


## Impact of the COVID-19 pandemic on water consumption behaviour

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### ABSTRACT

Access to drinking water is essential for life, and an adequate and constant distribution of water is necessary during the occurrence of contagious diseases and pandemic situations. Currently, COVID-19, caused by the SARS-COV-2 coronavirus, has spread throughout the world, and in Brazil, more than 5,300,000 cases and 157,000 deaths had been reported by 26th October 2020. Water is regarded as one of the most important resources in a pandemic, in order to provide the necessary sanitary conditions. Thus, the present study aims to analyse changes in hygiene behaviour in relation to the recommendations of the World Health Organisation and the impact on water consumption before and during the pandemic. The survey was conducted using a questionnaire, which was delivered online to 149 participants between June and July 2020. The results pointed to changes in hygiene behaviour, with a consequent effect on water consumption.

**Key words:** COVID-19, hygiene behaviour, water consumption behaviour

### HIGHLIGHTS

- The hygiene habits that had been influenced by the pandemic were washing hands with soap and water, cleaning floors and food hygiene.
- The changes in these habits were more significant in dwellings with elderly people, considered to be more vulnerable to the SARS-COV-2 virus.
- There was a significant change in the habit of washing hands when arriving home.

### INTRODUCTION

In late December 2019, the largest pandemic of the 21st century started in a hospital in the city of Wuhan in China (Xu *et al.* 2020). It was initially treated as an unusual pneumonia, but reached the status of a global health emergency within little over a month, and on 11th March 2020, a COVID 19 pandemic (Saadat *et al.* 2020) was declared. Currently, according to John Hopkins University (2020), the total number of infections involves 189 countries and more 43,000,000 people, with more than 1,150,000 deaths. The same database shows that in Brazil, the number of cases of COVID-19 has exceeded 5,300,000, with the deaths of more than 157,134 people<sup>1</sup>.

In general, countries, states and municipalities have endeavoured to implement the measures recommended by the World Health Organisation (WHO), such as constant hand washing, the use of masks, routine cleaning of environments and surfaces, and the restriction or closure of schools, universities, restaurants, public transport and other places where there may be clusters of infection (WHO 2020).

These actions have significantly changed lifestyles, and have imposed several changes in behaviour on society. Among these are water consumption patterns, since the maintenance of hygiene and disinfection of surfaces have been recommended as some of the most important actions for reducing transmission of the virus (WHO 2020).

<sup>1</sup> Data from October 26th, 2020.

However, these actions have caused a series of socioeconomic impacts. Nicola *et al.* (2020) presented a survey of publications on these impacts at various economic and social levels throughout the course of the pandemic. As an example of these impacts in the primary sector, the authors highlighted a 20% reduction in the prices of agricultural commodities caused by a reduction in food consumption, mainly in the hotel and restaurant industry. In addition, shortages in some supermarkets arose due to the panic buying that took place at the beginning of the pandemic. In the oil industry, the pandemic has caused uncertainty in a market that has been characterised by instability in recent months, and, according to these authors, has reduced the price of a barrel of oil.

Nicola *et al.* (2020) also warned of the impact that closing schools has had on society. According to these authors, more than 1.5 billion students, enrolled at various levels, were left without classes in more than 188 countries. This prolonged situation has incurred high costs, according to Lempel *et al.* (2009), who found that in the United States alone, a six-week stoppage could have direct and indirect costs of between 30 and 140 billion dollars.

In addition to these aspects, Campbell (2020) warns of an increase in reports of domestic violence (of between 30 and 50%) in several countries of the world, such as China, France, Italy and Brazil, due to long confinements inside homes.

From an environmental point of view, some of these impacts are already being measured. Saadat *et al.* (2020) state that although air and water pollution have been reduced during the confinement period, there has been a considerable increase in the generation of solid waste, especially hospital waste. As an example, the authors mention that in Wuhan alone, the production of hospital waste in a single day was four times greater than the city's incineration capacity.

Water is one of the most important resources needed in order to face the pandemic and to maintain good sanitary conditions. Hand washing, for example, has been shown to reduce virus transmission by 45%–55%, based on a summarised meta-analytical estimate (Brauer *et al.* 2020).

The importance of water can be seen in the research carried out by Kalbusch *et al.* (2020). These authors investigated, in the Southern Region of Brazil, water consumption in buildings before and after the government's imposition of quarantine and social isolation. The results showed a reduction in water consumption in commercial, industrial and public buildings and an increase in residential ones. However, no studies have yet investigated how the behaviour of users have changed in terms of water use in buildings, due to the pandemic. Thus, this article aims to analyse changes in behaviour and habits in relation to water consumption, before and during the pandemic period.

