



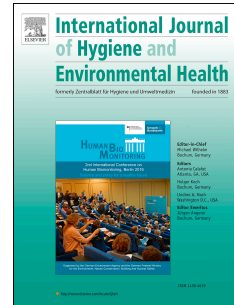
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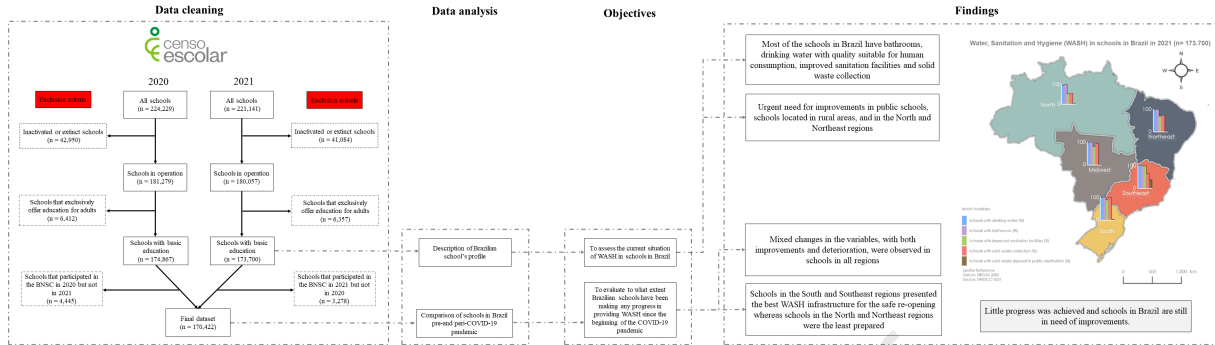
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Poague et al., 2022



Journal Pre-proof

# Water, sanitation and hygiene (WASH) in schools in Brazil pre-and peri-COVID-19 pandemic: are schools making any progress?

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## Abstract

The previous paucity of data and research on water, sanitation and hygiene (WASH) in schools in Brazil have been preventing an assessment of how safe and healthy schools are to reopen during the COVID-19 pandemic. This study aimed first to assess the current situation of WASH in schools in Brazil and, second, to evaluate to what extent Brazilian schools have been making any progress in providing WASH since the beginning of the COVID-19 pandemic. Data on WASH conditions in schools in Brazil was retrieved from the 2020 and 2021 Brazilian National School Census BNSC. For the first objective, frequencies of 31 variables were calculated for the whole country and regions, considering all 173,700 schools from BNSC of 2021. Five main variables were considered as indicators of adequate WASH infrastructure in schools. T-test and ANOVA were used to assess differences in these five variables according to the locality, management model and regions. For the second objective only schools presented in both datasets (n=170,422) were considered to compare WASH in schools pre- and peri-COVID-19 pandemic. Frequencies of 31 variables were calculated for the whole country and regions before and during the pandemic. Paired t-tests were conducted when differences in variables across the years were observed. At the present moment, the majority of schools in Brazil have bathrooms (97%), drinking water with quality suitable for human consumption (95%), improved sanitation facilities (78%) and solid waste collection (70%). Between 2020 and 2021, there was a mix of improvements and deterioration in the school's WASH infrastructure in all regions of the country. Overall, solely considering the WASH infrastructure, schools in the South and Southeast regions of the country are better prepared for the safe reopening. Nevertheless, public schools, schools located in rural areas and the North and Northeast regions of the country, are more in need of WASH interventions. Results indicate that little progress was achieved, and schools in Brazil are still in need of improvements.

**KEYWORDS:** SARS-CoV-2; solid waste; bathroom; water supply; students; education.

## Introduction

The COVID-19 pandemic revealed that many schools struggle to provide basic water, sanitation and hygiene (WASH). In 2019, 818 million children lacked basic hygiene services at their schools (WHO and UNICEF, 2020). That number included 355 million children whose schools had handwashing facilities with water but no soap and 462 million whose schools still had no hygiene service (no handwashing facility or water available) (WHO and UNICEF, 2020).

Handwashing has been playing a crucial role in the ongoing COVID-19 pandemic. It is one of the fundamental measures to combat the spread of the new coronavirus, is a cheap, easy, and simple solution, and the public is already quite familiar with the practice (Roy et al., 2020; WHO, 2020). It relies on the presence of sufficient, accessible and functional handwashing facilities, water and soap. Beyond the prevention of COVID-19, handwashing interrupts the transmission cycle of a series of illnesses associated with the lack of available water for personal hygiene called water-washed diseases (Bartram et al., 2021).

Besides expanding the handwashing infrastructure and providing adequate and sufficient supplies for hygiene, the World Health Organization (WHO) checklist to support schools reopening and preparation for COVID-19 also recommends that schools guarantee that water and sanitation facilities are operational, regularly cleaned and disinfected (Benzian et al., 2020). As has been emphasized in the literature, the adoption of hygiene practices in schools, such as handwashing, is not only influenced by the presence of handwashing infrastructure and supplies but also by the existence of adequate water and sanitation facilities and by training and health-related knowledge (Cronk et al., 2021; Lopez-Quintero et al., 2009; Shehmolo et al., 2021). Reversely, the availability and quality of water and sanitation in schools are also affected by existing hand hygiene facilities and hygiene materials provided in the school environment (Cronk et al., 2021; Morgan et al., 2021). The relevance of WASH in the context of the COVID-19 pandemic is not restricted to the school environment. However, the transmission of the new coronavirus among children is of special concern taking into account the associated increased incidence of Kawasaki disease and Multisystem inflammatory syndrome cases in children (MIS-C) (Dufort et al., 2020; Godfred-cato et al., 2020; Okarska-Napierała et al., 2020; Verdoni et al., 2020) and the emergence of the new pediatric hepatitis with unknown cause (Brodin and Ardit, 2022; Kendall et al., 2022.; The Lancet Infectious Diseases, 2022). Moreover, children can also experience the manifestation of persistent long-term COVID-19 symptoms after the infection (long COVID), which can ultimately result in their cognitive development impairment (Asadi-Pooya et al., 2021; Borch et al., 2022).

Apart from the prevention of COVID-19 and water-borne and water-washed diseases, the several benefits of the access to WASH in school include: i) decrease in school absenteeism among females (Alam et al., 2017; Montgomery et al., 2016) and among both girls and boys (Lopez-Quintero et al., 2009; Vally et al., 2019); ii) reduction in diarrheal diseases (Jasper et al., 2012; McMichael, 2019; Sangalang et al., 2020; Vally et al., 2019), gastrointestinal symptoms (Lopez-Quintero et al., 2009), soil-transmitted helminthiasis (Jasper et al., 2012; McMichael, 2019; Sangalang et al., 2020) and respiratory illness (Jasper et al., 2012; McMichael, 2019); iii) increase in girl's academic achievement (Bergensfeld et al., 2021), and adequate menstrual hygiene management (MHM) practices in the school environment (Bulto, 2021; Korir et al., 2018). The adherence to WASH practices (attitudes and behaviours) is associated with the student's level of knowledge on that topic (Aschale et al., 2021; Assefa and Kumie, 2014; Shehmolo et al., 2021). On that note, as learning environments, schools have the potential to enhance children's teaching and training of WASH practices (Anthonj et al., 2021).

