarding mandatory SARS-CoV-2 testing in schools. In Germany, schools were fully or partially closed for 38 weeks in total[9] (although evidence on the efficacy of school closures is equivocal[10]). To mitigate the risks of re-opening schools, many governments required children to undergo regular SARS-CoV-2 testing.

Although the medical risks of testing in schools were low, little is known about how children perceived this testing. Children's experience of being subjected to mandatory testing could influence their views and behavior regarding other public health measures, both now and in the future, particularly if their experiences were negative. People's thoughts and feelings play a critical role in their acceptance of public health measures[11] and low trust in such measures is associated with low compliance[12]. Although there was, overall, high acceptance of public health measures during the pandemic[13], most data is from adults. Regarding SARS-CoV-2 testing in particular, limited data from adults shows high acceptance [14–1617]. A large Norwegian cross-sectional study showed high compliance, especially among secondary school students. Regular testing in the aforementioned study was voluntary[18]. Other than that, data on acceptance of routine testing in asymptomatic children is scarce and with small cohorts[19–21].

In line with Jörgensen et al.'s pillars "power" and "preparation"[5], our study aims to close this knowledge gap by investigating children's appraisals of routine SARS-CoV-2 testing in schools. We sought to address the following questions:

1. How do children appraise two different routine SARS-CoV-2 test types (rapid antigen tests and pooled PCR tests)? What are the effects of demographic factors? What emotions do children associate with the two different SARS-CoV-2 test types?
2. What is the relationship between test ratings and SARS-CoV-2 vaccine hesitancy?
3. How do test ratings relate to mental health difficulties, pandemic-related stress/difficulties, and health-related quality of life?

Methods

Questionnaires and the recruitment strategy were developed by a multi professional team of different health care researchers. Data were collected between November and December 2021 using online questionnaires. Participants were recruited by distributing links and QR-codes in schools, day-care facilities, hospitals and parent organizations in two major German cities (Freiburg and Cologne) and inviting children aged 8-17 to complete the online questionnaires via REDCap[22,23]. Data from parents and caregivers of children aged 4-17 years were collected in parallel and have been reported separately[24].

During the data collection period, Sars-CoV-2 incidence in Germany was between 91 per 100,000 in October and >200 per 100,000 in November-December 2021[25]. The Delta variant was predominant during this period, which led to increased hospitalizations than other variants. Vaccination against SARS-CoV-2 was recommended and approved for children ≥12 years; the first vaccination for children ≥5 was approved after our data collection period. By Nov 20th 2021, 61.1% of children aged ≥12 years in Germany had been vaccinated at least once; 50.6% were fully vaccinated[26].

Participants provided demographic data and test information and completed a set of questionnaires addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties and health-related quality of life.

Patient and Public Involvement: No patient or public involved.

SARS-CoV-2 test type(s) and evaluation: Regular SARS-CoV-2 testing for pupils attending in-person lessons was mandatory in Germany during the data collection period. The most common test methods were rapid antigen tests and saliva-based pooled PCR tests ('pooled PCR tests pop-method')[27,28]. Both methods entailed multiple tests each week. If the school used both methods, participants reported on the test type they had most recently experienced. Participants rated the SARS-CoV-2 tests using a standard German school grading system (1=excellent to 6=fail). Additionally, participants received an Emotional Words List and reported on a 4-point Likert scale (0=*not at all* to 3=*very*) how strongly they experienced each of 22 emotions (e.g., *ängstlich* (fearful), *beruhigt* (reassured), *missgestimmt* (grumpy, ill-tempered), *fröhlich* (cheerful)) when performing the SARS-CoV-2 [29]. Item scores are summed to give scores on the Positive Domain and the Negative Domain, as well as Positive and Negative Subdomains. We focused on the Positive and Negative Domains and the three Negative Subdomains (A: Bad temperedness/Annoyance, B: Anxiety/Sadness, C: Deactivation).

Mental health difficulties: Participants completed the 25-item version of the Strength and Difficulties Questionnaire (SDQ)[30] to screen for emotional and behavioral difficulties. Here, we focused on the total difficulties score, which was categorized as being within the normal range (≤14) or borderline/abnormal (>14).

Health-related quality of life (HRQoL): Participants completed the KIDSCREEN-10[31], a short questionnaire with 10 items on a 5-point Likert scale to asses general HRQoL. The KIDSCREEN-10 has good test-retest reliability (r = .73; ICC = .72) and internal consistency (Cronbach's alpha for the current study = 0.87).

Pandemic-related stress: To evaluate COVID-19 pandemic related stress, we used a questionnaire[32] which assesses quality of social interactions, educational burdens in school, leisure time activities and emotional responses to the pandemic. Responses are on a 5-point Likert scale ranging from "much worse" to "much better".

Statistical analyses were performed in SPSS 29.0 (IBM). To examine effects of gender, school type, age (within the sub-group who attended secondary grammar school), vaccination status and mental health difficulties on ratings of the two different SARS-CoV-2 test types, we used ordinary multiway ANOVA. For vaccination status, we conducted separate analyses for 12-17 year olds and under 12 year olds, since at the time of the data collection, vaccination was recommended for children aged ≥12 but not for younger children. We also used multiway ANOVA to examine effects of test type on Positive Domain emotions on the Emotional Words Test. Scores on the Negative Domain and its three Subdomains were strongly right-skewed; we therefore used non-parametric (Mann-Whitney) tests to analyze effects of test type on these scores. We examined associations between test ratings and health-related quality of life and pandemic-related stress using Pearson correlations. Some children experienced both test types and reported on their experience of their most recent test. Mixed test types may have influenced results; we therefore conducted sensitivity analyses by repeating each analysis with data only from children who had only experienced one test type or the other. Since analyses were exploratory, all tests were two-tailed and we did not attempt to replace missing values; rather, we excluded missing values from statistical analyses.

The study funder had no role in study design, in the collection, analysis, and interpretation of data, in writing of the report, or in the decision to submit the paper for publication.

Results

Full data sets were available for 589 children. Due to low numbers, we excluded gender-diverse participants (n=4), those whose most recent test was an antigen spit test (n=8), and those whose last test was >7 days prior to the survey (n=8). The final sample therefore included 569 children. Data regarding demographics, SARS-CoV-2 testing and vaccination status are summarized in *Table 1.*

Children's **overall ratings** of the two test types and differences based on gender or school level (primary/secondary) showed that pooled PCR tests received better ratings than rapid antigen tests (main effect of test type, $F(1, 549)=28.400$, $p<.001$, partial $\eta^2=0.049$; estimated mean difference 0.95, 95% CI [0.60, 1.30]). The sensitivity analysis showed the same pattern of results. We found no statistically significant effects of age amongst secondary grammar school students *(see supplemental material for details)*. Participants with unclear (e.g., Steiner school) or missing school type were excluded (n=13).

Regarding **emotions associated with SARS-CoV-2 testing,** the Pooled PCR -test group reported higher mean Positive Domain scores associated with testing than the antigen rapid antigen test group (main effect of test type, $F(1, 565)=36.524$, $p<.001$, partial $\eta^2=.061$; estimated mean difference 2.17, 95% CI [1.46, 2.87]). The sensitivity analysis yielded the same pattern of effects. The pooled PCR-test group also reported had lower scores for the negative domain (mean rank 274.61) than the antigen test group (mean rank 308.0; Mann-Whitney U-test Z=-.261, $p=.024$). The same held for negative subdomain A (Bad temperedness/Annoyance), Z=-3.394, $p<.001$ and negative subdomain B

(Anxiety/Sadness), Z=-3.987, p<.001. For negative subdomain C (Deactivation), the Pooled PCR test group associated testing with higher deactivation levels (mean rank 295.8) than the antigen test group (mean rank 261.1 Mann-Whitney U, Z=-2.505, *p*=.012). The sensitivity analysis showed the same pattern of results for the Negative Domain and for Negative Subdomains A and B. For Negative Subdomain C, the difference was no longer statistically significant in the sensitivity analysis (*p*=.061).

