Determinants of school absences due to respiratory tract infections among children during COVID-19 pandemic: a cross-sectional study of the Sentinel Schools Network

Antoni Soriano-Arandes[1], Andreu Colom-Cadena[2], Anna Bordas[2], Fabiana Ganem[2], Lucia Alonso[3], Marcos Montoro[2], Mireia Gascon[4], Maria Subirana[4], Ariadna Mas[5], Jordi Sunyer[4], Pere Soler Palacín[1], and Jordi Casabona[2]

[1]Hospital Universitari Vall d'Hebron
[2]CEEISCAT
[3]IGTP
[4]ISGlobal
[5]Institut Català de la Salut

July 6, 2023

Abstract

We aimed to assess the association of household and classroom determinants with students' school absence due to respiratory tract infections (RTI) among 253 students (4-11 years) of 20 classrooms. We collected 71 absences; RTI incidence was very high during the study period, 17.5-33.1 cases per 100 population. Having someone else at home with respiratory symptoms was the most significant epidemiological factor (OR=9.12, CI 95%=2.54-33.39), suggesting that households are crucial for the transmission of RTI to the children. A positive but not statistically significant association was observed between higher median levels of CO2 and respiratory-related absences (OR=1.2, CI 95%=0.98-1.46).

Title: Determinants of school absences due to respiratory tract infections among children during COVID-19 pandemic: a cross-sectional study of the Sentinel Schools Network.

Short running title: School absences and respiratory infections

Antoni Soriano-Arandes[1,*,*], Andreu Colom-Cadena[2,3,*], Anna Bordas[2,3], Fabiana Ganem[2,3,4], Lucia Alonso[3,5], Marcos Montoro[2,3], Mireia Gascon[6,7,8], Maria Subirana[6,7,8], Ariadna Mas[9], Jordi Sunyer[6,7,8], Pere Soler-Palacin[1], Jordi Casabona[2,3,4,8] ; on behalf of Sentinel School Network of Catalonia*

1. Paediatric Infectious Diseases and Immunodeficiencies Unit. Children's Hospital. Vall d'Hebron Barcelona Hospital Campus, Barcelona, Catalonia, Spain.
2. Centre d'Estudis Epidemiològics sobre les ITS i Sida de Catalunya (CEEISCAT). Badalona, Spain.
3. Institut d'Investigació Germans Trias i Pujol (IGTP), Badalona, Spain.
4. Departament de Pediatria, d'Obstetrícia i Ginecologia i de Medicina Preventiva i de Salut Publica, Universitat Autònoma de Barcelona, Bellaterra, Spain.
5. Fundació Lluita contra les infeccions, Badalona, Spain.
6. ISGlobal, Barcelona. Spain.
7. Universitat Pompeu Fabra (UPF), Barcelona, Spain
8. Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública (CIBERESP) Instituto de Salud Carlos III, Madrid, Spain.

9. Direcció Assistencial d'Atenció Primària i Comunitària, Institut Català de la Salut, Barcelona, Catalonia, Spain

* Contributed equally to this work with: Antoni Soriano-Arandes, Andreu Colom-Cadena

* Corresponding author: Antoni Soriano- Arandes,*toni.soriano@vallhebron.cat*. ORCID: 0000-0001-9613-7228

Statements and Declarations

Funding

This work was supported by the Health Department of the Government of Catalonia with no grant number. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. AS-A, FG, AB, LA and ACC received a salary from the abovementioned funder.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

AS-A, ACC, AB, FG, MG, MS and JC conceived and designed the study. AS-A, ACC, and MS were responsible for the data collection; FG, LA, and MM performed the statistical and epidemiological analysis. AS-A and ACC wrote the first draft of the manuscript. All authors drafted the manuscript for important intellectual content, contributed to revision of the final version of the manuscript, approved the final version submitted, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Ethics approval

This study was approved on 17 December 2020 by the Ethical Committee of the Foundation University Institute for Research in Primary Health Care Jordi Gol i Gurina (IDIAPJGol) (code 20/192-PCV). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to participate

Informed consent providing information about anonymity, confidentiality, use of the collected data, risks, and general information about the study, was signed for parents or guardians of the participants because all they were children under 16 years old. Participants were free to decline/withdraw consent at any time without providing a reason and without being subject to any resulting detriment.