In 2010, access to safe drinking water and sanitation was formally recognized by the United Nations General Assembly as a human right, essential to the full enjoyment of life and the

realization of all other human rights (United Nations, 2015a). The Human Right to Water and Sanitation (HRTWS) is directly addressed in the 2030 Agenda for Sustainable Development by the Sustainable Development Goal (SDG) 6, which aims to *ensure availability and sustainable management of water and sanitation for all* (United Nations, 2015b). Notwithstanding that the agenda has a specific goal for WASH and that the HRTWS is explicitly reaffirmed in paragraph 7 of the Agenda's declaration, WASH in schools is included in SDG 4, aiming to *ensure inclusive and equitable quality education and promote lifelong learning opportunities for all* (United Nations, 2015b). Target 4.a seeks to *"build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all."* (United Nations, 2015b).

Despite all of the WHO/UNICEF Joint Monitoring Programme's efforts to globally monitor WASH in schools and evaluate the progress to achieving the SDG 4 objective 4.a, there is a noticeable paucity of data on WASH in schools in Brazil. In Brazil, up to 6 million (12%) school-aged population lack proper WASH services (with 15% of schools lacking water service and 5% of schools lacking sanitation services) (WHO and UNICEF, 2020). These statistics, however, only capture the reality of a small portion of schools in Brazil. The current state of water services in 85% and sanitation services in 95% of the Brazilian institutions could not be evaluated due to insufficient data (WHO and UNICEF, 2020). A recent systematic review performed by Poague et al. (2022) on WASH in schools in low- and middle-income (LMICs) countries also indicated limited data and research on WASH in schools in Brazil and Latin America as well. Out of 65 studies included in the review, only three were conducted in Central America, one in South America and none in Brazil (Poague et al., 2022). According to the WHO/UNICEF report on WASH in schools from 2020, Latin America and the Caribbean were the only regions to record a decrease in data availability on WASH in schools from 2000 to 2019 (WHO and UNICEF, 2020). As has been highlighted by Chatterley et al. (2018), harmonized nationally-representative data on WASH in schools is rarely available and, when provided, existing data are often not fully utilized. Since 2014 nationwide data on WASH in schools in Brazil have been publicly available by the Brazilian government as part of the information collected through the Brazilian National School Census (BSNC) (INEP, 2021). Hitherto, evaluation and dissemination of these data have not been done, yet they offer a robust foundation for improving WASH in the Brazilian context. Furthermore, the HRTWS is acknowledged as an unwritten and implicit fundamental right in Brazilian constitutionalism, derived from its connection with other domains and fundamental rights, especially health and dignity (Santiago and Vieira, 2021). In summary, in spite of the relevance of WASH in schools, the availability of data, and the urgent need to provide safe educational environments in the ongoing COVID-19 pandemic, the previous paucity of research on WASH in schools in Brazil have been preventing an assessment of how safe and healthy schools are to reopen during the COVID-19 pandemic.

Thus, the purpose of this study was to first (i) assess the current situation of WASH in schools in Brazil and, second, (ii) to evaluate to what extent Brazilian schools have been making any progress in providing WASH since the beginning of the COVID-19 pandemic.

## **Methods**

### **Country Context**

Schools in Brazil can be either private or government-owned and administrated by the municipality (public municipal school), state (public state school) or the Federal Government (or public federal school) (INEP, 2021). The basic education in Brazil is divided into five sequential levels: i) daycares (students aged 0 to 3 years old); ii) preschool (students aged 3 to 5 years old); iii) primary first cycle (students aged 6 to 10 years old); iv) primary second cycle (students aged 11 to 14 years old); v) secondary school (students aged 15 to 18 years old) (INEP, 2021). Hitherto, as of June 08 2022, Brazil is the third nation with the maximum number of accumulative cases of COVID-19 and the second in the number of deaths (WHO, 2022). Due to the pandemic, schools in Brazil have been closed since March 12 2020 (INEP, 2021). At the present moment, schools are already resuming on-site classes. In some regions, schools operate in a hybrid model, while in others, schools remain temporarily closed and with remote activities (UNESCO, 2022). For

this study, we consider the geopolitical division of the Brazilian territory into five major geographic regions, as shown in **Figure 1**.



**Figure 1:** Administrative divisions of Brazil (states and regions).

\***Midwest:** MT- Mato Grosso, MS – Mato Grosso do Sul, GO – Góias, DF – Distrito Federal; **Northeast:** MA – Maranhão, PI – Piauí, CE – Ceará, PE – Pernambuco, RN – Rio Grande do Norte, - PB – Paraíba, AL – Alagoas, SE – Sergipe, BA – Bahia; **North:** RO – Rondônia, AC – Acre, AM – Amapá, PA – Pará, AM – Amazonas, RR – Roraima; **Southeast:** MG – Minas Gerais, SP – São Paulo, ES – Espírito Santo, RJ – Rio de Janeiro; **South:** PR – Paraná, SC – Santa Catarina, RS – Rio Grande do Sul.

### **Data collection and cleaning**

Secondary data of schools were retrieved from the 2020 and 2021 Brazilian National School Census (BNSC) provided by the *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira* (INEP) (INEP, 2021). The available data in Portuguese was accessed and downloaded in CSV format from the INEP website (INEP, 2022). Since 2014 INEP, the Brazilian government entity responsible for the surveillance of schools, has been collecting and releasing information on an annual basis on the infrastructure of all basic education institutions in the country, regardless of the level of education, locality (rural vs urban) and management model (private or public) (INEP, 2021). Every year, the school's principals, headteachers, or the person in charge must reply to a self-reported survey sent by the INEP. The questionnaire contains 62 questions and should be filled out between June and August, considering the last Wednesday of May as the reference date for data collection (INEP, 2021). The final results are released at the end of January and the beginning of February from the following year. For the year 2020, due to the extraordinary situation of the COVID-19 pandemic, the reference date for collecting the data was postponed to March 11 2020, one day before the national closure of schools was established. Hence, the 2020 BNSC dataset describes the state of schools' infrastructure in Brazil right before they were closed. For 2021, the reference date for data collection returned to the original standard (last Wednesday of May of 2021). Thus, the 2021 BNSC, which was released on February 18 2022, reflects the impacts of the pandemic and the school closure on the state of schools' infrastructure in Brazil. We adopted the word "pre" to designate the state of schools before the beginning of the pandemic (2020 BNSC) and "peri" to refer to the state of schools during the pandemic (2021 BNSC).



Data cleaning and analysis phases, and how each phase is correlated to the research objectives is presented by **Figure 2**. The initial databases were first manually exported into Microsoft Excel (2016) by removing the schools that were inactivated or extinct before the pandemic. Inactivated schools are the institutions that are temporarily suspended from school activities, and extinct schools are those that are permanently closed from school activities due to reasons not related to COVID-19 (INEP, 2021). Keeping in mind that, compared to other age groups, children are differently affected by COVID-19 (Cao et al., 2020; Mansourian et al., 2021; Mendoza-Torres et al., 2021), we decided to only include schools that offer one or more levels of basic education and, therefore, attend students aged 0 to 18 years old (daycare, preschool, primary and secondary schools). In order to allow comparison between datasets (2020 vs 2021), a data quality assessment was conducted to identify schools that were present in both databases.

Data from the BNSC regarding general characteristics of the school and availability of water, sanitation, waste services, and sanitary facilities (bathrooms) were transformed into 31 variables for further analysis (described in **Table 1**). Binary variables were not exclusionary (i.e., schools can mark more than one option, for instance, schools can declare more than one water supply or more than one waste management pathway). More information about the transformations and compatibility of variables can be found in the Supplementary Material.