We also examined effects of **vaccination status**. Amongst 12-17 year olds, vaccinated/vaccine-willing adolescents gave the tests significantly better ratings than unvaccinated and vaccine-unwilling adolescents *(see figure 1)* (main effect of vaccination status, F(1,367)=110.650, p<.001, partial η^2=0.232; estimated mean difference 1.69, 95% CI [1.38, 2.01]). The pooled PCR tests received significantly better ratings than the antigen tests (main effect of test type, F(1,367)=29.088, p<.001, partial η^2 =0.073; estimated mean difference 0.87, 95% CI [0.55, 1.18]). The interaction was not significant. In the sensitivity analysis, the two main effects remained significant; in addition, a significant interaction (F(1, 265)=4.211, *p*=.041, partial η^2=0.016) arose because the difference between the two test types was significantly larger for unvaccinated/unwilling participants (mean difference 1.68, 95% CI [0.89, 2.47]) than for vaccinated/willing participants (mean difference 0.80, 95% CI for difference [0.49, 1.10]). However some subgroups in this analysis were extremely small.

Amongst under-12 year olds, vaccine-willing children rated the tests statistically significantly better than those who were vaccine-unwilling (main effect of vaccination status, F(1, 146)=36.786, p<.001, partial η^2=0.201; estimated mean difference 1.40, 95% CI [0.94, 1.86]). The effect of test type and the interaction were not statistically significant. In the sensitivity analysis, both main effects were statistically significant: not only did vaccine-willing children give the tests significantly better ratings than vaccine-unwilling children (as in the main analysis), but also the pooled PCR tests received better ratings than the antigen tests (F(1, 126)=5.175, *p*=.025, partial η^2=0.002, as seen in earlier). The interaction was not statistically significant.

Applying an ANOVA to examine the influence **mental health difficulties on testing experiences** yielded three significant main effects: test type: F(1, 561)=51.108, *p*<.001, partial η^2=.083; SDQ category: F(1, 561)=38.830, *p*<.001, partial η^2=.065; gender: F(1, 561)=11.204, *p*<.001, partial η^2<.020. In addition, the interaction between gender and SDQ category was significant, F(1, 561)=5.401, *p* =.020, partial η^2=.010. This arose because the gender difference in test ratings was statistically significant amongst those with borderline/abnormal SDQ scores (estimated mean difference 0.75, 95% CI [0.28, 1.22],) but not amongst those with normal SDQ scores (estimated mean difference 0.14, 95% CI [-0.08, 0.35]); see Figure 2. In the sensitivity analysis, the main effects SDQ category and test method remained statistically significant, ps<.001, but the main effect of gender and the interaction were no longer statistically significant.

Better **health-related quality of life**, as measured by KIDSCREEN scores, was statistically significantly correlated with better test ratings, r(567)=-.283, 95% CI [-.357, -.206]. Similarly, children who reported lower levels of **pandemic-related stress/difficulties**, as indicated by CBB scores, gave the tests better ratings, r(567)=.308, 95% CI [.232, .380]. For both correlations, there was no statistically significant difference between test types and the sensitivity analyses yielded similar patterns of effects.

Discussion

Our data, gathered directly from a large cohort of children, helps to narrow a knowledge gap in understanding children's experiences of being subjected to a regular, mandatory public health measure in school. In summary, our main findings were as follows:

1. Overall test ratings were better for pooled PCR tests. We found no significant effects of school type or age on test ratings. Children in the pooled PCR group reported more positive test-related emotions and less negative emotions (e.g., anxiety, annoyance). Interestingly, however, children in the pooled PCR group also reported more *Deactivation* emotions (e.g., tiredness, sleepiness, listlessness).
2. COVID-19 vaccinated or vaccine-willing students evaluated SARS-CoV-2 tests more positively than unvaccinated or vaccine-unwilling students, regardless of test type.
3. Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores. Similarly, children who reported better health-related quality of life and children with less pandemic-related stress also gave the tests better scores. These results were independent of the test type.

One strength of our study is the large sample size, which includes participants from two different areas in Germany (Cologne and Freiburg). Another major strength is that the reported data is directly from children and adolescents, which allows us to explore their emotional experience directly rather than via proxy report through caregivers.

An important limitation is that the sample was not representative; this is evident from the fact that 80% of our data was collected from secondary grammar school students, whose experiences may not reflect those of other groups. Further, we could not differentiate between nasal and oral rapid antigen swabs but solely differentiated between test types (PCR vs antigen) Swab location might influence test experience; however, most rapid antigen tests used at the time were nasal.

Overall, however, our study adds to existing data on acceptance of SARS-CoV-2 tests in general and the comparison of different sampling techniques. Schuster et al. found that students report a preference for nasal swabs over saliva tests[19]. However, they did not compare different test types (PCR vs antigen) and their sample size was rather small (67 students). Our study adds to their data with data from a large cohort considering different test types (not just test location). Franconeri et al. found good compliance and high satisfaction with regular voluntary testing among primary and secondary students. They focused on the satisfaction on the implementation of regular testing rather than the emotional experience during testing[18]. Adding to this study, our data expands the knowledge on testing acceptance considering mandatory tests and the actual experience when being tested. Moreover, we collected data from a wide age spectrum, which adds to Unger et al. who explored the acceptance of regular testing in focus group discussion found that students were in favor of testing at schools because it facilitated the return to in-person class. However they only interviewed high school students (Grade 10-12)[21].

In a parallel project[33], we investigated how parents evaluated the testing experience for their children and parents' reports on their children's responses and attitudes towards SARS-CoV-2 tests. The results were mostly in line with the data reported here: Parents also preferred pooled PCR tests for their children, parents of unvaccinated children tended to give tests worse ratings in general and parents of children with mental health difficulties gave worse ratings.

Considering our analysis, existing literature and the likelihood of future pandemics, our study aims to help prepare policy makers for "the next pandemic".

First, pooled PCR tests seem to be the preferred test option among children and adolescence. A recommendation for a specific test should always be given in light of current pandemic epidemiology and infection rates. Fear of infection can play an important role in how tests are perceived. SARS-CoV-2 incidence during our data collection period was high, which may have resulted in higher fear of COVID-19. Second, we advocate for age-specific support weighing the specific needs of elementary school students vs. adolescents. Third, children with mental health issues should be specifically prepared and supported in order to ensure a comfortable testing experience.

Our suggestions for "the next pandemic" stem from the direct insight of children's and adolescents experiences. Our study demonstrates the feasibility of collecting data directly from a large cohort of children rapidly to obtain insights into their experiences with a public health measure that influences their everyday life. For future pandemics, when public health measures might be necessary again, those measures could be adapted in real time to children's needs. Our study could serve as an example to prepare (→ "preparation") and give "power" to children and the chance to make a change[5]. Our study demonstrated that it is possible and necessary to involve large cohorts of children in research about public health measures. Children's rights are not a luxury and their right of participation[6] should not be disregarded, not even in light of a worldwide pandemic.

Finally, our study gives room to relevant questions and ideas about future research. As one example, we found an association between vaccination and testing acceptance. There is plenty of research regarding vaccine acceptance/hesitancy and associated factors[11,34]. We argue that parallels between vaccine acceptance and testing acceptance should be investigated. For example, what is the relationship between those "acceptances"? Are there common factors? Does this have implications for the implementation of public health measures? We consider this to be an important area for future research, with the goal of understanding children's experiences and motivations to comply with public health measures.

Funding statement: This work was supported by grant number ZMI1-2521COR004 by the Federal Ministry for Health.

Competing interest statement: The authors have no competing interests regarding this research article.

Data availability statement: The datasets presented in this article are not readily available because the ethics committee did not grant permission to share study data with third parties or to upload data in anonymized form. Requests to access the datasets should be directed to stephan.bender@uk-koeln.de.

Authors contributions:

- Christian Kimmig: Manuscript writing, recruitment, data collection, literature research
- Anneke Haddad: Manuscript writing, data analysis, literature research
- Stephan Bender: Study design and planning, data collection, data analysis, funding acquisition
- Thorsten Langer: Study design and planning, recruitment, reviewing and editing of manuscript
- Johanna Loy: Data preparation, reviewing and editing the manuscript

Ethical Approval Statement:

- The study was approved by the ethics committees of the universities of Cologne (no. 21-1479) and Freiburg (no. 21-1617).

