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Water Rationing, Water, Sanitation and Hygiene Practices and Social Distancing at the Time of the COVID-19 Pandemic: A Cross-Sectional Study of Melaka, Malaysia

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Abstract: As an uninterrupted water supply is crucial for water, sanitation and hygiene (WASH) practices, a water shortage exacerbates the propagation of communicable and often life-threatening diseases. Melaka, a water-stressed state in Malaysia, had to impose a two-month water rationing exercise amid the COVID-19 pandemic in early 2020. Taking advantage of these concurrent occurrences, this study thus examines the impact of water rationing on the state's residents' WASH practices during that time. In particular, it seeks to examine whether there has been any shift in their WASH performance during the periods of pandemic and rationing. It also analyzes the effect of external water collection activity during rationing on the residents' social-distancing performance. This study collects its data from 120 respondents; the data are tested using non-parametric tests and frequency analyses. The results demonstrate that most of the respondents had a significant negative perception of how the rationing affected their WASH practices during the pandemic. Yet even with the ongoing rationing, their WASH levels of performance had recorded significant growth. They also viewed external water collection activities as detrimental to their social distancing performance.

Keywords: water rationing; COVID-19; water; sanitation and hygiene; WASH; hand washings; social distancing

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1. Introduction

Fresh water is immensely precious. Yet, it is finite in supply. The UN's 2030 Sustainable Development Goal (SDG) 6, Clean Water and Sanitation, emphasizes the significance of ensuring the "availability and sustainable management of water and sanitation for all" [1]. Access to clean water and sanitation in essence underlines other fundamental aspects of the Goals, such as human rights and equality, reductions in poverty levels, and environmental protection. This makes SDG6's achievement a touchstone for accomplishing other SDGs such as, SDG3, Good Health and Well-Being; SDG5, Gender Equality; and SDG11, Sustainable Cities and Communities [2].

The Malaysian government, which is itself a signatory of the UN's SDG Program, has constantly sought to reform the national water services industry. However, a dismal view of the country's water resource management persists as unscheduled supply disruptions, which affect the domestic consumers hardest, become increasingly frequent. The disruptions are caused by uncontrolled river pollution, out-of-order infrastructure due to lack of maintenance and underinvestment, logging activities in critical water catchment areas, political bickering and incompetent management [3]. The freshwater sources in Malaysia are also susceptible to climate change caused by global warming. This was what befell Melaka, a Malaysian state, when the prolonged hot and dry weather spells at the end of

2019 dried out the water held by its dams. This prompted a statewide water-rationing exercise from 29 January 2020 to 1 April 2020, affecting more than half of its population [4].

Unfortunately for the residents in Melaka, the rationing coincided with the COVID-19 outbreak in the country and the subsequent nationwide Movement Control Order (MCO). During this time, public health services worldwide had been actively calling for heightened WASH practices to reduce the risk of SARS-CoV-2 viral transmission. These calls especially emphasized frequent hand washings and surface disinfections using water and soap. In addition, physical distancing and mask-wearing requirements had been imposed on individuals whenever they were out in public places, such as at water collection sites. Given this, access to appropriate WASH infrastructure was crucial in efforts to control the spread of COVID-19. Above all, ready access to a clean water supply strongly influences individuals' ability to perform the endorsed WASH practices. In consequence, households experiencing water shortages would find such called-for "new normal" hygiene practices challenging, and at worst, impossible [5].

There are several studies that were conducted in different countries during the pandemic which report rising domestic water usage during lockdowns [6–15]. There are also numerous studies worldwide on how individuals' WASH practices, especially hand washings, have changed during the pandemic [15–26]. However, nearly all of them have not directly undertaken the issue of water scarcity or rationing. In consequence, there remains an apparent gap regarding the implications of water scarcity on individuals' WASH practices during the pandemic. Thus, this study aims to address such gap by analyzing the impact of water rationing on the WASH practices and social distancing performance of residents of Melaka. It especially seeks to examine whether there has been any shift in the residents' WASH performance during the periods of pandemic and rationing.

This study contributes to the extant body of literature in several ways. First, it analyzed the unprecedented concurrent incidents of statewide water rationing and a global pandemic. Rather than relying on a hypothetical scenario, this study adopted these simultaneous real-life events to study how water shortage had affected individuals' WASH practices and social distancing performance during a global pandemic. It thus allows a particular insight on the ways individuals' hygiene practices evolved in the light of a life-threatening transmissible disease within the context of Melaka, Malaysia. As such, its results highlight the importance of appropriate WASH infrastructure to the inculcation of good hygiene practices in the community and henceforth as a disease-prevention measure. In addition, this study's findings offer integral value to a wide range of stakeholders in Malaysia especially, from the policymakers to the water management bodies, as well as the public healthcare authorities. On the whole, the findings are conducive in efforts to build the country's resilience to future disease outbreaks through sustained WASH practices.