**Table 1:** Description of WASH and school demographic variables.

Variable	Description
<b>WASH Variables</b>	
Schools with drinking water	The school provides drinking water with quality suitable for human consumption (i.e., ingestion, preparation, and production of food) according to the Brazilian national water quality standards (former <i>Portaria</i> n° 2.914/2011 now <i>Portaria de Consolidação</i> n°5/2017) (1 – Yes; 0 – No)
Schools with water from public network	The water in the school is supplied by a public network (1 – Yes; 0 – No).
Schools with water from borehole	The water in the school is supplied by a borehole (1 – Yes; 0 – No)
Schools with bathrooms	The school is equipped with sanitary facilities for personal hygiene/physiological needs (1 – Yes; 0 – No)
Schools with bathrooms for youngest children	The school is equipped with sanitary facilities for children 0 to 5 years old (1 – Yes; 0 – No)
Schools with disability-friendly bathroom	The school is equipped with disability-friendly sanitary facilities following the national guidelines (ABNT - NBR 9050) (1 – Yes; 0 – No)
Schools with bathrooms exclusively for staff	The school is equipped with sanitary facilities for personal hygiene/physiological needs exclusively for staff (1 – Yes; 0 – No)
Schools with bathrooms with showers for students	The school is equipped with sanitary facilities or changing room or washing room with appropriate equipment (shower) for bathing, exclusively for students (1 – Yes; 0 – No)
Schools with water from <i>cacimba</i> /cistern/well	The water in the school is supplied by a <i>cacimba</i> , cistern, or well (1 – Yes; 0 – No)
Schools with surface water	The water in the school is supplied by surface water source (1 – Yes; 0 – No)
Schools with no water source	There is no water supply in the school (1 – Yes; 0 – No)
Schools with more than one water source	The school has more than one water supply (considering public network, borehole, <i>cacimba</i> /cistern/well, and surface water as possible options) (1 – Yes; 0 – No)
Schools connected to a public sewerage system	The school dispose their sewage into a public sewerage system (1 – Yes; 0 – No)
Schools with septic tank	The school dispose their sewage into septic tank (1 – Yes; 0 – No)
Schools with improved sanitation facilities	The school dispose their sewage into a public sewerage system or into a septic tank (1 – Yes; 0 – No).
Schools with unimproved sanitation facilities	The school dispose their sewage into an inadequate facility such as rudimentary cesspit/pit/latrine (1 – Yes; 0 – No)
Schools without sewage collection/treatment	The school has no sewage disposal (1 – Yes; 0 – No)
Schools with solid waste collection	The solid waste in the school is regularly collected by the public cleaning service (1 – Yes; 0 – No)
Schools with solid waste disposal in public destination	The solid waste in the school is disposed in an area licensed by environmental agencies, intended to receive solid waste in a planned manner (e.g., landfills) (1 – Yes; 0 – No)
Schools with burned waste	The solid waste in the school is burned or incinerated (1 – Yes; 0 – No)
Schools with buried waste	The solid waste in the school is buried (1 – Yes; 0 – No)
Schools with waste disposal in another area	The solid waste in the school is disposed in another area (none of the other options) (1 – Yes; 0 – No)
<b>School demographic variables</b>	
Locality of Schools	The school is located in an urban (1) or rural area (2)
Schools' management model	The administration of the school is federal (1); state (2); municipal (3), or private (4). Federal, state, and municipal schools are considered public.
Schools with basic education	The institution offers one or more levels of basic education for children aged 0 to 18 years old (daycare, preschool, primary, secondary and high education) (1 – Yes, 0 – No)
Schools with daycare	The institution offers daycare for children aged 0 to 3 years old (1 – Yes, 0 – No)
Schools with preschool	The institution offers preschool for children aged 4 and 5 years old (1 – Yes, 0 – No)
Schools with primary education first cycle	The institution offers primary education first cycle (1 – Yes, 0 – No)
Schools with primary education second cycle	The institution offers primary education second cycle (1 – Yes, 0 – No)
Schools with secondary education	The institution offers any type of secondary education, including regular high education, high education with technical school, and propaedeutic high education (1 – Yes, 0 – No)
Schools with more than one level of education	The institution offers more than one level of education (1 – Yes, 0 – No)

Source: Adapted from INEP (2021) (INEP, 2021). \*Classification of improved and unimproved sanitation facilities followed the definitions of the Joint Monitoring Programme (JMP) (WHO and UNICEF, 2020).

## **Data analysis**

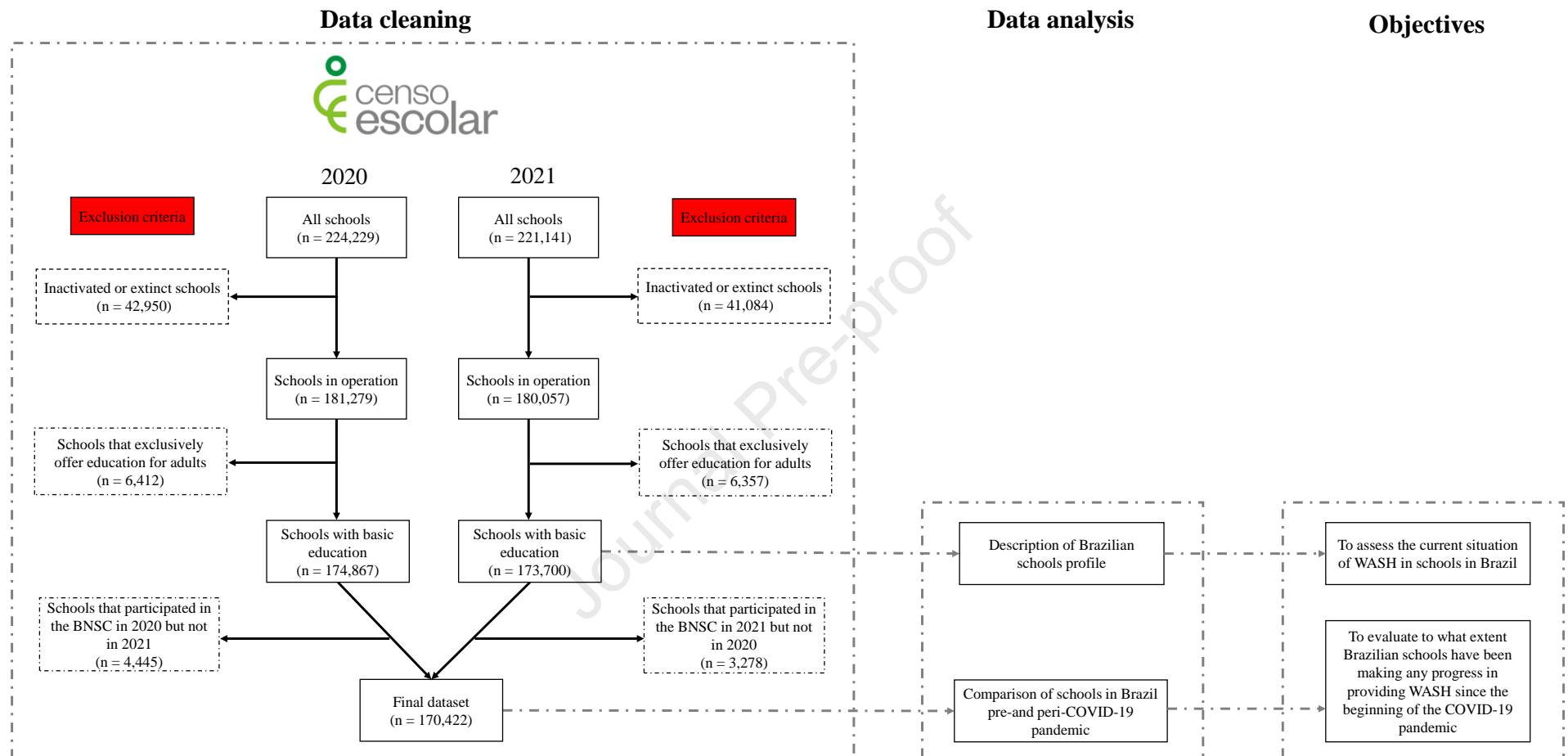
All analyses were conducted using Stata software, version 14 and ArcGIS Pro® software.