## MATERIAL AND METHODS

The research was conducted using a questionnaire applied via an online form (Google Forms), containing questions divided into three blocks: (i) information about users and their families (10 open questions and one categorical); (ii) personal hygiene and household habits before the COVID-19 pandemic (17 questions); and (iii) personal hygiene and household behaviour adopted during the pandemic (16 questions). In addition, data were collected on the actions suggested by the regulations and practiced by the participant at home during the pandemic (eight questions with categorical answers).

The questionnaire was submitted in compliance with the CAAE 2785820.6.0000.5083 process, and was approved by the Ethics and Research Committee of the Federal University of Goiás (UFG). The survey was conducted between 24th June and 12th July 2020.

The first case of COVID-19 confirmed by the Brazilian authorities was on 26th February 2020, in São Paulo. As of 24th March 2020, there were records of infected people in all 26 states and the Federal District. It is important to note that the questionnaire was applied approximately four months after the first case in Brazil and three months after the appearance of cases throughout the country.

### Preparation of the collection instrument

The questionnaire posed questions about personal hygiene behaviour related to hand washing, showering, food hygiene, washing clothes and dishes, and domestic cleaning. In addition, information was collected on the respondent's sex, age, place of residence, the ages of the other residents of the house, and proximity to people diagnosed with COVID-19 at the time of application of the questionnaire. All respondents were required to be over 18 years old.

### Selection of the sample population

Due to the context of the pandemic and the consequent social distancing measures, an online form was used. The form was distributed via the e-mail contacts and social networks of the researchers. Hence, convenience sampling was used, rather than

an intentional or probabilistic approach, since the questionnaire was sent to the people closest to the researchers without making distinctions between groups or specific locations, and therefore without reaching the total population.

### Data processing and analysis of results

In order to investigate whether there were changes in the hygiene behaviour of the interviewees during the COVID-19 pandemic, the answers obtained were initially tabulated to remove the noise (such as answers that were missing, incomplete or inconsistent with the question), and this was followed by a statistical description by means of graphs, using spreadsheet software (EXCEL 365).

A statistical analysis of hand washing and shower use behaviour was carried out to explore the changes in behaviour during the pandemic, and to compare these with users' perceptions. We also analysed changes in behaviour in homes with elderly residents (aged 60 years or more), using dependent (paired) samples, and for the categorical responses, McNemar's chi-square test was applied, also using Excel. For the continuous numerical responses, a paired-samples Wilcoxon test was applied, using the `dplyr` and `rstatix` and `stats` libraries in R (version 4.0.2 for Windows).

## RESULTS AND DISCUSSION

### Information about the users

The first part of the questionnaire collected information that could affect changes in behaviour during the pandemic; for example, the presence of elderly people in the residence, since they are more vulnerable to both infections and the effects of COVID-19.

Questions were also asked about the location of the dwelling, the sex of the respondent, the ages and personal information of people with close relationship to infected ones and people living in the residence. In total, 149 people participated in the survey. At the descriptive analysis stage, two responses were discarded because they were incomplete or inconsistent with the question. For statistical analyses, missing responses for either of the periods (before or during the pandemic) were also discarded, leaving 145 categorical responses for analysis, and 136 continuous numerical responses.

Respondents were located in nine different states across the country, and were more frequent in the state of Goiás (75.7%), since this was the state in which the research was conducted, and hence where the largest proportion of the referrals were made. The distribution of responses by state is shown in Table 1.

The interviewees were mostly women (55.2%), with an average age of 33.9 years. The age distribution of the respondents is shown in Figure A in the Supplementary Material.

In terms of the age of the people living in the same residence as the interviewees, four different groups of people were identified: children (up to 14 years old); adolescents (between 14 and 20 years old); adults (between 20 and 60 years old); and elderly adults (over 60 years old). The distribution of people in each of these age groups is illustrated in the boxplot in Figure B in the Supplementary Material.

In total, 23.4% of the residences contained elderly people, 96.6% contained adults between 20 and 60 years old, 18.6% had teenagers and 30.3% had children. Of the households interviewed, 41.4% contained only adults between 20 and 60 years old.

**Table 1** | Distribution of responses by state

State	Relative frequency
Distrito Federal	2.8%
Goiás	75.7%
Pernambuco	2.1%
Minas Gerais	2.8%
Rio de Janeiro	0.7%
Rio Grande do Norte	2.1%
Roraima	2.1%
São Paulo	11.1%
Tocantins	0.7%

Despite the fact that the questionnaire did not directly raise the issue of whether there were people in these homes with comorbidities that would place them within the COVID-19 risk group, the WHO points out that this disease can develop with more severe complications in people over 60. For this reason, the distinction between the proportions of the age groups of the households is important, in order to be able to compare how the information gathered since the first global cases were published reflects on the behaviour investigated in this research.