Data sharing

All anonymized databases and their corresponding codebooks are available. Requests for complementary data can be sent as a formal proposal to the CEEISCAT via email*ceeiscat@iconcologia.net or to the corresponding author* .

Acknowledgments

The authors would like to thank the Health Department and Department of Education of the Government of the Catalonia (Spain), the former D*ireccio General de Recerca i Innovacio en Salut* (DGRIS) and*Institut Catala de la Salut* (ICS) that made this project possible, and all the health care professionals acting as a COVID-19 pandemic health taskforce in Catalonia. Also, we would like to specially thank the effort and dedication all the sentinel schools' staff, students and families who participated in the project.

*** Sentinel School Network of Catalonia**

Principal investigators: Jordi Casabona [Centre d'Estudis Epidemiologics sobre les Infeccions de Transmissio Sexual i Sida de Catalunya (CEEISCAT)-CIBERESP], Josep Basora (Institut Universitari d'Investigacio en Atencio Primaria (IDIAP Jordi Gol).

Project manager: Anna Bordas (CEEISCAT).

Technical committee: Jordi Casabona (CEEISCAT), Jordi Sunyer (ISGlobal), Antoni Soriano (Hospital Universitari Vall d'Hebron), Rosina Malagrida (Living lab for Health, IRSICaixa) *as Work Package coordinators.* Cinta Folch, Pol Romano, Esteve Muntada, Anna Bordas, Fabiana Ganem, Andreu Colom i Jordi Casabona (CEEISCAT), Mireia Gascon, Maria Subirana, Pau Majo, Jordi Sunyer (ISGlobal), Rosina Malagrida, Laia Vives (Living lab for Health), Antoni Soriano, Pere Soler-Palacin (Vall d'Hebron Barcelona Hospital Campus).

Microbiology laboratories: Tomas Pumarola, Andres Anton, Cristina Andres, Juliana Esperalba, Albert Blanco (Hospital Universitari Vall d'Hebron), Ignacio Blanco, Pere-Joan Cardona, Maria Victoria Gonzalez, Gema Fernandez, Cristina Esteban (Hospital Universitari Germans Trias i Pujol)

Data Management and statistical analysis: Yesika Diaz, Lucia Alonso, Jordi Aceiton, Marcos Montoro (CEEISCAT).

Data Protection Officer and Technical Support: Esteve Muntada (CEEISCAT).

Communication manager: Pol Romano, Cristina Sanchez (CEEISCAT).

Field team: Maria Subirana, Pau Majo (ISGlobal), Jessica Fernandez, Laia Vives (Living Lab for Health, IRSICaixa), Andreu Colom, Isabel Martinez, Marina Herrero, Alba Garcia, Juan Rus, Paula Ribas, Alba Blanco (CEEISCAT).

Universitat Autonoma de Barcelona team: Juan Leyva, Mariela Patricia Aguayo, David Gimenez i Carolina Watson.

Community Paediatricians: Esperanca Macia i Silvia Burgaya (CAP Manlleu), Ma Teresa Riera-Bosch, Elisabet Sola (EAP Vic Nord), Lidia Aulet, Maria Mendoza, Lidia Busquets (EAP Vic Sud), Xavier Perramon, Julia Sebastia (EAP Eixample Dret), Ana Moreno (Cap Ripollet), Xavier Duran, Belen Perez (EAP Can Gibert del Pla), Anna Gatell (Equip Territorial de Pediatria Alt Penedes), Maria Coma (Hospital Universitari Joan XXIII).

Ministry of Health: Carmen Cabezas (Secretaria de Salut Publica de Catalunya, Departament de Salut), Ana Bocio (Subdireccio general de Promocio de la Salut), Ariadna Mas (Direccio Assistencial Atencio Primaria, Institut Catala de la Salut), Maria Antonia Llopis (Coordinacio dels laboratoris de l'Institut Catala de la Salut), Josep Vidal (Gerencia Territorial de la Catalunya Central, Institut Catala de la Salut), Sandra Pequeno and Jacobo Mendioroz (Subdireccio general de Vigilancia i Resposta a Emergencies de l'Agencia de Salut Publica de Catalunya, Departament de Salut), Robert Fabregat (former Direccio Gral Recerca i Innovacio, Departament de Salut).