### *Profile of schools in Brazil and in Brazilian regions*

For the first objective of this research, the frequencies of the 31 variables were calculated for the whole country and regions, considering all 173,700 schools from BNSC of 2021. Due to the large number of variables available, five main variables were chosen to perform further tests, namely: i) schools with drinking water; ii) schools with bathrooms; iii) schools with improved sanitation facilities; iv) schools with solid waste collection; v) schools with solid waste disposal in public destination;. These five variables can be considered indicators of adequate WASH infrastructure in the schools. The existence of differences according to locality (urban x rural) and management model (public x private) were assessed using t-test, while for regions (North, Northeast, Southeast, South and Midwest) by ANOVA test. The significance level was set as 5%.

### *Comparison of WASH conditions in schools in Brazil and in Brazilian regions before and during the COVID-19 pandemic*

For the second objective, the frequencies of the 31 variables for the whole country and all regions were calculated for 2020 (pre-COVID-19) and 2021 (peri-COVID-19), considering only schools presented in both datasets (n=170,422). Paired t-tests were conducted when differences in variables considering the whole country were observed between both years. The significance level was set as 5%.



**Figure 2:** Flowchart of the data cleaning and analysis steps.

## Results

### WASH in Schools in Brazil

In total, 173,700 schools serving 45,305,359 students were evaluated throughout the Brazilian territory (**Table 2**). The majority of the schools in Brazil are public institutions (78%), located in urban areas (69%). Most of the institutions are administered by municipal governments (61%), while the states, the federal government and the private sector play only a marginal role. Concerning the level of education, approximately 71% of the schools offer more than one level of basic education (e.g., schools offer primary and secondary education, daycare and preschool, or all the possible five levels of education, etc). The most frequent basic education levels offered in the institutions are primary education first cycle (students aged 6 to 10 years old) (62%) followed by preschool (students aged 3 to 5 years old) (58%).

**Table 2:** Characteristics of schools in Brazil and by geographical region in 2021.

	Brazil	North	Northeast	Southeast	South	Midwest
<b>Number and percentage of Schools (n/%)</b>	173,700 (100)	21,620 (12)	59,503 (34)	57,950 (33)	24,587 (14)	10,040 (6)
<b>Number of students enrolled</b>	45,305,359	4,777,381	13,415,129	17,628,109	5,961,399	3,523,341
<b>School's Administration model</b>						
Public schools (%)	78	93	83	68	78	76
Federal schools (%)	0	0	0	0	0	1
State schools (%)	16	17	10	18	22	26
Municipal schools (%)	61	75	72	49	56	49
Private schools	22	7	17	32	22	24
<b>Locality</b>						
Urban Schools (%)	69	38	54	89	83	85
<b>Educational Level*</b>						
Schools with daycare (%)	40	25	44	43	41	33
Schools with pre-school (%)	58	60	66	49	58	54
Schools with primary education (%)	61	79	72	49	51	59
Schools with secondary education (%)	36	42	33	33	37	44
Schools with high school (%)	17	12	12	21	19	24
Schools with more than one level of education (%)	71	74	75	63	77	74
<b>Water</b>						
Schools with drinking water (%)	95	82	95	99	97	98
Schools with water from public network (%)	75	32	68	92	90	86
Schools with water from borehole (%)	16	37	18	7	11	19
Schools with water from <i>cacimba</i> /cistern/well (%)	9	12	18	3	2	3
Schools with surface water (%)	4	20	2	2	1	2
Schools with no water source (%)	2	7	3	0	0	0
Schools with more than one water source (%)	6	8	9	4	4	10
<b>Bathroom</b>						
Schools with bathrooms (%)	97	85	97	99	100	99
Schools with bathrooms for youngest children (%)*	60	29	43	74	90	80
Schools with disability-friendly bathrooms (%)	49	31	41	53	62	73
Schools with bathrooms exclusively for staff (%)	54	33	38	70	69	66
Schools with bathrooms with shower for students (%)	44	30	40	47	51	62
<b>Sanitation</b>						
Schools connected to a public sewerage system (%)	56	13	38	88	63	54
Schools with septic tank (%)	23	33	31	8	27	28
Schools with improved sanitation facilities (%)	78	45	68	96	87	80
Schools with unimproved sanitation facilities (%)	18	36	28	4	14	20
Schools without sewage collection/treatment (%)	4	19	5	0	0	1
<b>Solid Waste</b>						
Schools with solid waste collection (%)	70	47	71	63	97	93
Schools with solid waste disposal in public destination (%)	13	1	3	36	2	1
Schools with burned waste (%)	19	51	29	4	3	7
Schools with buried waste (%)	2	9	2	0	3	3
Schools with waste disposal in another area (%)	3	16	2	1	0	1

The sum might exceed 100% because the categories are not exclusionary. \*Only schools with daycare (students aged 0 to 3 years old) or preschools (students aged 3 to 5 years old) were considered when analyzing bathrooms for the youngest children (sanitary facilities for children 0 to 5 years old) (n=112,927).

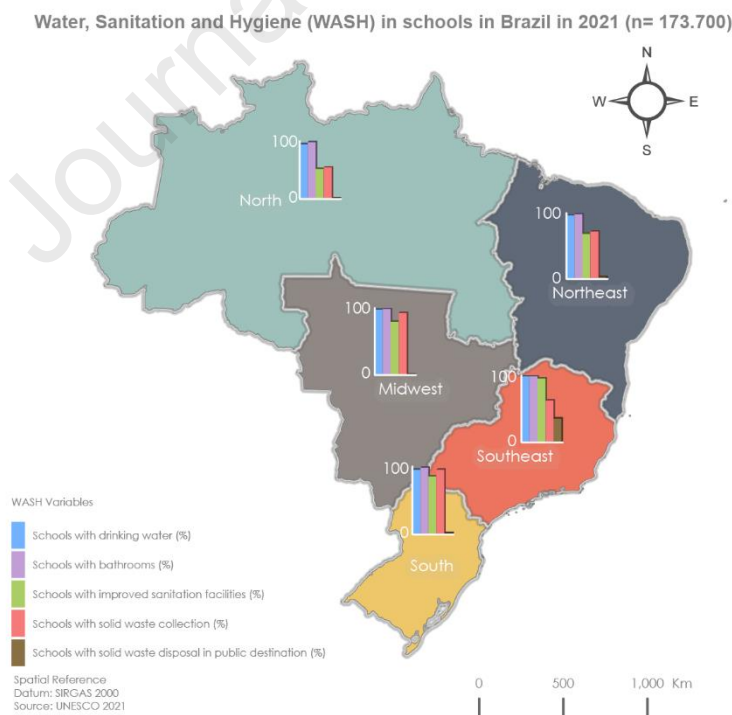
Considering the whole country, the majority of the schools have their water supplied by a public network system (75%), followed by boreholes (16%). Only 2% of the schools reported not having water. Sixty-three percent of the schools that reported not having access to any of the water supplies (public network, borehole, *cacimba/cistern/well* and surface water) also declared to provide drinking water for their students. It is noteworthy that the categories are not exclusionary. Approximately 6% of the schools in the country have access to water from more than one water supply (considering as options public network, borehole, *cacimba/cistern/well* and surface water).