The distribution of the sizes of families is shown in the boxplot in Figure C in the Supplementary Material, where it can be seen that there was an average of three people per house, with a median of 3.2 and a standard deviation of 1.7. One of the residences had 15 residents, but it was not possible to identify whether this was a collective dwelling.

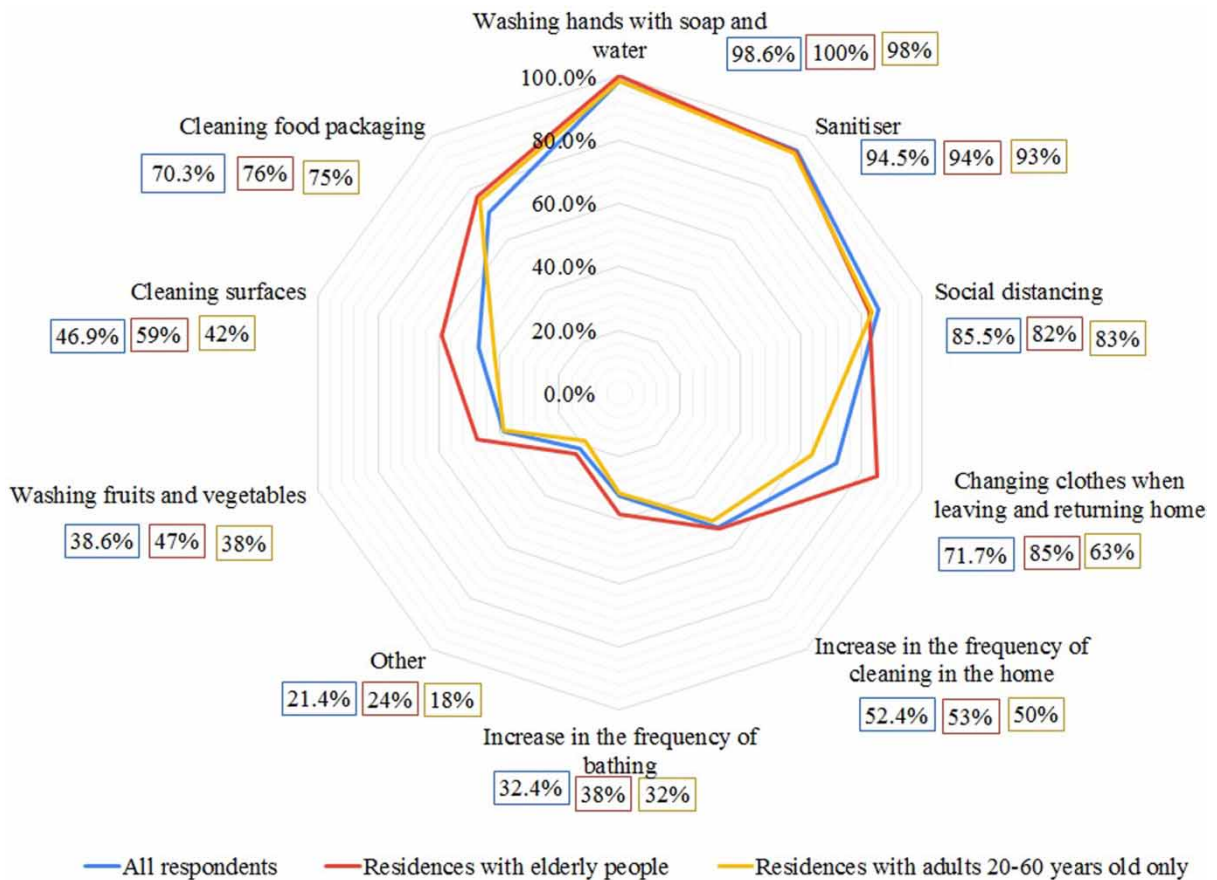
At the time of administering the questionnaire, 41.4% of the respondents reported that they knew of cases of close relatives infected with COVID-19, while 51.7% were unaware of any such infections and 6.9% were unsure.

**Hygiene and personal care habits**

In order to verify the interviewees’ perceptions of the actions recommended by the WHO with the aim of reducing contagion, the responses were analysed in percentage terms. Figure 1 shows the responses of the participants when asked about which behaviour they perceived as having been modified during the pandemic.

It can be observed that the main actions perceived to have been taken were hand washing (98.6%), use of alcohol gel (94.5%), social isolation (85.5%) and changing clothes (71.7%). When analyzing the food sanitizing, 70.3% of the respondents answered that they were sanitizing the food packaging and 38.1% fruits and vegetables. Domestic cleaning (46.9%) and showering more often (32.4%) are also actions that had increased during the pandemic.