This paper is organized in the following way. Section 2 presents the literature review and hypotheses development. Section 3 describes the data collection and analysis methods applied in this study. Section 4, meanwhile, discusses the results of the analyses. Section 5, as the final section, concludes this paper.

2. Literature Review and Hypothesis Development

2.1. Melaka: A Water-Stressed State

Comprising a land area of 1712.3 km^2, Melaka is the third smallest state in Malaysia, with an estimated population of 932,700 in the year 2020 [27]. Its main freshwater sources are its rivers and storage dams. Recent statistics show that from 2017 to 2019, the number of water accounts opened in Melaka increased by 4.11%. Likewise, its water-supply production and consumption during this period rose by 4.87% and 2.62%, respectively. At the same time, water supply disruption complaints in Melaka skyrocketed, increasing by 79.84% [28]. As the state's population grows over time, it is therefore inevitable that the water supply disruptions will persist and even intensify in future.

The direness of Melaka's water-stressed situation had hit its residents notably hard during the prolonged hot and dry weather spells at the end of 2019. The dried-out rivers

and dams precipitated a state-wide water rationing exercise from 29 January 2020, one which affected more than half of Melaka's population [4]. When the rationing ended on 1 April 2020 after heavy rainfalls, a total of 735,221 households had been affected [29].

During the two-month rationing, Melaka residents had to weather the COVID-19 pandemic and the subsequent lockdown. The first COVID-19 case in Malaysia was reported on 25 January 2020, a mere four days before the rationing began [30]. By 15 March 2020, the national cumulative number of cases had reached 428, prompting the Malaysian government to impose a nationwide MCO three days later [31]. The MCO was finally lifted on 1 November 2021 [32].

2.2. Literature Review and Hypothesis Development

SARS-CoV-2 virus, which causes COVID-19, is transmitted through direct, indirect and/or close contact with infected patients. Viral transmissions via direct and close contact happen through nose and mouth secretions. Meanwhile, indirect viral transmission occurs when contaminated water droplets land on surfaces and then transfer onto human skin upon contact [33]. Studies have observed that the virus can stay viable for a considerable period, subject to the material of the surface it landed upon [5,34]. It has also been found that, in addition, soap effectively shatters the bilipid layer encasing SARS-CoV-2 viral particles, and flowing water washes the inactivated particles clean away [5,35].

In response, worldwide health organizations had been actively calling for heightened WASH practices since the pandemic began. The recommended WASH practices included washing hands using sufficient soap and flowing water for at least twenty seconds, up to ten times per day. Regular surface disinfections, especially in common and open-access areas, were also insisted upon. Soft and porous surfaces, such as clothes, should be laundered using hot water and detergent. Hard and non-porous surfaces, like furniture and floors, should be cleaned with soap or diluted bleach and water [33,34,36]. Following the global campaigns, numerous studies conducted in various countries observed a significant rise in individuals' WASH practices, specifically, hand washing [15–26].

The WASH practices nevertheless inevitably require considerable water consumption. At least eight to ten liters of water would be needed daily for a person to adhere to the recommended hand washing practice. The computation is based on the common hand basin tap which on average uses two to three liters of water per minute [14]. However, this calculation has not included the amount of water needed for surface disinfection activities. Indeed, studies from multiple countries have collectively observed a significant rise in household water demand during the pandemic, especially as people were housebound due to lockdown [6–15]. Their results further substantiate the vital role that access to uninterrupted water supply plays for an individual's ability to effectively perform the recommended WASH practices [23,37].

Under the circumstances, WASH practices are challenging and at worst, impossible for households experiencing water shortages [5]. Water scarcity, which is prevalent in developing countries, persistently leads to substandard hand-hygiene behaviors [38,39]. A study of communities in rural Odisha, India has also identified the lack of water supply as a barrier to effective WASH practices [23]. Water shortages, particularly because of rationing, would cause households to have to prioritize in the use of their limited water reserves for WASH practices and daily ingestion, such as cooking and drinking [36,40]. Even with extensive calls for increased WASH practices, individuals affected by water rationing would have faced difficulties in following those practices, even if they had wished to [23]. In consequence, their ability to perform the recommended WASH practices would have been severely impacted [5,23].