Ninety-seven percent of the schools in the country reported having bathrooms. However, less than half of the educational institutions have bathrooms for people with disabilities (49%) and bathrooms with showers for students (44%). The percentage of schools with bathrooms exclusively for staff is 54%. Eight percent of the schools that reported having bathrooms for the youngest children (0 to 5 years old, daycare and preschool age) do not attend students from that age group.

Seventy-eight percent of the schools in the country have improved sanitation facilities. Eighteen percent of the schools have unimproved sanitation facilities and 4% of the educational institutions have no sewage collection or treatment.

The three most frequent solid waste management pathways in schools in Brazil are to have their solid waste regularly collected (70%), burned (19%) or disposed in a public destination (13%).

**Figure 3** summarizes the differences in the five main WASH variables (schools with drinking water, bathrooms, improved sanitation, solid waste collection, and solid waste disposal in a public destination), across Brazilian regions. Regarding these five chosen WASH variables, Student's t-test showed that a significantly ( $p < 0.001$ ) higher percentage of urban schools had all five indicators compared with rural schools, while a significantly ( $p < 0.001$ ) higher percentage of private schools had all five indicators compared with public institutions (**Table 3**).



**Figure 3:** Water sanitation and hygiene (WASH) in schools in Brazil in 2021 (n=173,700).

**Table 3:** Proportion of groups for t-Student tests.

	N	Schools with drinking water (%)	95% CI	Schools with bathrooms (%/CI)	95% CI	Schools with improved sanitation facilities (%)	95% CI	Schools with solid waste collection (%)	95% CI	Schools with solid waste disposal in public destination (%/CI)	95% CI
<b>Locality (Rural x Urban)</b>											
<b>Rural</b>	53,021	88	87.5 - 88.1	92	91.5 - 92.0	46	45.9 - 46.8	39	38.4 - 39.3	3	3.1 - 3.4
<b>Urban</b>	120,679	99	98.4 - 98.6	99	98.8 - 98.9	91	91.2 - 91.5	84	83.8 - 84.3	18	17.6 - 18.0
<b>Schools' Administration Model (Public x Private)</b>											
<b>Public</b>	135,785	94	94.0 - 94.3	96	96.1 - 96.3	72	72.2 - 72.7	67	66.6 - 67.1	12	11.8 - 12.1
<b>Private</b>	37,915	99	99.0 - 99.2	99	98.4 - 98.6	96	96.1 - 96.4	82	82.1 - 82.8	18	17.8 - 18.6

All p-values <0.001. CI: Confidence Interval.

### **WASH in Schools in Brazil by region**

Schools are mostly located in the Northeast (34%) and Southeast (33%) regions of the country (Table 2). The percentage of public schools is higher in the North and Northeast regions of the country. The majority of the institutions continue to be administered by the municipal governments. With regards to location, the educational institutions in the North are mainly located in rural areas (62%). Concerning the educational level, regardless of the region, most schools have a mix of different levels. The frequency of preschool and primary education first cycle institutions follows the same profile for the whole country. There are substantial differences according to the region for the other levels of education (daycare, primary education second cycle and secondary school).

Regarding water supply in schools, the North region differs from the other regions. Most institutions obtain their water from boreholes (37%) followed by a public network system (32%). The North region is also the one with the lowest percentage of schools with drinking water (82%) and with the highest frequency of schools with surface water (20%). Schools without water are mainly concentrated in the North and Northeast regions (representing 7% and 3% of the schools in the region, respectively). Lack of sanitary facilities was observed in schools in all regions. The institutions in the North and Northeast regions are the most deficient in terms of available restrooms (the lowest frequency of schools with all types of bathrooms). Except for the North region, most schools in the country have improved sanitation facilities, with the Northeast region having the lowest frequency (68%) and the Southeast the highest (96%). Thirty-six percent of schools in the North region reported having unimproved sanitation facilities, while 19% of schools reported not having sewage collection or treatment. The practice of burning solid waste is widespread in schools in the North and Northeast region, being the most frequent management pathway for solid waste in schools in the North region (51%). For all the other regions of the country, most of the institutions have their solid waste regularly collected.

The ANOVA followed by Tukey post-hoc test indicated differences in the percentage of schools with drinking water, improved sanitation facilities, and solid waste collection according to the region. The test also indicated no significant difference in the percentage of schools with solid waste disposal in public destinations in the North and Midwest regions (1% vs 1%), and between Northeast and South regions (3% vs 2%). Additionally, there was no difference in the percentage of schools with bathrooms between the South and Midwest regions (100% vs 99%). More information can be found in the Supplementary Material.

### **Comparison of WASH in Schools in Brazil pre- and peri-COVID-19 pandemic**

#### *Brazil*

**Table 4** compares the WASH conditions in schools in Brazil pre (2020) and peri (2021) COVID-19 pandemic. The entries in bold represent all variables that presented changes between the two years. Paired t-tests indicated that, for these variables, all differences were statistically significant ( $p < 0.001$ ) (more information can be found in the Supplementary Material). It is noteworthy that the percentage of schools in Brazil that have their solid waste regularly collected by a public cleaning service dropped from 81% in 2020 to 70% in 2021. In contrast, the percentage of schools with solid waste disposal in a public destination (such as landfills) in Brazil increased by 11 percentage points in 2021 compared to the previous year. Moreover, the percentage of schools in Brazil with bathrooms exclusively for staff increased from 49% to 54% between 2020 and 2021.

**Table 4:** Comparison of WASH conditions in schools in Brazil pre (2020) and peri (2021) COVID-19 pandemic (n = 170,422).

	<b>Brazil</b>		<b>North</b>		<b>Northeast</b>		<b>Southeast</b>		<b>South</b>		<b>Midwest</b>	
<b>N</b>	170,422		9,785		58,333		21,274		56,832		24,198	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
<b>Water</b>												
<b>Schools with drinking water (%)</b>	94	95	82	82	95	95	99	99	90	97	98	98
Schools with water from public network (%)	75	75	32	32	67	67	92	92	89	90	86	86