Bibliography

1. Mulkey, S. B., Bearer, C. F. & Molloy, E. J. Indirect effects of the COVID-19 pandemic on children relate to the child's age and experience. *Pediatr. Res.* **94**, 1586–1587 (2023).
2. Calvin, C. M. *et al.* Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. *Int. J. Epidemiol.* **40**, 626–644 (2011).
3. Clark, H. *et al.* A future for the world's children? A WHO–UNICEF–Lancet Commission. *The Lancet* **395**, 605–658 (2020).
4. Jörgensen, E. *et al.* The voices of children and young people during COVID-19: A critical review of methods. *Acta Paediatr. Oslo Nor. 1992* **111**, 1670–1681 (2022).
5. Jörgensen, E., Wood, L., Lynch, M. A., Spencer, N. & Gunnlaugsson, G. Child Rights during the COVID-19 Pandemic: Learning from Child Health-and-Rights Professionals across the World. *Child. Basel Switz.* **10**, 1670 (2023).
6. UN General Assembly Convention on the Rights of the Child. 1989. [(accessed on 08 April 2024)]. Available online: https://www.unicef.org/media/52626/file.
7. Jones, K. E. *et al.* Global trends in emerging infectious diseases. *Nature* **451**, 990–993 (2008).
8. Marani, M., Katul, G. G., Pan, W. K. & Parolari, A. J. Intensity and frequency of extreme novel epidemics. *Proc. Natl. Acad. Sci.* **118**, e2105482118 (2021).
9. Fuchs-Schündeln, N. Covid-induced school closures in the United States and Germany: long-term distributional effects. *Econ. Policy* **37**, 609–639 (2022).
10. Viner, R. M. *et al.* School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child Adolesc. Health* **4**, 397–404 (2020).
11. Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J. & Kempe, A. Increasing Vaccination: Putting Psychological Science Into Action. *Psychol. Sci. Public Interest J. Am. Psychol. Soc.* **18**, 149–207 (2017).

12. Nivette, A. *et al.* Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. *Soc. Sci. Med.* **268**, 113370 (2021).

13. Fiordelli, M., Rubinelli, S. & Diviani, N. Acceptance of Public Health Measures During the COVID-19 Pandemic: A Cross-Sectional Study of the Swiss Population's Beliefs, Attitudes, Trust, and Information-Seeking Behavior. *Int. J. Public Health* **68**, 1605982 (2023).

14. Wu, F. *et al.* The acceptance of SARS-CoV-2 rapid antigen self-testing: A cross-sectional study in China. *J. Med. Virol.* jmv.28227 (2022) doi:10.1002/jmv.28227.

15. Bevan, I., Stage Baxter, M., Stagg, H. R. & Street, A. Knowledge, Attitudes, and Behavior Related to COVID-19 Testing: A Rapid Scoping Review. *Diagnostics* **11**, 1685 (2021).

16. Nguyen, N. *et al.* A mixed methods study evaluating acceptability of a daily COVID-19 testing regimen with a mobile-app connected, at-home, rapid antigen test: Implications for current and future pandemics. *PloS One* **17**, e0267766 (2022).

17. Fallucchi, F., Görges, L., Machado, J., Pieters, A. & Suhrcke, M. How to make universal, voluntary testing for COVID-19 work? A behavioural economics perspective. *Health Policy* **125**, 972–980 (2021).

18. Franconeri, L. *et al.* Experiences with regular testing of students for SARS-CoV-2 in primary and secondary schools: results from a cross-sectional study in two Norwegian counties, autumn 2021. *BMC Public Health* **23**, 1548 (2023).

19. Schuster, J. E. *et al.* A COVID-19 Testing Preference Study in Schools. *Pediatrics* **152**, e2022060352H (2023).

20. Denford, S. *et al.* Feasibility and acceptability of daily testing at school as an alternative to self-isolation following close contact with a confirmed case of COVID-19: a qualitative analysis. *BMC Public Health* **22**, 742 (2022).

21. Unger, J. B. *et al.* COVID-19 Testing in Schools: Perspectives of School Administrators, Teachers, Parents, and Students in Southern California. *Health Promot. Pract.* **24**, 350–359 (2023).

22. Harris, P. A. *et al.* The REDCap consortium: Building an international community of software platform partners. *J. Biomed. Inform.* **95**, 103208 (2019).

23. Harris, P. A. *et al.* Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J. Biomed. Inform.* **42**, 377–381 (2009).

24. Loy, J. K. *et al.* Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. *Front. Public Health* **12**, 1264019 (2024).

25. Robert Koch Institute. Coronavirus Disease 2019 (COVID-19). Daily Situation Report [cited 2024 04/15]. Available from: 707 https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Situationsberichte/Archiv_Sit 708 uationsberichte.html?nn=13490888.

26. Robert Koch-Institut. COVID-19-Impfungen in Deutschland. [object Object] https://doi.org/10.5281/ZENODO.10516840 (2024).

27. Polechová, J. *et al.* SARS-CoV-2 rapid antigen tests provide benefits for epidemic control – observations from Austrian schools. *J. Clin. Epidemiol.* **145**, 14–19 (2022).

28. Joachim, A. *et al.* Pooled RT-qPCR testing for SARS-CoV-2 surveillance in schools - a cluster randomised trial. *EClinicalMedicine* **39**, 101082 (2021).

29. Janke, B. & Janke, W. Untersuchungen zur Erfassung des Befindens von Kindern: Entwicklung einer Selbstbeurteilungsmethode (EWL40-KJ). *Diagnostica* **51**, 29–39 (2005).

30. Goodman, R. Psychometric Properties of the Strengths and Difficulties Questionnaire. *J. Am. Acad. Child Adolesc. Psychiatry* **40**, 1337–1345 (2001).

31. the European KIDSCREEN Group *et al.* Reliability, construct and criterion validity of the KIDSCREEN-10 score: a short measure for children and adolescents' well-being and health-related quality of life. *Qual. Life Res.* **19**, 1487–1500 (2010).

32. Döpfner, M. *et al.* Die psychische Belastung von Kindern, Jugendlichen und ihren Familien während der COVID-19-Pandemie und der Zusammenhang mit emotionalen und

Verhaltensauffälligkeiten. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz* **64**, 1522–1532 (2021).

33. Loy JK, Kimmig C, Klos S, Wunram HL, Langer T, Breitinger E and Bender S (2024) Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. Front. Public Health 12:1264019. doi: 10.3389/fpubh.2024.1264019, accepted 26 June 2024.

34. Pourrazavi, S., Fathifar, Z., Sharma, M. & Allahverdipour, H. COVID-19 vaccine hesitancy: A Systematic review of cognitive determinants. *Health Promot. Perspect.* **13**, 21–35 (2023).

Table 1: Demographics of participants, including Sars-CoV-2 testing data and vaccination status

DEMOGRAPHICS: SARS-COV-2 TESTING DATA AND VACCINATION STATUS	
Male, n	202 (35.5%)
Age in years, mean (SD)	13.1 (2.6)
School type, n	
- **Elementary school**	73 (12.8%)
- **Secondary school**	
○ **Secondary grammar school**	455 (80.0%)
○ **Non-acadamic-track secondary schools**	19 (3.4%)
○ **other**	22 (3,9%)
City, n	
- **Freiburg city**	326 (57.3%)
- **Freiburg region**	35 (6.2%)
- **Cologne city**	182 (32.0%)
- **Cologne region**	14 (2.5%)
- **Other**	12 (2.1%)
SARS-CoV-2 test type, n	
- **Only pooled PCR tests**	334 (58.7%)
- **Only rapid antigen tests (oral/nasal)**	102 (17.9%)
- **Mixed tests, most recent test Pooled PCR test**	58 (10.2%)
- **Mixed tests, most recent test rapid antigen (oral/nasal)**	75 (13.2%)
Vaccination status (12 years and over), n	
- vaccinated	300 (75.4%)
- unvaccinated, vaccine-willing	33 (8.3%)
- unvaccinated, vaccine-unwilling	38 (9.5%)
- missing data regarding vaccination/vaccine-willingness	27 (6.8%)
Vaccination status (under 12 years), n	
- vaccine-willing	119 (69.6%)
- vaccine-unwilling	31 (18.1%)
- missing data regarding vaccine-willingness	20 (11.7%)
SDQ scores	
- **NORMAL**	452
- **BORDERLINE/ABNORMAL**	117