Additionally, the likelihood that rationing could adversely affect the quality of available water supply for WASH purposes should be considered [36]. It is commonplace that the water supply provided during rationing is of a lower quality, since drought often causes soil to be introduced into the water reservoirs, forming muddy sediments [41]. In fact, using contaminated water in any WASH practice, above all hand washings, defeats the

very objective of sanitation and disease prevention [36,42]. Furthermore, several studies have reported the presence of SARS-CoV-2 virus in wastewater, where it can remain viable for a few days, subject to the environmental conditions [43–48].

In view of the limited water reserve utilized by households undergoing rationing, it is customary for individuals to scrimp and reuse water as much as possible. Nevertheless, such economization was not advisable during the pandemic, as using unclean water elevates the risk of disease infection. In particular, a positive correlation between household water recycling and COVID-19 transmission rate in Indonesia had been specifically noted [49].

The two-month water rationing period which coincided with the pandemic had been challenging for the residents in Melaka. While WASH practices are crucial in reducing viral transmission in the community, the rationing severely limited the residents' ability to do so effectively. Furthermore, MCO enforcement during that period had required that entire households stay at home around-the-clock, which consequently resulted in an increased demand for water. This put further strain on the households' already limited water reserves, which could then lead to conflicts in their water usage prioritization.

In view of the above discussions, this study therefore hypothesizes that:

Hypothesis 1 (H1). *There is a significant negative perception among the residents in Melaka on how water rationing had influenced their WASH practices during the COVID-19 pandemic.*

Hypothesis 2 (H2). *There are significant differences in their WASH performance in the periods before the pandemic and rationing, during the pandemic and rationing, as well as after the rationing but with the pandemic still ongoing.*

As with any airborne disease, COVID-19 infection risk is higher in crowded places, especially those with poor ventilation. Accordingly, the public had been repeatedly advised to avoid crowds and close contact with others whenever possible. In addition, physical distancing of at least one meter from others, alongside proper mask-wearing, had been mandated to reduce the risk of community transmission [50].

Even so, water rationing often requires people to leave their home to gather water. During the rationing exercise in Melaka, the local government had organized water supply distributions at identified local points throughout the state [51]. Moreover, rationing can prompt water sharing practices among households, which could be between households in different locations. Such arrangements inevitably compel people to travel, often over significant distances, and be near others for considerably long periods [5,6,35,52].

Taking place during the pandemic, external water gathering and household water sharing would therefore have inappropriately put people into close physical contact. At the same time, they would have had greater contact with shared common objects like water buckets, hoses and taps. In consequence, it would have been hard for them to effectively exercise social distancing measures, ultimately increasing the risk of COVID-19 transmission in the community [5,6,23,34,36,37,53].

In consideration of the above discussions, this study hypothesizes that:

Hypothesis 3 (H3). *External water collections during the rationing period had a significant negative impact on the social distancing performance by residents in Melaka.*

3. Materials and Methods

3.1. Data Collection Mechanism

Employing a quantitative research method, this study developed a web-based questionnaire to assess how water rationing affected the WASH practices and social distancing performance of residents of Melaka during the COVID-19 pandemic. Before its distribution, the questionnaire was validated by an independent researcher who specialized in

primary data research. It was also subjected to pilot testing on a small group of pre-selected respondents to evaluate its clarity and reliability. The questionnaire was then reviewed and approved by the Research Ethics Committee of Multimedia University.

The questionnaire was administered for a two-month period, i.e., from August to October 2020, using the Google Form platform. A total of 250 survey invitations were sent out during August 2020 to the researchers' personal contacts in Melaka via online channels such as email, instant messaging applications, and social media accounts. Respondents were also encouraged to share the invitation link with their families and friends in Melaka. At the end of the survey, a total of 120 (48%) valid responses had been collected.

This study adopted a purposive sampling method based on the following justifications. Firstly, although it is restricted in generalizability, this method is especially well suited for studies in which the information can only be provided by a limited population [54]. Furthermore, it is warranted as appropriate in situations where researchers are to select unique cases which are especially informative or to single out respondents for particularly difficult research. In addition, the purposive sampling method is deemed to be a fitting approach for researchers seeking to identify singular types of cases for in-depth investigation, being "less to generalize to a larger population than it is to gain a deeper understanding of types" [55]. Since this study's data collection process took place during an ongoing pandemic and nationwide MCO, its access to the entire population of Melaka was indeed considerably hampered. Additionally, the central focus of this study was specifically to gauge the residents' feedback on how the rationing impacted their WASH practices and social distancing performance during the pandemic. Thus, its application of the purposive sampling method allowed for a quick, safe and efficient data-collection process during the challenging time. This method has also been adopted by prior published studies on WASH practices during the pandemic [23,56–61].