Schools with water from borehole (%)	16	16	38	38	18	18	7	7	11	11	19	19
Schools with water from cacimba/cistern/well (%)	9	9	12	12	18	18	3	3	2	2	3	3
Schools with surface water (%)	4	4	20	20	2	2	2	2	2	1	2	2
Schools with no water source (%)	2	2	6	7	3	3	0	0	0	0	0	0
<b>Schools with more than one water source (%)</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>8</b>	<b>9</b>	<b>9</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>10</b>	<b>10</b>
<b>Bathroom</b>												
<b>Schools with bathrooms (%)</b>	<b>96</b>	<b>97</b>	<b>84</b>	<b>85</b>	<b>97</b>	<b>97</b>	<b>99</b>	<b>99</b>	<b>99</b>	<b>100</b>	<b>99</b>	<b>99</b>
<b>Schools with bathrooms for youngest children (%)*</b>	<b>59</b>	<b>60</b>	<b>29</b>	<b>29</b>	<b>41</b>	<b>42</b>	<b>73</b>	<b>74</b>	<b>88</b>	<b>90</b>	<b>78</b>	<b>79</b>
<b>Schools with disability-friendly bathrooms (%)</b>	<b>47</b>	<b>48</b>	<b>30</b>	<b>31</b>	<b>39</b>	<b>41</b>	<b>51</b>	<b>53</b>	<b>59</b>	<b>61</b>	<b>71</b>	<b>73</b>
<b>Schools with bathrooms exclusively for staff (%)</b>	<b>49</b>	<b>54</b>	<b>29</b>	<b>33</b>	<b>33</b>	<b>37</b>	<b>66</b>	<b>70</b>	<b>63</b>	<b>68</b>	<b>58</b>	<b>65</b>
Schools with bathrooms with shower for students (%)	44	44	31	30	41	40	47	47	52	51	62	62
<b>Sanitation</b>												
Schools connected to a public sewerage system (%)	56	56	13	12	37	37	88	88	63	63	53	53
Schools with septic tank (%)	23	23	33	33	31	31	8	8	26	27	28	28
<b>Schools with improved sanitation facilities (%)</b>	<b>78</b>	<b>77</b>	<b>45</b>	<b>45</b>	<b>68</b>	<b>67</b>	<b>96</b>	<b>96</b>	<b>86</b>	<b>86</b>	<b>80</b>	<b>80</b>
<b>Schools with unimproved sanitation facilities (%)</b>	<b>18</b>	<b>19</b>	<b>35</b>	<b>36</b>	<b>27</b>	<b>28</b>	<b>4</b>	<b>4</b>	<b>14</b>	<b>14</b>	<b>19</b>	<b>20</b>
<b>Schools without sewage collection/treatment (%)</b>	<b>5</b>	<b>4</b>	<b>21</b>	<b>19</b>	<b>6</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Solid Waste</b>												
<b>Schools with solid waste collection (%)</b>	<b>81</b>	<b>70</b>	<b>46</b>	<b>47</b>	<b>70</b>	<b>71</b>	<b>96</b>	<b>63</b>	<b>97</b>	<b>97</b>	<b>92</b>	<b>92</b>
<b>Schools with solid waste disposal in public destination (%)</b>	<b>2</b>	<b>13</b>	<b>8</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>0</b>	<b>36</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>1</b>
Schools with burned waste (%)	19	19	52	51	30	29	4	4	4	3	7	7
Schools with buried waste (%)	2	2	1	9	2	2	1	0	2	3	1	3
Schools with waste disposal in another area (%)	3	3	15	16	2	2	1	1	0	0	1	1

The sum might exceed 100% because the categories are not exclusionary. \*Only schools with daycare (students aged 0 to 3 years old) or preschools (students aged 3 to 5 years old) were considered when analyzing bathrooms for the youngest children (sanitary facilities for children 0 to 5 years old) (n = 110,251). In bold are all variables that presented changes between 2020 and 2021, considering the whole country, in which paired T-tests were conducted and all differences were statistically significant (p <0.001)

### *Brazilian regions*

The water component was the one with fewer changes from 2020 to 2021, mainly in schools in the South region. The percentage of schools with drinking water in the South region increased from 90 to 97%. Furthermore, there was an increase of 1 percentage point in the frequency of schools with water from public networks and a decrease of 1% in the frequency of schools with surface water in the South region. Results, therefore, indicate improvements from 2020 to 2021 regarding the water conditions in schools in that region. However, there was also an increase of 1% in the percentage of schools with no water source in the North region.

There was an increase of 1% in the percentage of schools with bathroom in the North (from 84 to 85%) and in Southeast region (from 99 to 100%). The frequency of schools with bathroom for youngest children increased in the Northeast (from 41 to 42%), Southeast (from 73 to 74%), South (from 88 to 90%), and Midwest regions (from 78 to 79%). The frequency of schools with disability-friendly bathrooms and bathrooms exclusively for staff increased in schools in all country regions. Regarding the presence of disability-friendly bathrooms in schools, there was an increase of 1% in the North (from 30 to 31%), 2% in the Northeast (from 39 to 41%), in the Southeast (from 51% to 53%), in the South (from 59 to 61%) and in the Midwest region (from 71 to 73%). The percentage of schools with bathrooms exclusively for staff was the variable with the biggest variation from 2020 to 2021. There was an increase of 4% in the North (from 29 to 33%), 4% in the Northeast (from 33 to 37%) and in the Southeast (from 66 to 70%), 5% in the South (from 63 to 68%) and 7% in the Midwest region (from 58 to 65%). The percentage of schools with bathrooms with showers for students, however, decreased by 1% in the North (from 31 to 30%), Northeast (from 41 to 40%) and Southeast regions (from 52 to 51%).

There was an increase of 1% in the frequency of schools with septic tank in the South region (from 26% in 2020 to 27% in 2021) but also in the frequency of schools with unimproved sanitation facilities in the North (35% vs 36%), Northeast (27% vs 28%) and Midwest regions (19% vs 20%). The percentage of schools with improved sanitation facilities in the Northeast region decreased from 68% to 67% in the

analyzed period. The frequency of schools with no sewage collection or treatment, however, dropped in the North (21% vs 19%), Northeast (6% vs 5%) and Midwest regions (2% vs 1%).

Results concerning the solid waste management and disposal in schools were very mixed, and the North region was the one with the most changes (with variations in all variables). The percentage of schools with solid waste collected increased in the North region (46% vs 47%) and decreased in the Northeast (70% vs 71%) and Southeast regions (96% vs 33%). Similarly, the frequency of schools with solid waste disposal in a public destination decreased in the North (8% vs 1%), South (3% vs 2%) and Midwest regions (3% vs 1%), while it increased in the Northeast (2% vs 3%) and Southeast regions (0% vs 36%). The percentage of schools that burned their waste dropped in 1 percentage point in the North (52% vs 51%), Northeast (30% vs 29%) and South regions (4% vs 3%). The frequency of schools that buried their solid waste, however, increased in the North (1% vs 9%), South (2% vs 3%) and Midwest regions (1% vs 3%). Moreover, there was also an increase of 1% in the percentage of schools with waste disposal in another area in the North region (15% vs 16%).

## Discussion

Evaluating 173,700 schools, this study is one of the largest studies to evaluate WASH in schools in Brazil through the COVID-19 pandemic. The present study had two main objectives. First, to describe the current situation of WASH in schools in Brazil, and second, to compare the availability of WASH in schools in Brazil before and during the ongoing COVID-19. To our knowledge, this is the first analysis using the robust 2021 BSNC dataset on WASH in schools.

### The current state of WASH in Schools in Brazil

The results revealed that the majority of schools in Brazil have bathrooms (97%), drinking water with quality suitable for human consumption (95%), improved sanitation facilities (78%) and solid waste collection (70%). Results also indicated significant rural-urban and public-private disparities in access to WASH in schools, with government-owned schools and schools located in rural areas presenting greater WASH deficiencies. As has been highlighted before in the literature, in LMICs, rural schools are more likely to lack WASH conditions and facilities than urban schools (Adams et al., 2014; Jordanova et al., 2015; WHO and UNICEF, 2020). This result is of particular concern considering that in Brazil, the highest out-of-school rates (children and adolescents aged 4 to 17 years old) are documented in rural locations (UNICEF, 2021). As part of the institutions' infrastructure, poor WASH conditions contribute to a less appealing learning environment. Improved school WASH conditions have been reported to reduce student absence (Jasper et al., 2012; McMichael, 2019) and school evasion (with higher impact on girls) (Agol and Harvey, 2018; Bergenfeld et al., 2021) by providing services and reducing disease transmission.

With regards to regional differences, the North is the region with schools with the highest lack of appropriate WASH conditions across all domains (lowest frequency of schools with bathrooms, drinking water, improved sanitation facilities, solid waste collection and the highest percentage of schools with surface water and burning waste). The Northeast region follows as the second region with schools presenting the worst panorama. Results also evidenced significant inequalities in the access to WASH in schools according to the region where they are located. The North region is the one with the highest percentage of the out-of-school population aged 4 to 17 years old, while the Northeast region has in absolute number the majority of the out-of-school population in the country (UNICEF, 2021). In summary, the locations where the school-aged population are more in risk of school absenteeism and dropout (rural areas, North and Northeast regions) are also the ones with the less appropriate school environment in terms of WASH.