In addition, we aimed to observe whether these habits were different between houses in which there were elderly people and houses where there were only adults aged between 20 and 60. This analysis was carried out to determine whether these



**Figure 1** | Actions adopted to prevent the spread of COVID-19 by all respondents, those in residences with elderly people, and those in residences with only adults aged between 20 and 60.

hygiene habits, which are recommended as preventive actions against COVID-19, were more prevalent in homes containing people who were more susceptible to the harmful effects of the virus. It was observed that most of these habits were practiced with greater care in homes with elderly people. The actions for which the difference between these groups was greatest were changing clothing (13.6%) and domestic cleaning (11.93%). It should be noted that in relation to domestic cleaning, 59% of the households with elderly people reported that they were cleaning more often, compared to only 42% in the homes where only adults aged 20–60 lived. In most households containing only adults aged 20–60, the other changes were also generally less marked, with the exception of isolation and cleaning of processed foods.

By analysing the data related to increases in the frequency of showering during the pandemic, it was observed using the McNemar test that participants who claimed not to bathe daily before during the pandemic, and the participants who claimed to bathe once per day, did not change their behaviour. Participants who bathed twice daily before the pandemic increased their frequency to three during the pandemic period.

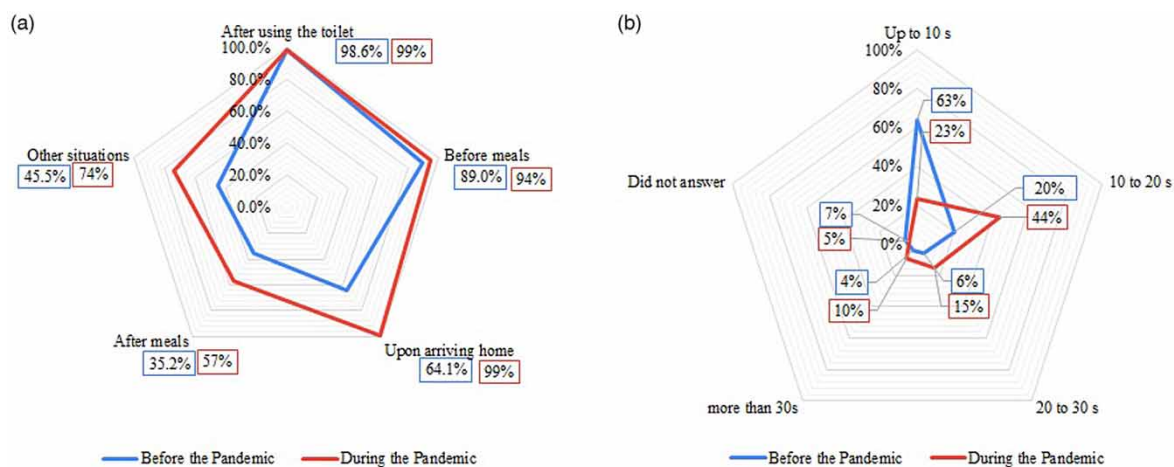
The habits that showed the least significant changes among the groups were hand washing, the use of alcohol gel and social distancing. Of the households interviewed, dwellings with elderly people and those with only adults aged 20–60 showed several differences: for hand washing, the differences were  $-1.4\%$  and  $0.3\%$ , respectively; for the use of alcohol gel,  $0.4\%$  and  $1.1\%$ ; and for social isolation,  $3.2\%$  and  $2.2\%$ . These are the actions most widely recommended by health agencies and the media, so it was expected that they would be the most frequently applied by all groups.

Respondents were asked about hand washing behaviour, in terms of the time taken to wash their hands and whether they washed them before or after certain activities, as illustrated in Figure 2.

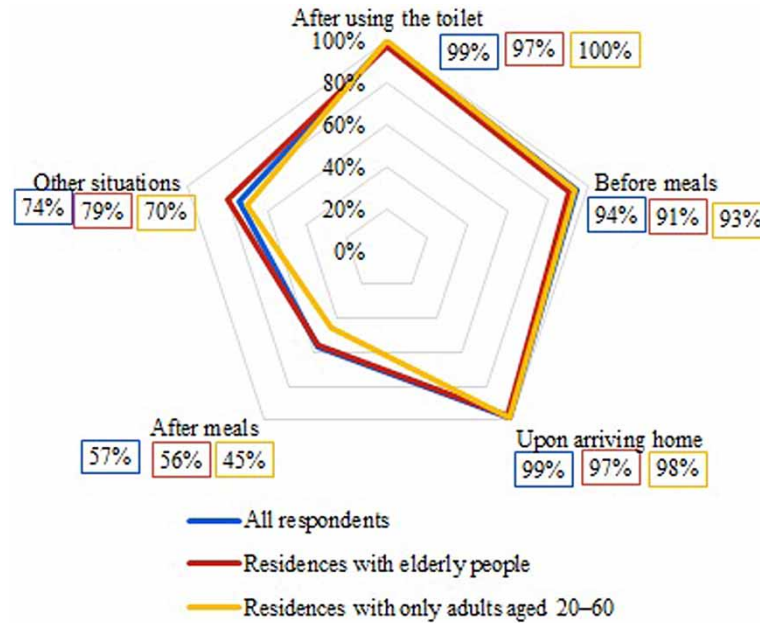
Figure 2(a) shows that most users reported washing their hands after using the bathroom, and there was practically no change after the pandemic (from 98.6% to 99%). The proportion who washed their hands before meals also showed only a small increase (5%). The habit that stands out in terms of the changes due to the start of the pandemic was that of washing hands when arriving home; only 64.1% of users said they washed their hands as soon as they got home before the pandemic, compared with 99% during the pandemic, representing an increase of 34.5%.