To increase its accessibility and clarity, the questionnaire was designed to use both the English and Malay languages. It began with a brief description of the study, its objectives, and the assurance of respondents' anonymity and confidentiality. All respondents, who were required to be at least eighteen years old, had to provide their informed consent before continuing with the survey. The questionnaire, which was comprised of multiple-choice questions, contained four parts with a total of thirty-three questions. Part A consisted of ten demographic questions. Parts B and C were concerned with H1 and H2, which examined the impact of water rationing on the respondents' WASH practices. In particular, Part B asked three questions regarding the respondents' perceptions of how the water rationing impacted their WASH practices. Part C, meanwhile, asked for the respondents' WASH performance frequency over three periods: before the pandemic and rationing (pre-December 2019); during the pandemic and rationing (January to March 2020); and after the rationing, but with the pandemic still ongoing (April 2020 onwards). Five types of WASH practices were asked about, bringing the total number of questions in Part C to fifteen. Part D, in testing H3, contained five questions about how the respondents' external water collection activity affected their social distancing performance.

The reliability of the questionnaire as to Parts B to D was assessed using Cronbach's α. The Cronbach's α values, which are presented in Table 1 below, are all above the generally accepted value of 0.8 [62] (p. 709). They show that the questionnaire's scales had high reliability scores. Therefore, the questionnaire possessed strong reliability.

Table 1. Cronbach's α values for the questionnaire's scales.

Questionnaire Scale	Number of Items	Cronbach's α Value
Part B: Respondents' perceptions of water rationing impact on hygiene practices	3	0.983
Part C: Respondents' hygiene performance frequency over periods	15	0.980
Part D: Respondents' external water collection's effect on social distancing performance	5	0.924

3.2. Data Analysis Methodology

Firstly, this study examined the normality of its data distribution using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Both tests indicated that the data distribution was not normal ($p < 0.01$) and thus rendered parametric tests unsuitable. While there are views on the non-parametric tests' lack of power as compared to parametric tests, they are only true when non-parametric tests are applied to normally distributed data instead of parametric tests [62] (p. 214). In view of this, and consistent with its aims, this study accordingly tested its hypotheses by way of non-parametric tests.

This study employed two non-parametric tests to analyze each of its hypotheses, which are as tabulated in Table 2 below. The second tests served to validate the results of the first tests, which then boosted the robustness of this study's findings. This study employed the Mann–Whitney U test and Kruskal–Wallis test to examine H1. Frequency analysis and Friedman's ANOVA test were used for analyzing H2. This study was consistent with the assumptions of Friedman's ANOVA test in having a random sample from the population measured on at least three different occasions, the sample's data being not normally distributed, and the dependent variables measured at ordinal and continuous levels [62] (p. 484). The results from the Friedman's ANOVA test were then validated using the Wilcoxon signed-rank test. All these tests were two-sided at the significance level of 5%. H3 was subsequently tested using frequency analysis and then validated using Spearman's correlation analysis. The bootstrapping method was applied in performing the correlation to address the data's lack of normal distribution [62] (p. 276).

Table 2. Statistical tests for hypotheses.

Hypothesis	Main Test	Validation Test
H1: There is a significant negative perception among the residents in Melaka on how water rationing had influenced their WASH practices during the COVID-19 pandemic	Mann–Whitney U test	Kruskal–Wallis test
H2: There are significant differences in the residents' WASH performance in the periods before the pandemic and rationing, during the pandemic and rationing, as well as after the rationing but with the pandemic still ongoing.	Frequency analysis and Friedman's ANOVA test	Wilcoxon signed-rank test
H3: External water collections during the rationing period had a significant negative im-pact on the social distancing performance by residents in Melaka.	Frequency analysis	Spearman's correlation analysis

4. Results and Discussions

4.1. Demographic Statistics

Table 3 presents the demographic profile of the respondents ($n = 120$) who participated in this study. They consisted of 35 males (29.17%) and 85 females (70.83%). More than half of the respondents were between 31 to 50 years old (63.33%). The sample was representative

of the country's three major ethnicities, i.e., Malay (45.83%), Chinese (36.67%) and Indian (16.67%). A total of 81.67% of the respondents had tertiary education and 65.83% were full-time employees. Furthermore, they came from all three districts in Melaka (Alor Gajah = 20.00%; Jasin = 9.17%; Melaka Tengah = 70.83%). Out of the 120 respondents, only 73 (60.83%) were affected by the water rationing exercise. The remaining 47 (39.17%) respondents were not impacted due to their having large-capacity water retaining tanks at home, as well as the proximity of their respective residences to hospitals, which were exempted from the rationing.