Due to the incompatibility of the terms and definitions used in the census and the JMP (WHO and UNICEF, 2020), schools in Brazil could not be classified as having basic, limited, no water service and with improved or unimproved water sources. This, however, is not an issue restricted to Brazil. As with

WASH in schools monitoring, indicators vary between sources and countries, which hampers the comparison of WASH in schools across locations (Chatterley et al., 2018). According to the systematic review on WASH in schools in LMICs conducted by Poague et al. (2022) considering 18,465 schools described in 65 studies across 30 different countries, the water source in 6% of schools (n=1118) was classified as “unknown” because the terms and indicators used in the studies did not fit the JMP classification. In Brazil, for instance, the standard when working with WASH is to use the definitions and indicators of the *Plano Nacional de Saneamento Básico* (Brazil, 2014). Based on the PLANSAB guidelines, water, sanitation and waste services can be classified into three categories: i) adequate; ii) poor; iii) or with no service. One of the main premises for the classification of water and sanitation services into the “adequate” category is the quality of the water (potable, safe and with quality suitable for human consumption) and the treatment of the wastewater. Although the JMP concept of “improved” water source involves the potential to deliver safe water, the classification itself does not guarantee that the quality of the drinking water provided by the schools is suitable and safe for human consumption. The same discussion also applies to the sanitation domain. The JMP concept of “improved” sanitation facilities, which considers the existence of an infrastructure designed to hygienically separate excreta from human contact, however, does not guarantee that the sewage, after being collected and separated, is proceeded by treatment. Moreover, packaged and delivered water are also considered improved water sources, whereas according to the PLANSAB, delivered water by water trunks can be classified as poor service. More information about the classification and definitions of the PLANSAB in English can be found in the Supplementary Material.

With regards to sanitation, however, our study indicates a worst scenario compared to the 2020 WHO/UNICEF report on the progress on WASH in schools (WHO and UNICEF, 2020). While the JMP estimates that 5% of schools in Brazil have no sanitation service, which represents 2 million students without this resource in the school environment, our findings indicated that 22% of the Brazilian schools could be classified as with no sanitation service, ultimately impacting over 9 million of students. Nonetheless, the percentage of schools with improved sanitation facilities found in this study is higher than what was reported by Poague et al. (2022) in LMICS (31%) and in Central America (64%, though this estimate was based on data from 412 schools included in only three studies).

Nevertheless, the frequency of schools with toilets accessible for students with disabilities in our study was approximately 10 percentage points higher (49%) than what was reported in the WHO/UNICEF report (38%) (WHO and UNICEF, 2020). Additionally, the percentage of schools with piped water and toilets (in our study the equivalent to schools with water from public networks and schools with bathrooms) was similar. It draws our attention that 87% of the schools assessed by the WHO/UNICEF (WHO and UNICEF, 2020) were located in urban areas, in contrast to 69% in this study. It is not clear what were the inclusion criteria, the total number of schools evaluated in the report and what were the main data sources from Brazil.

### **WASH in Schools in Brazil pre- and peri-COVID-19**

Results indicated improvements in the percentage of schools with drinking water, solid waste disposal in public destinations, bathrooms, bathrooms for the youngest people, disability-friendly bathrooms, and bathrooms exclusively for staff. However, findings also revealed a decrease in the percentage of schools with solid waste collection and improved sanitation facilities (consequently, an increase in the frequency of schools with unimproved or without sanitation facilities). At first sight, changes of one percentage point observed in most of the variables might seem too small to matter, and its statistical significance might be attributed to the large size of the datasets. However, when taking into account the total number of schools (170,422), we can observe that those are relevant variances. For instance, approximately 1,704 schools that did not have bathrooms in 2020 incorporated the sanitary infrastructure in the next year.

Simultaneously mix of improvements and deterioration in the variables were observed in schools in all regions of the country. Improvements in water indicators were observed in schools in the South region,

while deterioration was noticed in schools in the North region. As for bathrooms, improvements were observed in all regions and in all variables, with the exception of the frequency of schools with bathrooms with showers that reduced in the North, Northeast and South regions. Regarding sanitation, findings indicate a mix of improvements and deterioration of the school's infrastructure in the North, Northeast and Midwest regions. Changes in the solid waste variables followed the same trend as sanitation, with variations in all regions and with changes of most concern in the North region.

### **Schools reopening during the COVID-19 pandemic**

Overall, solely considering the WASH infrastructure, schools in the South and Southeast regions of the country are better prepared for the safe reopening. At the present moment, schools in the North and Northeast regions are the ones more in need of changes in the WASH infrastructure. Approximately 4,768 schools (684 in the North and 4,083 in the Northeast region) do not have a water source and, therefore, cannot provide the adequate infrastructure for handwashing and cleaning of facilities.

Additionally, there is a need for improvements in the sanitation domain in schools in all regions. Despite the fact that most schools have bathrooms, the wastewater puts the students and staff at risk of faecal-oral diseases if not properly managed and disposed. Our study shows that 97% of schools reported having bathrooms, but only 77% have sanitation facilities designed to hygienically separate excreta from human contact. Moreover, the presence of the virus and its genetic material in faeces of COVID-19 patients (Chen et al., 2020; Wu et al., 2020) and in the sewage (Chavarria-Miró et al., 2020; Fongaro et al., 2020; Medema et al., 2020) suggests that COVID-19 might also be transmitted through faecal-oral routes (such as by the ingestion of contaminated water or by touching mouths, noses or eyes with hands that had been in direct contact with faeces). On that note, providing adequate and improved sanitation facilities should be a major concern in the school environment, considering that gastrointestinal symptoms of COVID-19 infection (such as diarrhoea and vomiting) are more frequent in children than in adults (Mendoza-Torres et al., 2021). Due to the fact that children have smaller body fluid reserves than adults, they are more at risk of rapidly dehydrating and developing shock when infected by gastrointestinal diseases (Aronson and Shope, 2020).

Among infants, children under three years old are more likely to be infected with SARS-CoV-2 (Mendoza-Torres et al., 2021). Children are still learning the basic principles of hygiene at that age and their developmentally appropriate behaviours include self-soothing by putting their hands and other objects in their mouths (Aronson and Shope, 2020). In addition, in their first three years of life, some children are still learning how to walk, spending much of their time closer to the ground and constantly using (and touching) surfaces to support their balance and movements (Aronson and Shope, 2020). That said, special attention should be given to providing adequate WASH infrastructure in daycares and preschools. However, according to the results, 40% of schools that attend children aged 0 to 5 years old in Brazil are not equipped with sanitary facilities for children of that age. From 2020 to 2021, there was no change in the frequency of schools with bathrooms for the youngest children in the North region, where the lowest proportion of restroom availability for this age group was reported.

The low frequency of schools in the country equipped with disability-friendly sanitary facilities (60%) also deserves attention. In schools without those facilities, students have to crawl and touch the floor to access the bathrooms (Erhard et al., 2013; Zaunda et al., 2018). When facing these obstacles, students with disabilities also avoid using the facilities during their time in the schools or practising open defecation (Erhard et al., 2013; Zaunda et al., 2018). Therefore, the lack of adequate WASH infrastructure in the school environment results in students adopting non-hygiene practices, which puts them at risk of COVID-19 and other hygiene-related diseases. Despite the improvement in the percentage of schools with disability-friendly bathrooms from 2020 to 2021, less than 50% of schools in the North and Northeast regions have these facilities.