The length of time for which the participants washed their hands with soap and water also changed. Figure 2(b) shows that 63% of respondents took up to 10 s, and only 4% more than 30 s. During the pandemic, the proportion who took between 10 and 20 s increased by between 20% and 44%; the proportion who took between 20 and 30 s rose from 6% to 15%; and the proportion who took more than 30 s rose from 4% to 10%. According to the WHO's recommendations, the correct time for which hands should be washed with soap and water is 40–60 s, and with alcohol gel, 20–30 s. Hence, only 10% of the respondents followed this recommendation, even after the start of the pandemic.

From Figure 3, it can be observed that there were no significant differences between the groups of total respondents, homes with elderly people and homes with only adults aged 20–60 years. Of these groups, households containing only adults aged 20–60 showed a lower percentage for washing hands after meals of 45% versus a total of 57%.



**Figure 2** | (a) Situations in which participants washed their hands; (b) changes in the time spent washing hands.

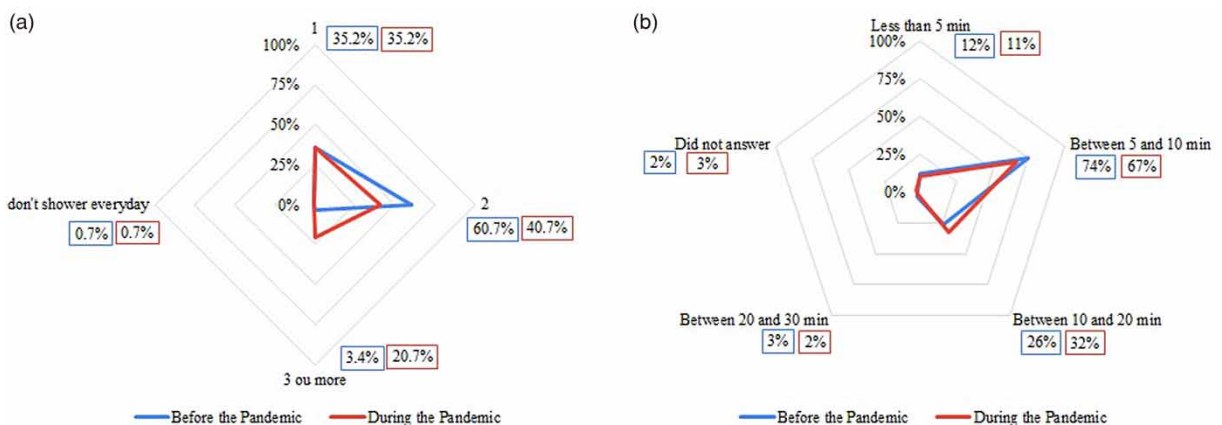


**Figure 3** | Situations in which respondents washed hands, showing the total results, results for residences with elderly people, and results for residences containing only adults aged 20–60.