Department of Education: Josep Gonzalez-Cambray (Conseller d'Educacio), Nuria Mora (Secretaria de Transformacio Educativa), Maria Neus Fornells (former Gabinet del Conseller), Rut Ribas (former Direccio General de l'Alumnat), Anna Chillida (Direccio General de l'Alumnat).

Abstract

We aimed to assess the association of household and classroom determinants with students' school absence due to respiratory tract infections (RTI) among 253 students (4-11 years) of 20 classrooms. We collected 71 absences; RTI incidence was very high during the study period, 17.5-33.1 cases per 100 population. Having someone else at home with respiratory symptoms was the most significant epidemiological factor (OR=9.12, CI 95%=2.54-33.39), suggesting that households are crucial for the transmission of RTI to the children. A positive but not statistically significant association was observed between higher median levels of CO_2 and respiratory-related absences (OR=1.2, CI 95%=0.98-1.46).

Keywords

COVID-19, respiratory infections, ventilation, school, CO_2, Indoor air quality

Main text

Introduction

Different public health measures were implemented during the COVID-19 pandemic to maintain the schools open[1,2]. Regarding COVID-19 vaccination, at the beginning of this study, more than 92% and 40% of population older than 12 years and children aged 5-11 years in Spain was fully vaccinated against COVID-19, respectively[3].

Ventilation was proposed as one of the main strategies to reduce aerosol transmission for SARS-CoV-2 during the pandemic. A study from Germany assessed the efficiency of air purifiers in reducing aerosols in high-school classrooms[4]. However, no clinical endpoints were investigated and, therefore, a very low certainty of evidence was graded by a Cochrane review[5]. In an Italian study, the authors concluded that ventilation reduced the likelihood of SARS-CoV-2 infection in classrooms by 80%[6]. Moreover, a survey study from the US reported that elementary schools with face masks and ventilation strategies in place had lower SARS-CoV-2 incidence rates[7]. In a Lancet Task Force Commission review[8], the authors concluded that improving building ventilation systems may carry benefits beyond protection from COVID-19. However, there is scarce evidence that demonstrate the association of epidemiological and environmental risk factors, including CO_2 concentrations, with the incidence of respiratory tract infections (RTI) in children who are attending schools.

The present study is part of COVID-19 Sentinel Schools Network of Catalonia (CSSNC), a project including 23 schools and 5687 students, teachers and other school staff with the aim to monitor SARS-CoV-2 and other respiratory viruses, their determinants and preventive measures in Catalonia[9]. The objectives of this study are to assess the potential association of demographic and epidemiological factors, including the indoor environmental conditions (CO_2levels) in the classrooms, with students' school absence due to RTI.

Methods

Study design and participants

This is a cross-sectional study conducted in two different periods, the first from April 19 to June 21, 2022, and the second from November 8 to December 21, 2022. The main outcome of the study was the absence of the child from attending the school in person due to RTI or other non-respiratory medical causes.

The study population was composed of 253 students (4-11 years) belonging to 20 classrooms, 11 in spring 2022 and 9 in autumn 2022, attending 4 and 16 classrooms of preschool (4 to 5 years-old) and primary school (6 to 11 years-old) stages, respectively. A written informed consent was previously obtained from parents or guardians of children.

Procedures

Absences from school attendance were notified by the tutor/teacher to the study researchers. We proceed to collect epidemiological and clinical/diagnostic data within the first 48 hours through a case report form deposited on the digital platform REDCap(c). All the absences (cases) were followed-up through telephone calls made by health professionals until their return to the school. RTI was registered according to the symptoms described during the telephonic interview and confirmed through the computerised health record programme of the Health Ministry (eCAP).

Sensors to monitor the CO_2 concentrations (DIOXCARE DX700 PDF, Smartcare Services, Spain) were installed in classrooms, recording data every 10 minutes. For the analysis we only used the measurements taken during the time in which the students were in the classroom. We obtained a median [IQR] of CO_2

levels which was used to conduct our analyses. All the participating schools received an operational protocol to install the sensor correctly and download data weekly.

Statistical analysis

We calculated the RTI incidence per week and for the total study period. We performed a descriptive analysis of all survey variables, stratifying them by respiratory-related absence or absence due to other causes. Additionally, we ran a univariate logistic model to study the association between the type of absence and each described variable to obtain the corresponding odds ratios, 95% confidence intervals and p-values.