### **Limitations and strengths of the Brazilian National School Census**

Some limitations of the BNSC have to be highlighted. As a self-reported survey, the information provided by the schools might not be truly accurate and representative of the reality. Despite completion required by law, which means that all schools in Brazil must reply every year to the survey, the differences between the schools that participated across the years (2020 and 2021) indicated that the census has not been able to capture all the educational institutions in the country. Additionally, a series of inconsistencies in the dataset were observed during analysis. Schools that do not have a water supply should not be able to provide drinking water, and only schools with students aged 0 to 5 years old (with daycare and preschool) should have bathrooms for the youngest children. However, more than half of the schools that do not have a water supply reported having drinking water and 8% of the schools that reported having bathrooms for youngest children do not have students of that age. These results might indicate that the census is being answered without full comprehension of its concepts and the definition of the variables. This possibility is similarly observed in the change in solid waste management in schools in the Southeast region. In 2020, 96% of the schools in that region had their solid waste regularly collected, and 0% of the schools had their solid waste disposed in public destinations. The next year, however, the percentage of schools with solid waste collection in that region dropped to 63%, and the frequency of schools with waste disposal in public destination rose to 36%. Most likely, that happened because the differences between both categories were not clear to respondents. These inconsistencies may also be the consequence of the fact that categories are not exclusionary. For instance, schools can report having all the possible solid waste management choices. We should also consider the possibility that schools without a water supply are able to provide drinking water by purchasing delivered or packaged water, such as water supplied by water trunks or bottled water (Ribeiro et al., 2018). It is also possible that respondents tend to choose the “desirable” answer of the survey (e.g. that the school had drinking water when they did not) because of social desirability bias (Hawthorne effect).

Furthermore, even though the BNSC provides an extensive dataset on WASH in schools in Brazil, it lacks essential information for the assessment of the safety of the school's infrastructure for its community against COVID-19 and other diseases. The census does not provide any information on the presence of handwashing stations, soap, student to toilet ratio and drinking fountains in schools. The Brazilian Ministry of Education recommends a student to toilet ratio of 20:1 and the placement of drinking fountains in daycares and preschools (Brazil, 2006). The manual for School Building Performance, also elaborated by the Brazilian Ministry of Education suggests a student to toilet ratio of 40:1 and one handwashing station for every 30 students (Brazil, 2005). Additionally, the manual also specifies the placement of one soap dish for every two toilets and that at least 5% of a school's toilets must be suitable for persons with physical disabilities (Brazil, 2005). However, no information about these infrastructures is collected through the BNSC. Hence, it is not possible to assess if the schools are following the national guidelines. Regardless of the type of water supply (public network, boreholes, wells, etc.), schools in Brazil lack cups for students at drinking fountains (Borges-pedro et al., 2018; Pereira and Sorlini, 2019). When cups are not made available in sufficient quantities in schools, they are shared between students (Borges-Pedro et al., 2018; Pereira and Sorlini, 2019), which is a practice of high risk and concern for the transmission of COVID-19. Schools in Brazil are also known for not having toilets in enough quantities (Coswosk et al., 2019). The lack of cups and toilets in sufficient quantity in schools might lead to students queuing to use the facilities and, thus, disrespecting the social distancing measures. No data is also supplied on the functionality of the infrastructure and on the normative contents of the HRTWS – availability, accessibility, quality and safety, acceptability, privacy and dignity (United Nations, 2015a).

Despite these limitations the BSNC is the main available and public up-to-date source of data on WASH in schools in Brazil. Through a collaborative network coordinated by INEP and composed of municipal, state and federal educational entities of the Brazilian government, the BSNC provides a vast dataset on Brazilian schools, which is essential for the formulation of public policies in education. The consistency seen in the frequency of the majority of the WASH variables, which is evidenced by the small changes

in the variables across the years (especially variables that are of easy comprehension and interpretation by the survey's respondents such as the presence of bathroom and the type of water supply), attest for the reliability of BNSC as research tool. Even though the first nationwide BNSC dates from 2014, the WASH information available in datasets has been rarely used and the BNSC hardly cited in scientific publications. The data provided by the BNSC can and should be used for research and public policy purposes, but with parsimony, keeping in mind its areas of improvement and integrating it with other methods and sources.

The BNSC defined bathrooms as "sanitary facilities for personal hygiene/physiological" needs. Thus, it was not clear if handwashing stations were included as part of the sanitary facilities a bathroom should have. If so, the presence of bathrooms in schools could have been used as a proxy for the assessment of handwashing infrastructure in schools in Brazil. However, we chose not to do so based on our understanding that the existence of bathrooms in school does not imply the existence of handwashing and that, most likely, the respondents of the survey also had that understanding. Moreover, even though the authors recognize that schools that are currently inactivated might be activated once again in the future, these educational institutions were not part of the scope of this research. Due to the urgency in providing safe educational environments in the ongoing COVID-19 pandemic, we prioritized assessing the state of the schools that are currently providing services in Brazil (remotely, in hybrid mode or with face-to-face activities).

### **Conclusion and future research**

Results of this study on WASH in schools in Brazil, considering 173,700 schools, indicate that most of the schools in Brazil have bathrooms, drinking water with quality suitable for human consumption, improved sanitation facilities and solid waste collection. Nonetheless, results point out the urgent need for improvements in public schools, schools located in rural areas, and in the North and Northeast regions of the country. Within WASH domains, schools are more in need of changes in the sanitation infrastructure and solid waste management. As for the comparison of WASH in schools pre-and peri-COVID-19 pandemic, 170,422 schools were analyzed. Mixed changes in the variables, with both improvements and deterioration, were observed in schools in all regions of the country. Schools in the South and Southeast regions presented the best WASH infrastructure for the safe reopening, whereas schools in the North and Northeast regions of the country were the least prepared.

Furthermore, it is also important to highlight that WASH infrastructure interventions are time-consuming. Hence, the study might not have been able to capture more changes in the school's infrastructure due to the short time of comparison (2020 and 2021). On that note, we suggest developing a new similar study once the data from the BNSC from 2022 and 2023 are available. Based on the results of this study we also recommend that further research should be conducted to: i) cross-check the reliability of the data from the BNSC, and if the data provided by this dataset really corresponds to the reality of schools; ii) complete the assessment of WASH in schools in Brazil with information regarding the fulfilment of the premises of the HRTWS and the presence of handwashing stations, water and soap available for handwashing, number of handwashing facilities, water drinking fountains, toilets and disability-friendly bathrooms; iii) investigate the origins of the inconsistencies reported in the data provided by the BNSC and the existence of an association between WASH in schools and school absence/dropout rates in Brazil; iv) assess the compatibility of WASH indicators adopted in Brazil (e.g., PLANASAB) and in other Latin American countries and the JMP service ladder and indicators;

### **Author Contribution**

KIHMP: conception of the research, data collection, data cleaning, analysis and writing; CA, JIB and JAM: overall design and revision.

### **Conflicts of Interest**

The authors declare no conflict of interest.

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## Highlights

- The paucity of data and research on WASH in schools in Brazil prevents an assessment of how safe and healthy schools are to reopen;
- Description of the current state of WASH in schools in Brazil and in the Brazilian regions;
- Results indicate that 9 million students in Brazil lack sanitation services in their schools;
- Comparison of WASH in schools pre- and peri-COVID-19 pandemic reveal little improvement;
- Public schools, in rural areas, and in the North and Northeast regions are most in need of WASH improvements.

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