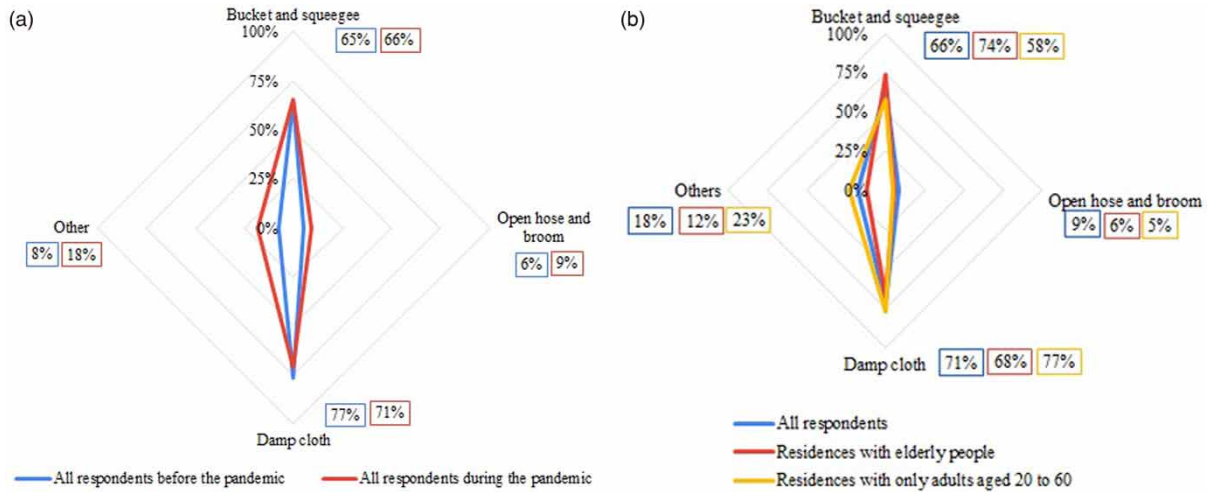
Behaviour related to daily showering also changed, mainly in terms of the proportion of people who used to bathe twice daily and changed this to three times, as shown in Figure 4(a). Another important point is that although 60.7% of the respondents claimed to bathe twice daily before the pandemic, this was reduced to 40.7% during the pandemic, while the proportion of respondents showering three times increased from 3.4% to 20.7%. The length of time spent showering, however, did not change significantly, as shown in Figure 4(b), with a decrease of 8% in those showering for 5–10 minutes and an increase of 6% among those showering for between 10 and 20 minutes.

**House cleaning, laundry and dish washing**

Behaviour related to household cleaning are shown in Figure 5. It can be seen from Figure 5(a) that the majority of interviewees maintained very similar behaviour before and during the pandemic, in terms of cleaning the floor, mainly using a bucket and squeegee (from 65% to 66%) and a wet cloth (from 77% to 71%) to clean the floor. The use of an open hose and broom increased by only 3%.



**Figure 4** | (a) number of daily showers; (b) average time spent in the shower.



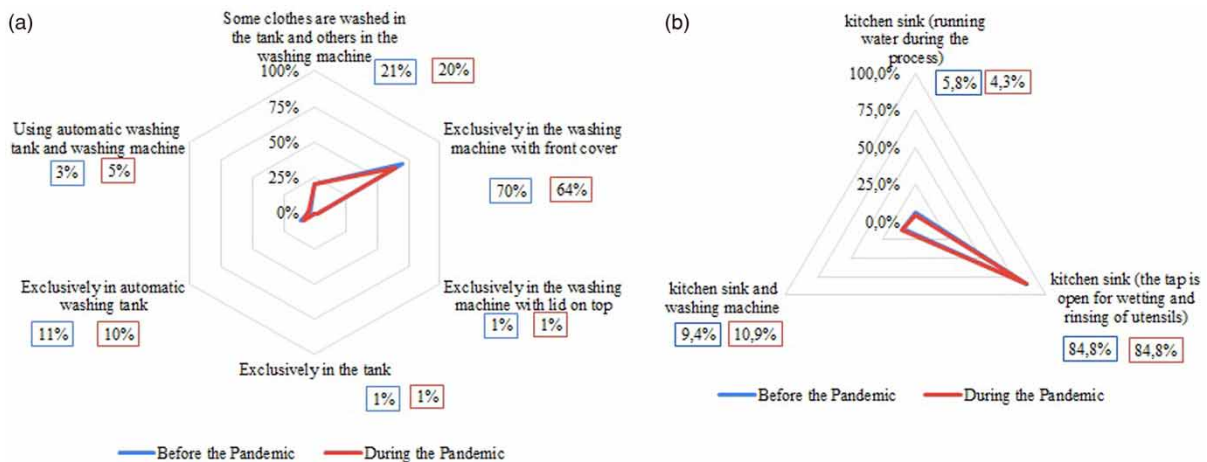
**Figure 5** | Household cleaning behaviour of all respondents (a) before and during the pandemic; (b) during the pandemic, including homes with elderly people and homes with only adults aged 20–60 years.

A comparison of the preferences between respondents showed that there was a difference between dwellings with elderly people and homes with only adults aged between 20 and 60. In households with only adults aged 20–60, there was a greater preference for the use of a wet cloth (77%) and other methods (23%), while in homes with elderly people, the highest preference was to use a bucket and squeegee (74%).

Figure 6(a) illustrates the laundry behaviour for the entire sample. It can be seen that there were no major changes in behaviour relating to washing clothes. The proportion of users who washed clothes only in the washing machine before the pandemic dropped from 70% to 64% during the pandemic, while respondents who used washing clothes sink rose from 3% to 5% during the pandemic.