Furthermore, we conducted a Latent Class Analysis (LCA) to explore potential groups of students with similar symptomatology. We started exploring the optimal number of latent classes, trying two to five classes, and we selected the best model using the entropy criterion, which indicates the accuracy of the latent classes, combined with other goodness of fit criteria such as BIC, cAIC and likelihood ratio. All these measures suggested that the optimal number of classes was two. However, we also examined the rest of number of classes to see if their classification had more clinical significance. All statistical analyses were performed in R (version 4.2.2).

Results

We registered one-hundred and five school absences during the study, 43 in the first study period (spring 2022), and 62 in the last one (autumn 2022) (**Supplementary Figure 1**). Among these, we could obtain data related to the diagnosis in 98 (93%) cases, the rest of them were lost during the follow-up of the absence. Seventy-one absences were respiratory-related and 27 were due to other causes, mainly with gastrointestinal symptoms (66.7%). Among the absences due to RTI, the most were upper RTI (56/71, 78.9%), and only six (8.5%) were confirmed infections, 2 caused by influenza virus and 4 due to SARS-CoV-2 infection. These results represent a RTI incidence of 15.9 and 33.1 cases per 100 population in the first and second study period, respectively. The maximum weekly RTI incidence was of 10.2 cases per 100 population in December 12-18, 2022.

The clinical, epidemiological and environmental characteristics of study sample are summarized in **table 1** , categorized by type of absence (respiratory versus non-respiratory). We found a statistically significant association with absences due to RTI when someone else at home had respiratory symptoms (OR=9.12, CI 95%=2.54-33.39). We found a positive association between higher median levels of CO_2at class and respiratory-related absences (OR=1.2, CI 95%=0.98-1.46). Moreover, there were more respiratory absences in autumn (OR=2.4, CI 95%=0.97-5.94). However, these last two associations did not reach statistical significance at a level of 0.05; although their p-values were lower than 0.1.

No other epidemiological risk factors were associated with RTI incidence, such as household floor level, number of people living at home, living with smokers, having any comorbidity or being vaccinated against COVID-19.

Finally, in **Figure 1** , we present the symptomatology of absences belonging to each of the two latent classes. We can see that in the first cluster, the most frequent symptoms were cough, nasal congestion and fever, whereas in the second one, fever, gastrointestinal symptoms, and fatigue predominated.

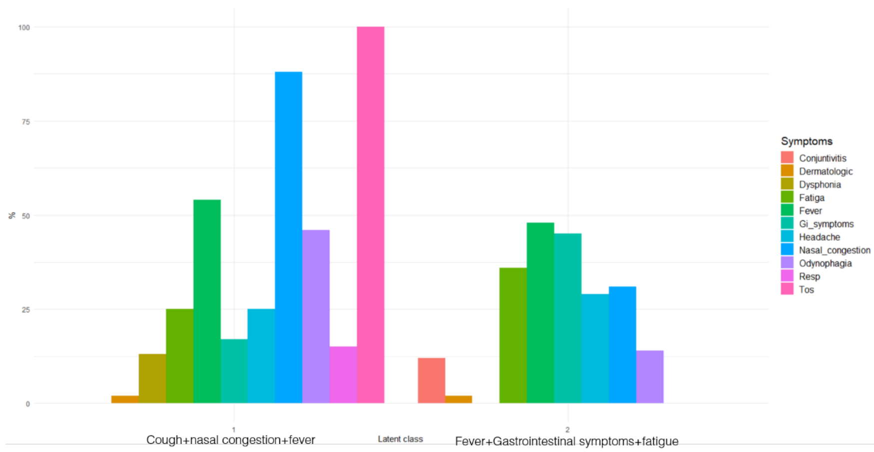

Figure 1. Latent class analysis with two latent classes to compare school absences due to RTI from other causes. Latent class 1: Cough+nasal congestion+fever; Latent class 2: Fever+Gastrointestinal symptoms+fatigue.

Discussion

Our findings confirm that the RTI incidence during the study period was very high in children attending in the CNSSC schools, and the main medical cause of school absence. Although differences on school absence due to RTI were observed between spring and autumn, they were not statistically significant and in any case they may be due to the respiratory viruses' seasonal pattern. In fact, the most important and significantly associated risk factor for RTI was the presence of someone else at home with respiratory symptoms, suggesting that households could be the main setting for initiating of the transmission of RTI.