Figure Legends:

Figure 1: Test ratings for the two test types (lolli tests and antigen tests) separated by vaccination status. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

Figure 2: Mean Corona test for boys and girls by SDQ score category (normal or borderline/abnormal), not separated by test type. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

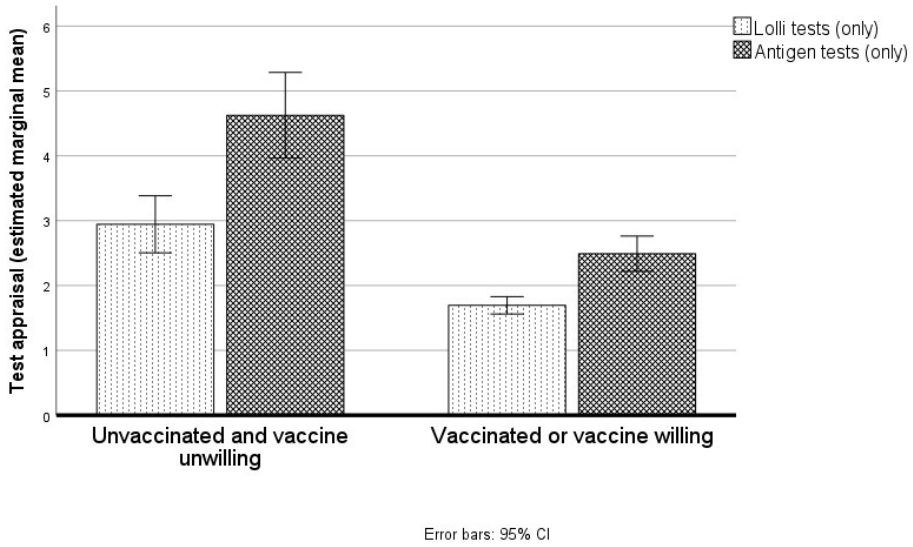

Figure 1: Test ratings for the two test types (lolli tests and antigen tests) separated by vaccination status. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

224x132mm (96 x 96 DPI)

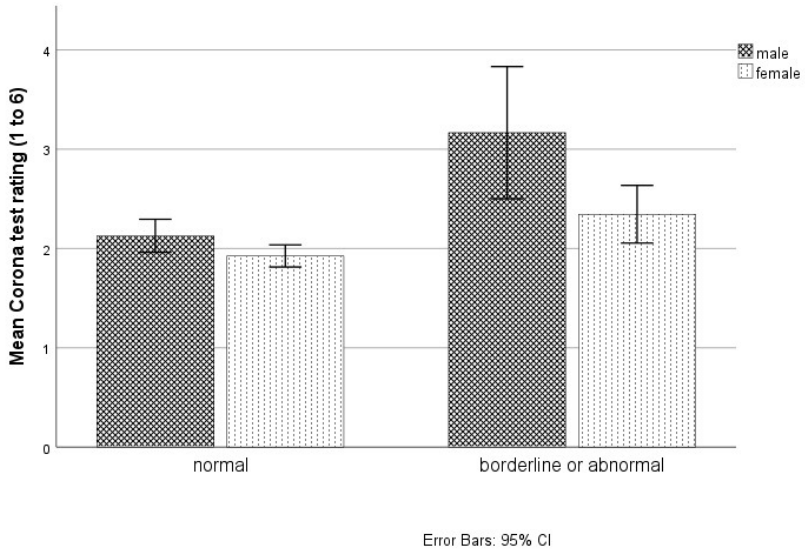

Figure 2: Mean Corona test for boys and girls by SDQ score category (normal or borderline/abnormal), not separated by test type. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

224x132mm (96 x 96 DPI)

Supplementary:

Effect of age:

We restricted our analysis of effects of **age** on test ratings this analysis to secondary grammar school students, since school type may have been confounded with age; secondary grammar school was the best represented school type in our cohort (n=455) and this subgroup included children aged between 10 and 17. The 2 (test type) x 2 (gender) ANCOVA with age as a covariate revealed significant main effects of test method, $F(1, 450)=40.946$, $p<.001$, partial $\eta^2=.083$, and gender, $F(1, 450)=5.974$, $p=.015$, partial $\eta^2=.013$. The main effects of age and the interactions were not significant ($p>.224$). Pooled PCR tests received better ratings than antigen tests (estimated mean difference 0.72, 95% CI [0.48, 0.94]) and girls gave better ratings than boys (estimated mean difference 0.28, 95% CI [0.05, 0.50]). In the sensitivity analysis, the effect of gender was no longer significant ($p=.136$), though the Pooled PCR tests still received significantly better ratings than antigen tests ($p<.001$).

BMJ Paediatrics Open

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools: A cross-sectional survey

Journal:	*BMJ Paediatrics Open*
Manuscript ID	bmjpo-2024-002974.R2
Article Type:	Original research
Date Submitted by the Author:	10-Oct-2024
Complete List of Authors:	Kimmig, Christian; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Langer, Thorsten; Medical Center-University of Freiburg Center for Pediatrics, Department of Neuropediatrics and Muscle Disorders Loy, Johanna K.; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Bender, Stephan; Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy Haddad, Anneke; Medical Center - University of Freiburg, Institute for Infection Prevention and Control
Keywords:	Health Policy, COVID-19, Child Health, Adolescent Health

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title

Children and adolescents' experiences of mandatory SARS-CoV-2 testing in schools: A cross-sectional survey

Authors

Christian Kimmig[1*], Thorsten Langer[1], Johanna Loy[2], Stephan Bender[2+], Anneke Haddad[3+]

[1] Medical Center - University of Freiburg, Center for Pediatrics, Mathildenstraße 1, D-79106 Freiburg, Germany
[2] Medical Faculty of the University of Cologne and University Hospital Cologne, Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, Robert-Koch-Str. 10, D-50935 Cologne, Germany
[3] Medical Center - University of Freiburg, Institute for Infection Prevention and Control, Breisacherstr. 115B, D-79106, Germany
*Corresponding Author
[+] These authors contributed equally to the manuscript.

Correspondence to:
Christian Kimmig
Address: Breisacher Straße 62, 79106 Freiburg, Germany
Email: christian.kimmig@uniklinik-freiburg.de
Phone: +49 761 270 43761

Keywords:
Health Policy, COVID-19, Child Health, Adolescent Health

Word count:
Manuscript: 3595 (including abstract and key messages)
Abstract: 256
Key messages: 134

Abstract

Background:

Public health measures during the COVID-19 pandemic had dramatic consequences for children and adolescents. However, policy makers and health care researchers did not give sufficient weight to children's perspectives. One common public health measure was mandatory SARS-CoV-2 tests in schools. This study examines the evaluation of such mandatory testing.

Methods:

We investigated the effects of test type (pooled PCR tests vs. antigen rapid tests) and of demographic and psychological factors on evaluations of the experience of being tested testing. A total of 569 children (8-17 years) in two major German cities completed online questionnaires between October and December 2021. Participants answered questions addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties, and health-related quality of life.

Results:

Our results showed that overall test ratings were better for pooled PCR tests (p<.001). Vaccine-willing students evaluated SARS-CoV-2 tests more positively than vaccine-unwilling students, regardless of test type (p<.001). Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores (p<.001). Additionally, children who reported better health-related quality of life and children with less pandemic-related stress rated the tests more positively.

Conclusions:

Our results suggest that there are differences in the appraisal of the test types and that specific subgroups' experiences of regular testing vary. Our study provides insights for policy makers in future pandemics and raises questions regarding parallels between testing and vaccination hesitancy. Moreover, our study demonstrates the feasibility and value of collecting data directly from a large cohort of children in order to understand their experiences.