Figure 6(b) illustrates behaviour in relation to washing dishes. For this activity, the changes during the pandemic were very small. The proportion of respondents who used running water during the whole washing process fell from 5.8% to 4.3% during the pandemic, while the number of people using both a sink and dishwasher rose from 9.4% to 10.9% during the pandemic.

These two cleaning processes changed very little, a result which is likely to be due to the cost of purchasing a dishwasher or a washing machine.



**Figure 6** | Habits relating to (a) laundry before and during the pandemic; (b) washing dishes before and during the pandemic.

**Food hygiene and general observations of respondents**

The emergence of the use of a cloth with 70% alcohol during the pandemic should be noted, and also the combination with vinegar or soap. These three forms of food hygiene accounted for 4.1% of respondents in total, and these practices started during the pandemic. Figure 7 illustrates washing fruits and vegetables behaviour before and during the pandemic.

In addition to sanitising fruits and vegetables, respondents were also asked whether they sanitised processed and packaged items before the pandemic. It is noteworthy that 80% reported that they never washed these items, compared to 7.6% who said that they always washed their purchases, 2.8% that they cleaned them with a cloth, and 9.7% that rarely cleaned purchases, and only when there was visible dirt.

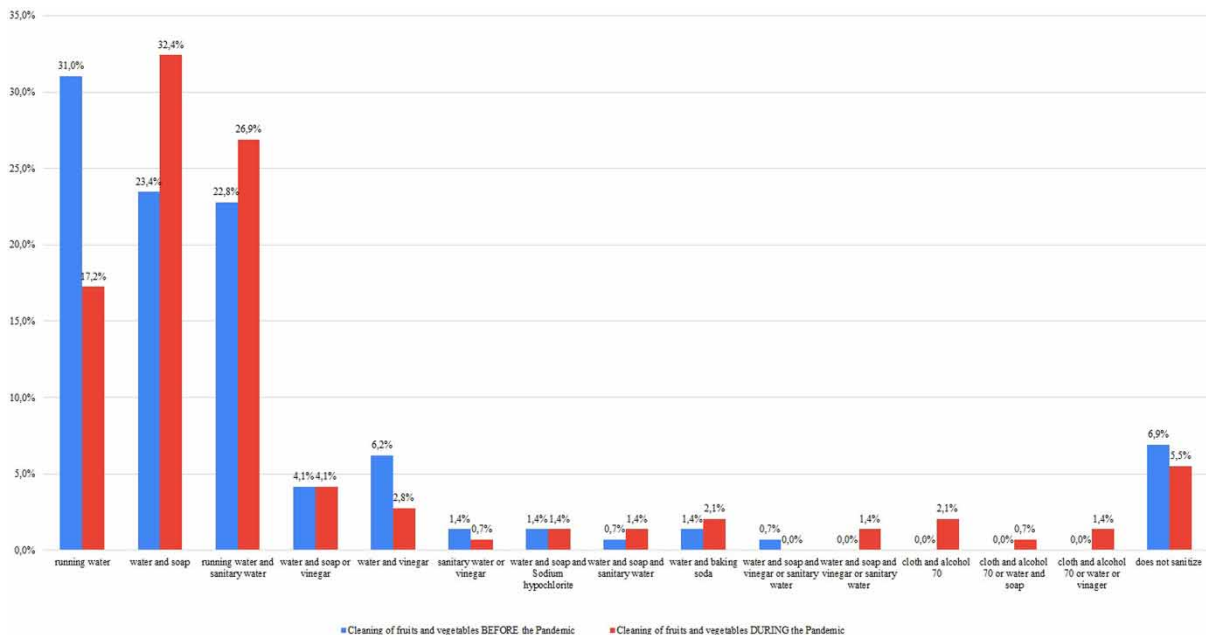
Another question was related in a discursive way to the respondents’ perceptions of changes in water consumption. About 40% reported that they had noticed changes, either in the items mentioned in the previous questions or in other aspects (for example, washing shoes), and emphasised that they intensified cleaning of the house and the packaging of foods from the supermarket or deliveries. Other situations were also reported, such as increased cleaning of dishes due to the higher rate of home-cooked meals and more changes of clothes for those who went out to work.

**Considerations about washing hands and showering behaviour**

Hand washing is the main preventive measure against COVID-19, according to the WHO. We therefore sought to verify statistically whether there was in fact a change in this habit during the pandemic. A McNemar test was applied to compare the paired samples at a significance level of 5%.

The results of the McNemar test confirmed that there was a change in hand washing behaviour when arriving home, regardless of the presence of elderly people in the residence. Although a change in the proportion of respondents washing hands before meals was expected, due to the possibility of contact with the mouth, only 5% reported a change in this behaviour, and the discordant responses were not sufficient to infer a change in habit.