We observed a slightly association between RTI and median of CO_2 levels in classrooms (p=0.07), which is an indicator of the degree of ventilation. However, we cannot exclude other potential factors such as rainfall, ambient temperature, or air pollutants (e.g. $PM_{2.5}$, NO_2, etc.) influencing on this outcome, as suggested by other authors[10]. To our knowledge, previous studies assessed the CO_2concentration as a proxy of ventilation to evaluate the risk transmission of SARS-CoV-2 in schools[11,12], but they did not analyse the association between CO_2 median values and RTI incidence.

Finally, we studied the symptomatology associated with the school absences through a LCA. The best approach to differentiate RTI from other causes was using two latent classes, and the most frequent symptoms were cough, nasal congestion and fever.

The major strength of this study is our extensive data collection on clinical, epidemiological and environmental factors related to the school and also to the households of the participants. However, there were limitations such as possible incomplete reporting of RTI or insufficient sample size to determine small effect sizes. CO_2 concentration was only measured in a selection of classrooms per school, so it may not be representative for the entire study period and school.

In conclusion, RTI incidence was very high during the study period being the most important and significantly associated factor with RTI to have anyone else at home with respiratory symptoms. This suggests that households and not schools could be the key epidemiological factor for initiating the transmission of RTI to the children. Improving household preventive measures could reduce childhood RTI. In the LCA, the most frequent symptoms associated with RTI were cough, nasal congestion and fever. Although we found a slightly association between RTI and reduced ventilation we cannot exclude other potential factors influencing on this outcome. The study has been crucial to assess the feasibility and potential utility of collecting both school absence and morbidity data for further developing a systematic monitoring system.

References

1. UNESCO map on school closures (2022). Available from:*https://en.unesco.org/covid19/educationresponse*and UIS,*http://data.uis.unesco.org/*. Accessed 14 June 2023.
2. Kratzer S, Pfadenhauer LM, Biallas RL, Featherstone R, Klinger C, Movsisyan A, Rabe JE, Stadelmaier J, Rehfuess E, Wabnitz K, Verboom B (2022). Unintended consequences of measures implemented in the school setting to contain the COVID-19 pandemic: a scoping review. The Cochrane database of Syst Rev, 6(6), CD015397.*https://doi.org/10.1002/14651858.CD015397*
3. Real Decreto 286/2022, de 19 de abril, por el que se modifica la obligatoriedad del uso de mascarillas durante la situación de crisis sanitaria ocasionada por la COVID-19. (2022)*https://www.boe.es/boe/dias/2022/04/20/pdfs/BOE-A-2022-6449.pdf*[accessed: May 8, 2023].
4. Curtius J, Granzin M & Schrod J (2021) Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2. Aerosol Sci Technol, 55:5, 586-599, DOI: 10.1080/02786826.2021.1877257
5. Krishnaratne S, Littlecott H, Sell K, Burns J, Rabe JE, Stratil JM, Litwin T, Kreutz C, Coenen M, Geffert K, et al. (2022). Measures implemented in the school setting to contain the COVID-19 pandemic. The Cochrane database Syst Rev, 1(1), CD015029.*https://doi.org/10.1002/14651858.CD015029*
6. Buonanno G, Ricolfi L, Morawska L, Stabile L. (2022) Increasing ventilation reduces SARS-CoV-2 airborne transmission in schools: A retrospective cohort study in Italy's Marche region. Front Public Heal. Frontiers; 10:1087087. doi: 10.3389/fpubh.2022.1087087.
7. Gettings J, Czarnik M, Morris E, Haller E, Thompson-Paul AM, Rasberry C, Lanzieri TM, Smith-Grant J, Aholou TM, Thomas E, et al. (2021) Mask use and ventilation improvements to reduce COVID-19 incidence in elementary schools—Georgia, November 16–December 11, 2020. MMWR Morb Mortal Wkly Rep; 70:779. doi: 10.15585/mmwr.mm7021e1
8. Sachs JD, Karim SSA, Aknin L, Allen J, Brosbøl K, Colombo F, Barron GC, Espinosa MF, Gaspar V, Gaviria A, et al. (2022) The Lancet Commission on lessons for the future from the COVID-19 pandemic. Lancet. Elsevier; 400:1224–80. doi: 10.1016/S0140-6736(22)01585-9
9. Bordas A, Soriano-Arandes A, Subirana M, Malagrida R, Reyes-Urueña JM, Folch C, Soler-Palacin P, Gascón M, Sunyer J, Anton A, et al. (2022) Study protocol for monitoring SARS-CoV-2 infection and its determinants in Catalonia (Spain): an observational and participatory research approach in a Sentinel Network of Schools. BMJ Open. 12(1):e055649. doi: 10.1136/bmjopen-2021-055649.
10. He Y, Jiang W, Gao X, Lin C, Li J, Yang L. (2023) Short-term effects and economic burden of air pollutants on acute lower respiratory tract infections in children in Southwest China: a time-series study. Environ Health. 22(1):6. doi: 10.1186/s12940-023-00962-3.
11. Ding E, Zhang D, Hamida A, García-Sánchez C, Jonker L, de Boer AR, Bruijning PCJL, Linde KJ, Wouters IM, Bluyssen PM (2023) Ventilation and thermal conditions in secondary schools in the Netherlands: Effects of COVID-19 pandemic control and prevention measures. Build Environ. 229:109922. doi: 10.1016/j.buildenv.2022.109922.
12. Di Gilio A, Palmisani J, Pulimeno M, Cerino F, Cacace M, Miani A, de Gennaro G (2021) CO_2 concentration monitoring inside educational buildings as a strategic tool to reduce the risk of Sars-CoV-2 airborne transmission. Environ Res. 202:111560. doi: 10.1016/j.envres.2021.111560.