Key messages

What is already known on this topic:

Data on the experience of routine SARS-CoV-2 testing in asymptomatic children and adolescents is scarce. Moreover, factors associated with test appraisal are not sufficiently understood and there are no comparisons of different test types.

What this study adds:

We found that young people report give pooled PCR tests better ratings than rapid antigen tests. Additionally, children that are vaccine-willing, children without mental health difficulties and children that report better health-related quality of life give better overall test scores.

How this study might affect research, practice or policy:

This study provides data directly from children about their experiences of a mandatory public health measure; this could help policy-makers, practitioners and researchers to take young people's

perspectives into account and better balance competing goals in implementing public health measures. Moreover, it demonstrates the feasibility and value of rapidly collecting direct data from large cohorts of children.

Introduction

Public health measures implemented during the COVID-19 pandemic had – and continue to have – dramatic consequences for children and adolescents. Decreased in-person social contact, isolation and increased screen time through home schooling are just some of many ways that young people's everyday lives were affected, regardless of whether or not they were infected[1].

Given that the medical risks of COVID-19 for most young people are low, the most significant and widespread risks of the pandemic for this age group therefore arose as a result of public health measures themselves. Thus one major challenge during the pandemic was to mitigate tensions between negative effects of public health measures on children and adolescents specifically and (high) medical risks for other demographic groups if such measures were not implemented. This consideration is critical, because childhood and adolescence are important and potentially vulnerable periods of sociocognitive development[2,3].Investing in children's health is critical not only for individual flourishing but also to ensure beneficial development of whole societies, as highlighted by the WHO-UNICEF-Lancet commission "*A future for the world's children*"[3]

Yet early in the pandemic, policy-makers did not give sufficient weight to children's rights, and children had no feasible opportunities to raise possible concerns regarding public health measures. Moreover, healthcare researchers investigating COVID-19 did not adequately consider children's and adolescents' experiences[4]. As a result, young people's perspectives on public health measures that directly and significantly affected them were neglected. To address this, Jörgensen et al. suggested adding the pillars "preparation (for future child health crisis)" and "power (authority of children's voices, which requires meaningful participation)"[5] to the existing 3P-Network (provision, protection and participation), anchored in the United Nations Convention on the Rights of the Child[6].

Although the SARS-CoV-2 pandemic is formally over, considering children's opinions on public health measures continues to be important. The frequency of pandemics has increased over the past century[7] and estimates for the lifetime risk of another pandemic range from 17% to 44%[8]. Consequently, we need to prepare for future situations where tensions arise between the need to prevent spread of infection and the desire to avoid subjecting children to mandatory public health measures. Data on perspectives from children themselves could yield new insights into how policy makers, public health authorities, schools and researchers could better balance such considerations.

Here, we present on data on children's perspectives regarding mandatory SARS-CoV-2 testing in schools. In Germany, schools were fully or partially closed for 38 weeks in total[9] (although evidence on the efficacy of school closures is equivocal[10]). To mitigate the risks of re-opening schools, many governments required children to undergo regular SARS-CoV-2 testing.

Although the medical risks of testing in schools were low, little is known about how children perceived this testing. Children's experience of being subjected to mandatory testing could influence their views and behavior regarding other public health measures, both now and in the future, particularly if their experiences were negative. People's thoughts and feelings play a critical role in their acceptance of public health measures[11] and low trust in such measures is associated with low

compliance[12]. Although there was, overall, high acceptance of public health measures during the pandemic[13], most data is from adults. Regarding SARS-CoV-2 testing in particular, limited data from adults shows high acceptance [14–1617]. A large Norwegian cross-sectional study showed high compliance, especially among secondary school students. Regular testing in the aforementioned study was voluntary[18]. Other than that, data on acceptance of routine testing in asymptomatic children is scarce and with small cohorts[19–21].

In line with Jörgensen et al.'s pillars "power" and "preparation"[5], our study aims to close this knowledge gap by investigating children's appraisals of routine SARS-CoV-2 testing in schools. We sought to address the following questions:

1. How do children appraise two different routine SARS-CoV-2 test types (rapid antigen tests and pooled PCR tests)? What are the effects of demographic factors? What emotions do children associate with the two different SARS-CoV-2 test types?
2. What is the relationship between test ratings and SARS-CoV-2 vaccine hesitancy?
3. How do test ratings relate to mental health difficulties, pandemic-related stress/difficulties, and health-related quality of life?

Methods

Questionnaires and the recruitment strategy were developed by a multi professional team of different health care researchers. Data were collected between November and December 2021 using online questionnaires. Participants were recruited by distributing links and QR-codes in schools, day-care facilities, hospitals and parent organizations in two major German cities (Freiburg and Cologne) and inviting children aged 8-17 to complete the online questionnaires via REDCap[22,23]. Data from parents and caregivers of children aged 4-17 years were collected in parallel and have been reported separately[24].

During the data collection period, Sars-CoV-2 incidence in Germany was between 91 per 100,000 in October and >200 per 100,000 in November-December 2021[25]. The Delta variant was predominant during this period, which led to increased hospitalizations than other variants. Vaccination against SARS-CoV-2 was recommended and approved for children ≥12 years; the first vaccination for children ≥5 was approved after our data collection period. By Nov 20th 2021, 61.1% of children aged ≥12 years in Germany had been vaccinated at least once; 50.6% were fully vaccinated[26].

Participants provided demographic data and test information and completed a set of questionnaires addressing test evaluation, vaccination status, pandemic-related stress, mental health difficulties and health-related quality of life.

Patient and Public Involvement: No patient or public involved.

SARS-CoV-2 test type(s) and evaluation: Regular SARS-CoV-2 testing for pupils attending in-person lessons was mandatory in Germany during the data collection period. The most common test methods were rapid antigen tests and saliva-based pooled PCR tests ('pooled PCR tests pop-method')[27,28]. Both methods entailed multiple tests each week. If the school used both methods, participants reported on the test type they had most recently experienced. Participants rated the SARS-CoV-2 tests using a standard German school grading system (1=excellent to 6=fail). Additionally, participants received an Emotional Words List and reported on a 4-point Likert scale (0=*not at all* to 3=*very*) how strongly they experienced each of 22 emotions (e.g., *ängstlich* (fearful), *beruhigt* (reassured), *missgestimmt* (grumpy, ill-tempered), *fröhlich* (cheerful)) when performing the SARS-CoV-2 [29]. Item scores are summed to give scores on the Positive Domain and the Negative Domain, as well as Positive and Negative Subdomains. We focused on the Positive and Negative

Domains and the three Negative Subdomains (A: Bad temperedness/Annoyance, B: Anxiety/Sadness, C: Deactivation).

Mental health difficulties: Participants completed the 25-item version of the Strength and Difficulties Questionnaire (SDQ)[30] to screen for emotional and behavioral difficulties. Here, we focused on the total difficulties score, which was categorized as being within the normal range (≤14) or borderline/abnormal (>14).

Health-related quality of life (HRQoL): Participants completed the KIDSCREEN-10[31], a short questionnaire with 10 items on a 5-point Likert scale to asses general HRQoL. The KIDSCREEN-10 has good test-retest reliability (r = .73; ICC = .72) and internal consistency (Cronbach's alpha for the current study = 0.87).

Pandemic-related stress: To evaluate COVID-19 pandemic related stress, we used a questionnaire[32] which assesses quality of social interactions, educational burdens in school, leisure time activities and emotional responses to the pandemic. Responses are on a 5-point Likert scale ranging from "much worse" to "much better".

Statistical analyses were performed in SPSS 29.0 (IBM). To examine effects of gender, school type, age (within the sub-group who attended secondary grammar school), vaccination status and mental health difficulties on ratings of the two different SARS-CoV-2 test types, we used ordinary multiway ANOVA. For vaccination status, we conducted separate analyses for 12-17 year olds and under 12 year olds, since at the time of the data collection, vaccination was recommended for children aged ≥12 but not for younger children. We also used multiway ANOVA to examine effects of test type on Positive Domain emotions on the Emotional Words Test. Scores on the Negative Domain and its three Subdomains were strongly right-skewed; we therefore used non-parametric (Mann-Whitney) tests to analyze effects of test type on these scores. We examined associations between test ratings and health-related quality of life and pandemic-related stress using Pearson correlations. Some children experienced both test types and reported on their experience of their most recent test. Mixed test types may have influenced results; we therefore conducted sensitivity analyses by repeating each analysis with data only from children who had only experienced one test type or the other. Since analyses were exploratory, all tests were two-tailed and we did not attempt to replace missing values; rather, we excluded missing values from statistical analyses.