To analyse the duration of hand washing and showering, the Wilcoxon Test was applied, after verifying whether data relating to the differences before and during the pandemic obeyed a normal distribution, using the Shapiro Wilk test for a level significance of 5%. Changes were observed in the duration of hand washing ( $p$ -value = 2.001e-15) and showering ( $p$ -value = 0.01028), both of which increased during the pandemic.



**Figure 7 |** Washing fruits and vegetables before and during the pandemic.



### Perception and real changes in behaviour

Throughout the research, some questions were asked in order to assess personal perception regarding the change in hygiene habits and water consumption of families thanks to the COVID-19 pandemic. Through this analysis and the data presented above, it was possible to observe that the participant's perception differs, sometimes, from the real behavioral changes in some aspects.

In the questionnaire, several questions aimed to assess personal perceptions of changes in hygiene habits and water consumption by families due to the COVID-19 pandemic. From this analysis and the data presented above, it was observed that the participants' perceptions sometimes differed from the real behavioural changes in some respects.

The perceptions of the respondents were that there was an increase in water consumption due to the greater frequency of showering, hand washing, food hygiene, laundry and domestic cleaning. However, when the objective responses to the questionnaire were analysed, it became clear that some of these changes were not as large as they were perceived to be by the participants. This can be explained based on behavioural intentions to comply with social norms and rules. Research has consistently shown that when individuals are faced with information that describes their behaviour in relation to the expectations of their peers or colleagues, they are likely to try to align their behaviour with these expectations (Koop *et al.* 2019). There is therefore a problematic relationship between reported behaviour and use, and there may be an overestimation of up to 30% (Berk *et al.* 1993).

About 41% of the respondents reported they knew of cases of COVID-19 related to them (family or friends), but this was not sufficient to motivate more effective and consistent changes in hygiene habits, such as washing hands when using the bathroom and before meals. It is possible that the low number of deaths (476) from COVID-19 reported in Goiás during the research period (COVID Goiás 2020) compared to other Brazilian states may have affected the behaviour of the participants, since the vast majority of participants resided in the state of Goiás.

### Reliability of the questionnaire

An important factor considered in the analysis was the reliability of the internal consistency of the questionnaire; that is, the consistency of the results of the evaluation of the research items. This reliability can be influenced by three different factors: the number of items, the time of application of the questionnaire, and the sample of evaluators (Freitas & Rodrigues 2005). When assessing the number of items, we ensured that this was sufficiently able to reduce the sampling error by increasing the sample size, but without causing impulsive and relapsing responses due to fatigue or disinterest.

With regard to the time of application of the questionnaire, since it was open to responses for approximately one month, the occurrence of impulsive and relapsed responses can also be ruled out. Finally, regarding the sample of respondents, responses were obtained from a heterogeneous range of people from different age groups, localities and family arrangements, thus ensuring variance in the responses. In view of this, we believe that the questionnaire applied in our study was reliable.

## CONCLUSIONS

This research aimed to investigate the influence of the pandemic on personal hygiene and household's behaviour, in terms of actions intended to prevent and control the propagation of COVID-19, caused by the SARS-COV-2 virus, such as hand washing, showering, changing clothes, sanitising food and domestic cleaning.

Based on data obtained from a sample of 149 participants, the majority of whom were adult women aged between 20 and 60 years old and mostly resident in the state of Goiás, we found that:

- The hygiene habits that had been most strongly influenced by the pandemic were (in decreasing order): washing hands with soap and water, cleaning floors, food hygiene, and showering, all of which involve water consumption;
- The changes in these habits were more significant in dwellings with elderly people (adults over 60 years old), who are considered to be more vulnerable to the SARS-COV-2 virus;
- There was a significant change in the habit of washing hands when arriving home, both for the total sample and for the group with elderly people at home, as evidenced by the increases in the frequency and length of hand washing. Surprisingly, there was an increase in the number of people who started washing their hands after meals, while hand washing both before meals and after using the bathroom did not show sufficient difference to prove a change in behaviour;

- An increase in the length of time for which respondents washed their hands was seen primarily among those participants who spent up to 10 s before the pandemic and then changed this to between 10 and 20 s. However, this period is below the average of 40 s recommended by the WHO;
- Participants who bathed twice per day increased their frequency of showering to three or more times per day, while participants who bathed once daily did not change this habit during the pandemic;
- There was an increase in the proportion of respondents who sanitised fruits and vegetables with water and disinfected them with bleach during the pandemic;
- Domestic hygiene with regard to floor cleaning did not change significantly during the pandemic, with the main methods being cleaning with a bucket and squeegee (which was more frequent in homes with elderly people), and with a wet cloth.

It was therefore possible to observe a change in certain hygiene behaviour during the pandemic in the sample population, evidenced mainly by actions that involved the consumption of water.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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