Table 1. Descriptive analysis of clinical, epidemiological and environmental variables comparing absences due to Respiratory tract infections (RTI) from absences due to other causes.

	Total absences from attending school in person	**Absences d**
Characteristic	N = 98	N = 71
Age group		
4-6 years	66 (67.3)	45 (63.4)
7-9 years	12 (12.2)	11 (15.5)
10-11 years	20 (20.4)	15 (21.1)
Period		

	Total absences from attending school in person	**Absences du**
First year (spring)	36 (36.7)	22 (31)
Second year (autumn)	62 (63.3)	49 (69)
Sex		
Male	46 (46.9)	34 (47.9)
Female	52 (53.1)	37 (52.1)
Sports		
Yes	52 (53.1)	40 (56.3)
No	45 (45.9)	30 (42.3)
Missing	1 (1)	1 (1.4)
Floor level		
First floor or lower	54 (55.1)	41 (57.7)
Upper floors	43 (43.9)	29 (40.8)
Missing	1 (1)	1 (1.4)
Number of cohabitants, median (IQR)	4 (4-4)	4 (4-4)
Number of cohabitants		
<4	24 (24.5)	16 (22.5)
>=4	73 (74.5)	54 (76.1)
Missing	1 (1)	1 (1.4)
Smokers at home		
Yes	35 (35.7)	25 (35.2)
No	63 (64.3)	46 (64.8)
Hospital admissions		
Yes	0 (0)	0 (0)
No	98 (100)	71 (100)
Comorbidities		
Yes	10 (10.2)	8 (11.3)
No	88 (89.8)	63 (88.7)
Asthma		
Yes	5 (50)	5 (62.5)
No	5 (50)	3 (37.5)
Complete COVID-19 vaccination		
Yes	19 (19.4)	12 (16.9)
No	79 (80.6)	59 (83.1)
Complete COVID-19 vaccination at home		
Yes	84 (85.7)	63 (88.7)
No	11 (11.2)	6 (8.5)
Missing	3 (3.1)	2 (2.8)
Anyone at home with respiratory symptoms		
Yes	41 (41.8)	38 (53.5)
No	57 (58.2)	33 (46.5)
Level of CO2, median (IQR)	567.76 (485-637.78)	606.51 (485-8
Level of CO2		
< 1000	79 (80.6)	54 (76.1)
>= 1000	19 (19.4)	17 (23.9)
Symptoms		
Fever (yes)	50 (51.0)	40 (56.3)
Cough (yes)	53 (54.0)	49 (69.0)
Odynophagia (yes)	31 (31.6)	30 (42.3)
Nasal congestion (yes)	60 (61.2)	54 (76.1)

	Total absences from attending school in person	Absences du
Gastrointestinal symptoms (yes)	30 (30.6)	12 (16.9)

Fig. 1 Latent class analysis with two latent classes to compare school absences due to RTI from other causes. Latent class 1: Cough+nasal congestion+fever; Latent class 2: Fever+Gastrointestinal symptoms+fatigue.