The study funder had no role in study design, in the collection, analysis, and interpretation of data, in writing of the report, or in the decision to submit the paper for publication.

Results

Full data sets were available for 589 children. Due to low numbers, we excluded gender-diverse participants (n=4), those whose most recent test was an antigen spit test (n=8), and those whose last test was >7 days prior to the survey (n=8). The final sample therefore included 569 children. Data regarding demographics, SARS-CoV-2 testing and vaccination status are summarized in *Table 1.*

Children's **overall ratings** of the two test types and differences based on gender or school level (primary/secondary) showed that pooled PCR tests received better ratings than rapid antigen tests (main effect of test type, $F(1, 549)=28.400$, $p<.001$, partial $\eta^2=0.049$; estimated mean difference 0.95, 95% CI [0.60, 1.30]). The sensitivity analysis showed the same pattern of results. We found no statistically significant effects of age amongst secondary grammar school students *(see supplemental material for details)*. Participants with unclear (e.g., Steiner school) or missing school type were excluded (n=13).

Regarding **emotions associated with SARS-CoV-2 testing,** the Pooled PCR -test group reported higher mean Positive Domain scores associated with testing than the antigen rapid antigen test group (main effect of test type, F(1, 565)=36.524, *p*<.001, partial η^2=.061; estimated mean difference 2.17, 95% CI [1.46, 2.87]). The sensitivity analysis yielded the same pattern of effects. The pooled PCR-test group also reported had lower scores for the negative domain (mean rank 274.61) than the antigen test group (mean rank 308.0; Mann-Whitney U-test Z=-.261, *p*=.024). The same held for negative subdomain A (Bad temperedness/Annoyance), Z=-3.394, *p* <.001 and negative subdomain B (Anxiety/Sadness), Z=-3.987, p<.001. For negative subdomain C (Deactivation), the Pooled PCR test group associated testing with higher deactivation levels (mean rank 295.8) than the antigen test group (mean rank 261.1 Mann-Whitney U, Z=-2.505, *p*=.012). The sensitivity analysis showed the same pattern of results for the Negative Domain and for Negative Subdomains A and B. For Negative Subdomain C, the difference was no longer statistically significant in the sensitivity analysis (*p*=.061).

We also examined effects of **vaccination status**. Amongst 12-17 year olds, vaccinated/vaccine-willing adolescents gave the tests significantly better ratings than unvaccinated and vaccine-unwilling adolescents *(see figure 1)* (main effect of vaccination status, F(1,367)=110.650, p<.001, partial η^2=0.232; estimated mean difference 1.69, 95% CI [1.38, 2.01]). The pooled PCR tests received significantly better ratings than the antigen tests (main effect of test type, F(1,367)=29.088, p<.001, partial η^2 =0.073; estimated mean difference 0.87, 95% CI [0.55, 1.18]). The interaction was not significant. In the sensitivity analysis, the two main effects remained significant; in addition, a significant interaction (F(1, 265)=4.211, *p*=.041, partial η^2=0.016) arose because the difference between the two test types was significantly larger for unvaccinated/unwilling participants (mean difference 1.68, 95% CI [0.89, 2.47]) than for vaccinated/willing participants (mean difference 0.80, 95% CI for difference [0.49, 1.10]). However some subgroups in this analysis were extremely small.

Amongst under-12 year olds, vaccine-willing children rated the tests statistically significantly better than those who were vaccine-unwilling (main effect of vaccination status, F(1, 146)=36.786, p<.001, partial η^2=0.201; estimated mean difference 1.40, 95% CI [0.94, 1.86]). The effect of test type and the interaction were not statistically significant. In the sensitivity analysis, both main effects were statistically significant: not only did vaccine-willing children give the tests significantly better ratings than vaccine-unwilling children (as in the main analysis), but also the pooled PCR tests received better ratings than the antigen tests (F(1, 126)=5.175, *p*=.025, partial η^2=0.002, as seen in earlier). The interaction was not statistically significant.

Applying an ANOVA to examine the influence **mental health difficulties on testing experiences** yielded three significant main effects: test type: F(1, 561)=51.108, *p*<.001, partial η^2=.083; SDQ category: F(1, 561)=38.830, *p*<.001, partial η^2=.065; gender: F(1, 561)=11.204, *p*<.001, partial η^2<.020. In addition, the interaction between gender and SDQ category was significant, F(1, 561)=5.401, *p* =.020, partial η^2=.010. This arose because the gender difference in test ratings was statistically significant amongst those with borderline/abnormal SDQ scores (estimated mean difference 0.75, 95% CI [0.28, 1.22],) but not amongst those with normal SDQ scores (estimated mean difference 0.14, 95% CI [-0.08, 0.35]); see Figure 2. In the sensitivity analysis, the main effects SDQ category and test method remained statistically significant, ps<.001, but the main effect of gender and the interaction were no longer statistically significant.

Better **health-related quality of life**, as measured by KIDSCREEN scores, was statistically significantly correlated with better test ratings, r(567)=-.283, 95% CI [-.357, -.206]. Similarly, children who reported lower levels of **pandemic-related stress/difficulties**, as indicated by CBB scores, gave the tests better ratings, r(567)=.308, 95% CI [.232, .380]. For both correlations, there was no statistically significant difference between test types and the sensitivity analyses yielded similar patterns of effects.

Discussion

Our data, gathered directly from a large cohort of children, helps to narrow a knowledge gap in understanding children's experiences of being subjected to a regular, mandatory public health measure in school. In summary, our main findings were as follows:

1. Overall test ratings were better for pooled PCR tests. We found no significant effects of school type or age on test ratings. Children in the pooled PCR group reported more positive test-related emotions and less negative emotions (e.g., anxiety, annoyance). Interestingly, however, children in the pooled PCR group also reported more *Deactivation* emotions (e.g., tiredness, sleepiness, listlessness).
2. COVID-19 vaccinated or vaccine-willing students evaluated SARS-CoV-2 tests more positively than unvaccinated or vaccine-unwilling students, regardless of test type.
3. Children with mental health difficulties (abnormal/borderline SDQ scores) evaluated SARS-CoV-2 tests more negatively than children with normal SDQ scores. Similarly, children who reported better health-related quality of life and children with less pandemic-related stress also gave the tests better scores. These results were independent of the test type.

One strength of our study is the large sample size, which includes participants from two different areas in Germany (Cologne and Freiburg). Another major strength is that the reported data is directly from children and adolescents, which allows us to explore their emotional experience directly rather than via proxy report through caregivers.

An important limitation is that the sample was not representative; this is evident from the fact that 80% of our data was collected from secondary grammar school students, whose experiences may not reflect those of other groups. Further, we could not differentiate between nasal and oral rapid antigen swabs but solely differentiated between test types (PCR vs antigen) Swab location might influence test experience; however, most rapid antigen tests used at the time were nasal.

Overall, however, our study adds to existing data on acceptance of SARS-CoV-2 tests in general and the comparison of different sampling techniques. Schuster et al. found that students report a preference for nasal swabs over saliva tests[19]. However, they did not compare different test types (PCR vs antigen) and their sample size was rather small (67 students). Our study adds to their data with data from a large cohort considering different test types (not just test location). Franconeri et al. found good compliance and high satisfaction with regular voluntary testing among primary and secondary students. They focused on the satisfaction on the implementation of regular testing rather than the emotional experience during testing[18]. Adding to this study, our data expands the knowledge on testing acceptance considering mandatory tests and the actual experience when being tested. Moreover, we collected data from a wide age spectrum, which adds to Unger et al. who explored the acceptance of regular testing in focus group discussion found that students were in favor of testing at schools because it facilitated the return to in-person class. However they only interviewed high school students (Grade 10-12)[21].

In a parallel project[33], we investigated how parents evaluated the testing experience for their children and parents' reports on their children's responses and attitudes towards SARS-CoV-2 tests. The results were mostly in line with the data reported here: Parents also preferred pooled PCR tests for their children, parents of unvaccinated children tended to give tests worse ratings in general and parents of children with mental health difficulties gave worse ratings.

Considering our analysis, existing literature and the likelihood of future pandemics, our study aims to help prepare policy makers for "the next pandemic".

First, pooled PCR tests seem to be the preferred test option among children and adolescence. A recommendation for a specific test should always be given in light of current pandemic epidemiology and infection rates. Fear of infection can play an important role in how tests are perceived. SARS-CoV-2 incidence during our data collection period was high, which may have resulted in higher fear of COVID-19. Second, we advocate for age-specific support weighing the specific needs of elementary school students vs. adolescents. Third, children with mental health issues should be specifically prepared and supported in order to ensure a comfortable testing experience.

Our suggestions for "the next pandemic" stem from the direct insight of children's and adolescents experiences. Our study demonstrates the feasibility of collecting data directly from a large cohort of children rapidly to obtain insights into their experiences with a public health measure that influences their everyday life. For future pandemics, when public health measures might be necessary again, those measures could be adapted in real time to children's needs. Our study could serve as an example to prepare (→ "preparation") and give "power" to children and the chance to make a change[5]. Our study demonstrated that it is possible and necessary to involve large cohorts of children in research about public health measures. Children's rights are not a luxury and their right of participation[6] should not be disregarded, not even in light of a worldwide pandemic.

Finally, our study gives room to relevant questions and ideas about future research. As one example, we found an association between vaccination and testing acceptance. There is plenty of research regarding vaccine acceptance/hesitancy and associated factors[11,34]. We argue that parallels between vaccine acceptance and testing acceptance should be investigated. For example, what is the relationship between those "acceptances"? Are there common factors? Does this have implications for the implementation of public health measures? We consider this to be an important area for future research, with the goal of understanding children's experiences and motivations to comply with public health measures.

Funding statement: This work was supported by grant number ZMI1-2521COR004 by the Federal Ministry for Health.

Competing interest statement: The authors have no competing interests regarding this research article.

Data availability statement: The datasets presented in this article are not readily available because the ethics committee did not grant permission to share study data with third parties or to upload data in anonymized form. Requests to access the datasets should be directed to stephan.bender@uk-koeln.de.

Authors contributions:

- Authors' contributions:
- Christian Kimmig: Manuscript writing, recruitment, data collection, literature research. Guarantor.
- Anneke Haddad: Manuscript writing, data analysis, literature research
- Stephan Bender: Study design and planning, data collection, data analysis, funding acquisition
- Thorsten Langer: Study design and planning, recruitment, reviewing and editing of manuscript

- Johanna Loy: Data preparation, reviewing and editing the manuscript

Ethical Approval Statement:

- The study was approved by the ethics committees of the universities of Cologne (no. 21-1479) and Freiburg (no. 21-1617).

Bibliography

1. Mulkey, S. B., Bearer, C. F. & Molloy, E. J. Indirect effects of the COVID-19 pandemic on children relate to the child's age and experience. *Pediatr. Res.* **94**, 1586–1587 (2023).
2. Calvin, C. M. *et al.* Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. *Int. J. Epidemiol.* **40**, 626–644 (2011).
3. Clark, H. *et al.* A future for the world's children? A WHO–UNICEF–Lancet Commission. *The Lancet* **395**, 605–658 (2020).
4. Jörgensen, E. *et al.* The voices of children and young people during COVID-19: A critical review of methods. *Acta Paediatr. Oslo Nor. 1992* **111**, 1670–1681 (2022).
5. Jörgensen, E., Wood, L., Lynch, M. A., Spencer, N. & Gunnlaugsson, G. Child Rights during the COVID-19 Pandemic: Learning from Child Health-and-Rights Professionals across the World. *Child. Basel Switz.* **10**, 1670 (2023).
6. UN General Assembly Convention on the Rights of the Child. 1989. [(accessed on 08 April 2024)]. Available online: https://www.unicef.org/media/52626/file.
7. Jones, K. E. *et al.* Global trends in emerging infectious diseases. *Nature* **451**, 990–993 (2008).
8. Marani, M., Katul, G. G., Pan, W. K. & Parolari, A. J. Intensity and frequency of extreme novel epidemics. *Proc. Natl. Acad. Sci.* **118**, e2105482118 (2021).
9. Fuchs-Schündeln, N. Covid-induced school closures in the United States and Germany: long-term distributional effects. *Econ. Policy* **37**, 609–639 (2022).
10. Viner, R. M. *et al.* School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child Adolesc. Health* **4**, 397–404 (2020).

11. Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J. & Kempe, A. Increasing Vaccination: Putting Psychological Science Into Action. *Psychol. Sci. Public Interest J. Am. Psychol. Soc.* **18**, 149–207 (2017).

12. Nivette, A. *et al.* Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. *Soc. Sci. Med.* **268**, 113370 (2021).

13. Fiordelli, M., Rubinelli, S. & Diviani, N. Acceptance of Public Health Measures During the COVID-19 Pandemic: A Cross-Sectional Study of the Swiss Population's Beliefs, Attitudes, Trust, and Information-Seeking Behavior. *Int. J. Public Health* **68**, 1605982 (2023).

14. Wu, F. *et al.* The acceptance of SARS-CoV-2 rapid antigen self-testing: A cross-sectional study in China. *J. Med. Virol.* jmv.28227 (2022) doi:10.1002/jmv.28227.

15. Bevan, I., Stage Baxter, M., Stagg, H. R. & Street, A. Knowledge, Attitudes, and Behavior Related to COVID-19 Testing: A Rapid Scoping Review. *Diagnostics* **11**, 1685 (2021).

16. Nguyen, N. *et al.* A mixed methods study evaluating acceptability of a daily COVID-19 testing regimen with a mobile-app connected, at-home, rapid antigen test: Implications for current and future pandemics. *PloS One* **17**, e0267766 (2022).

17. Fallucchi, F., Görges, L., Machado, J., Pieters, A. & Suhrcke, M. How to make universal, voluntary testing for COVID-19 work? A behavioural economics perspective. *Health Policy* **125**, 972–980 (2021).

18. Franconeri, L. *et al.* Experiences with regular testing of students for SARS-CoV-2 in primary and secondary schools: results from a cross-sectional study in two Norwegian counties, autumn 2021. *BMC Public Health* **23**, 1548 (2023).

19. Schuster, J. E. *et al.* A COVID-19 Testing Preference Study in Schools. *Pediatrics* **152**, e2022060352H (2023).

20. Denford, S. *et al.* Feasibility and acceptability of daily testing at school as an alternative to self-isolation following close contact with a confirmed case of COVID-19: a qualitative analysis. *BMC Public Health* **22**, 742 (2022).

21. Unger, J. B. *et al.* COVID-19 Testing in Schools: Perspectives of School Administrators, Teachers, Parents, and Students in Southern California. *Health Promot. Pract.* **24**, 350–359 (2023).

22. Harris, P. A. *et al.* The REDCap consortium: Building an international community of software platform partners. *J. Biomed. Inform.* **95**, 103208 (2019).

23. Harris, P. A. *et al.* Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J. Biomed. Inform.* **42**, 377–381 (2009).

24. Loy, J. K. *et al.* Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. *Front. Public Health* **12**, 1264019 (2024).

25. Robert Koch Institute. Coronavirus Disease 2019 (COVID-19). Daily Situation Report [cited 2024 04/15]. Available from: 707 https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Situationsberichte/Archiv_Sit 708 uationsberichte.html?nn=13490888.

26. Robert Koch-Institut. COVID-19-Impfungen in Deutschland. [object Object] https://doi.org/10.5281/ZENODO.10516840 (2024).

27. Polechová, J. *et al.* SARS-CoV-2 rapid antigen tests provide benefits for epidemic control – observations from Austrian schools. *J. Clin. Epidemiol.* **145**, 14–19 (2022).

28. Joachim, A. *et al.* Pooled RT-qPCR testing for SARS-CoV-2 surveillance in schools - a cluster randomised trial. *EClinicalMedicine* **39**, 101082 (2021).

29. Janke, B. & Janke, W. Untersuchungen zur Erfassung des Befindens von Kindern: Entwicklung einer Selbstbeurteilungsmethode (EWL40-KJ). *Diagnostica* **51**, 29–39 (2005).

30. Goodman, R. Psychometric Properties of the Strengths and Difficulties Questionnaire. *J. Am. Acad. Child Adolesc. Psychiatry* **40**, 1337–1345 (2001).

31. the European KIDSCREEN Group *et al.* Reliability, construct and criterion validity of the KIDSCREEN-10 score: a short measure for children and adolescents' well-being and health-related quality of life. *Qual. Life Res.* **19**, 1487–1500 (2010).

32. Döpfner, M. *et al.* Die psychische Belastung von Kindern, Jugendlichen und ihren Familien während der COVID-19-Pandemie und der Zusammenhang mit emotionalen und Verhaltensauffälligkeiten. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz* **64**, 1522–1532 (2021).

33. Loy JK, Kimmig C, Klos S, Wunram HL, Langer T, Breitinger E and Bender S (2024) Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities. Front. Public Health 12:1264019. doi: 10.3389/fpubh.2024.1264019, accepted 26 June 2024.

34. Pourrazavi, S., Fathifar, Z., Sharma, M. & Allahverdipour, H. COVID-19 vaccine hesitancy: A Systematic review of cognitive determinants. *Health Promot. Perspect.* **13**, 21–35 (2023).

Table 1: Demographics of participants, including Sars-CoV-2 testing data and vaccination status

DEMOGRAPHICS: **SARS-COV-2 TESTING DATA AND VACCINATION STATUS**	
Male, n	202 (35.5%)
Age in years, mean (SD)	13.1 (2.6)
School type, n	
- **Elementary school**	73 (12.8%)
- **Secondary school**	
○ **Secondary grammar school**	455 (80.0%)
○ **Non-acadamic-track secondary schools**	19 (3.4%)
○ **other**	22 (3,9%)
City, n	
- **Freiburg city**	326 (57.3%)
- **Freiburg region**	35 (6.2%)
- **Cologne city**	182 (32.0%)
- **Cologne region**	14 (2.5%)
- **Other**	12 (2.1%)
SARS-CoV-2 test type, n	
- **Only pooled PCR tests**	334 (58.7%)
- **Only rapid antigen tests (oral/nasal)**	102 (17.9%)
- **Mixed tests, most recent test Pooled PCR test**	58 (10.2%)
- **Mixed tests, most recent test rapid antigen (oral/nasal)**	75 (13.2%)
Vaccination status (12 years and over), n	
- vaccinated	300 (75.4%)
- unvaccinated, vaccine-willing	33 (8.3%)
- unvaccinated, vaccine-unwilling	38 (9.5%)
- missing data regarding vaccination/vaccine-willingness	27 (6.8%)
Vaccination status (under 12 years), n	
- vaccine-willing	119 (69.6%)
- vaccine-unwilling	31 (18.1%)
- missing data regarding vaccine-willingness	20 (11.7%)
SDQ scores	
- **NORMAL**	452
- **BORDERLINE/ABNORMAL**	117

Figure Legends:

Figure 1: Test ratings for the two test types (lolli tests and antigen tests) separated by vaccination status. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

Figure 2: Mean Corona test for boys and girls by SDQ score category (normal or borderline/abnormal), not separated by test type. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

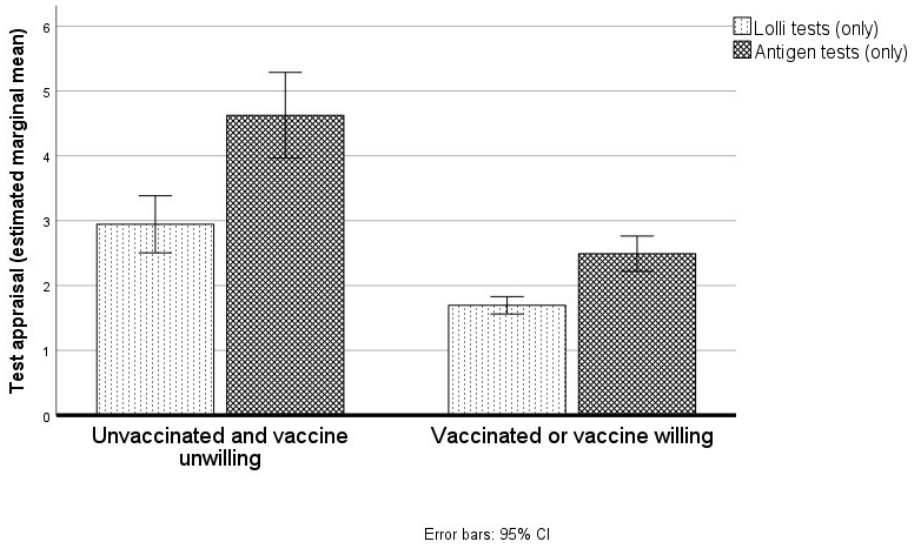

Figure 1: Test ratings for the two test types (lolli tests and antigen tests) separated by vaccination status. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

224x132mm (96 x 96 DPI)

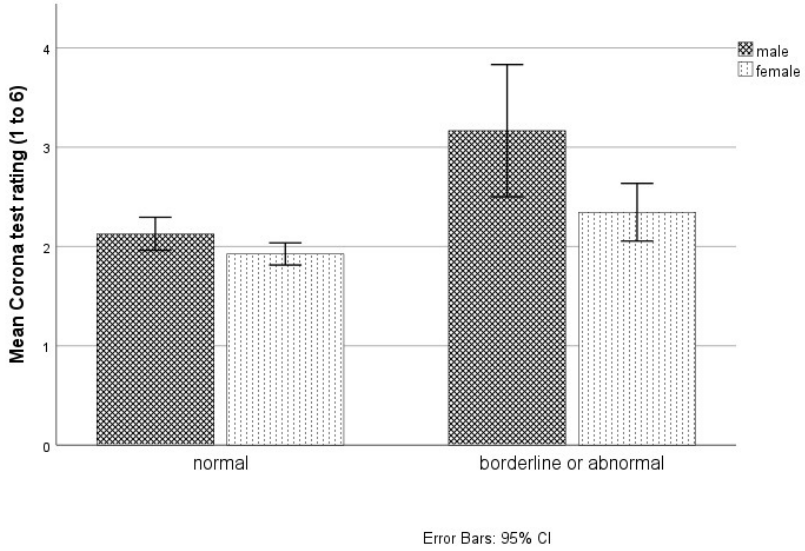

Figure 2: Mean Corona test for boys and girls by SDQ score category (normal or borderline/abnormal), not separated by test type. Test appraisal is measured with the standard German school grading system (1=excellent to 6=fail).

224x132mm (96 x 96 DPI)

Supplementary:

Effect of age:

We restricted our analysis of effects of **age** on test ratings this analysis to secondary grammar school students, since school type may have been confounded with age; secondary grammar school was the best represented school type in our cohort (n=455) and this subgroup included children aged between 10 and 17. The 2 (test type) x 2 (gender) ANCOVA with age as a covariate revealed significant main effects of test method, F(1, 450)=40.946, $p<.001$, partial $\eta^2=.083$, and gender, F(1, 450)=5.974, $p=.015$, partial $\eta^2=.013$. The main effects of age and the interactions were not significant (p>.224). Pooled PCR tests received better ratings than antigen tests (estimated mean difference 0.72, 95% CI [0.48, 0.94]) and girls gave better ratings than boys (estimated mean difference 0.28, 95% CI [0.05, 0.50]). In the sensitivity analysis, the effect of gender was no longer significant (p=.136), though the Pooled PCR tests still received significantly better ratings than antigen tests (p<.001).