Table 3. Demographic statistics of respondents (n = 120).

Demographic Profile		*n*	Percentage
Gender	Male	35	29.17%
	Female	85	70.83%
Age	18–20	14	11.67%
	21–30	15	12.50%
	31–40	36	30.00%
	41–50	40	33.33%
	51–60	11	9.17%
	61 and above	4	3.33%
Ethnicity	Malay	55	45.83%
	Chinese	44	36.67%
	Indian	20	16.67%
	Others	1	0.83%
Level of education	Secondary school and below	14	11.67%
	Undergraduate	60	50.00%
	Postgraduate	38	31.67%
	Professional qualification	8	6.67%
Employment status	Self-employed	12	10.00%
	Full-time employee	79	65.83%
	Part-time employee	2	1.67%
	Retired	4	3.33%
	Unemployed	2	1.67%
	Student	21	17.50%
Monthly income [amount in Ringgit Malaysia (RM)]	Less than RM2500	18	15.00%
	RM2500–RM5000	41	31.47%
	RM5001–RM7500	29	24.17%
	RM7501–RM10,000	16	13.33%
	RM10,001–RM12,500	7	5.83%
	RM12,501–RM15,000	6	5.00%
	RM15,001 and above	3	2.50%
Household size	1 member	1	0.83%
	2 members	15	12.50%
	3 members	23	19.17%
	4 members	36	30.00%
	5 or more members	45	37.50%
District	Alor Gajah	24	20.00%
	Jasin	11	9.17%
	Melaka Tengah	85	70.83%
Affected by water rationing exercise	Yes	73	60.83%
	No	47	39.17%
Collected water from external source(s) during the rationing	Yes	27	22.50%
	No	93	77.50%

4.2. Respondents' Perceptions Regarding Water Rationing's Impact on WASH Practices

Table 4 presents the scores for the respondents' perception of how water rationing impacted their WASH practices. A total of 82.20% of the respondents had been concerned about the water rationing taking place during the pandemic (mean score = 4.23 ± 0.124). Additionally, 86.30% of them acknowledged that the water rationing had hindered their ability to perform WASH practices (mean score = 4.36 ± 0.127). Meanwhile, 72.60% of the respondents had prioritized their household water usage more for WASH practices rather than for drinking and cooking (mean score = 3.97 ± 0.135).

Table 4. Respondents' perceptions regarding water rationing's impact on personal hygiene measures (n = 73).

	SA (%)	A (%)	N (%)	D (%)	SD (%)	Mean (Std. Dev.)
Concern about water rationing during the COVID-19 pandemic.	**53.40**	28.80	9.60	4.10	4.10	4.23 (0.124)
Water rationing had hindered the ability to perform WASH practices.	**63.00**	23.30	5.50	2.70	5.50	4.36 (0.237)
Prioritization of water reserve for WASH practices over drinking and cooking during the rationing.	**41.10**	31.50	17.80	2.70	6.80	3.97 (0.135)

SA = Strongly Agree (5); A = Agree (4); N = Neutral (3); D = Disagree (2); SD = Strongly Disagree (1); Std. dev. = Standard deviation. Highest scores are presented in bold.

The demographic analysis results for the respondents' perceptions regarding how water rationing affected their WASH practices are in Table 5. Their levels of concern over the rationing taking place during the pandemic and how it affected their ability to perform WASH practices were significantly influenced by their age [H(5) = 15.51, p = 0.008; H(5) = 11.63, p = 0.040] and employment status [H(5) = 17.63, p = 0.003; H(5) = 11.88, p = 0.036]. In particular, the mean rank value indicates that respondents aged between 51 to 60 years old were the most concerned about and affected by the water rationing, while those between 18 to 20 years old were the least concerned. It also demonstrated that retired respondents were the most concerned about the rationing, in that both retired and unemployed respondents found that the exercise had most affected their performance of WASH practice.

The results complemented prior studies' findings that older individuals significantly and inherently saved more water [63–65]. As inherent water-savers, older individuals would therefore be more perturbed by water shortages and rationing exercises. In addition, the finding could be attributed to the fact that older individuals are found to be more susceptible to COVID-19 complications, especially when they are comorbid [66–69].

Additionally, the respondents' prioritization of their water reserves for WASH practices rather than for cooking and drinking during the rationing was significantly affected by their household size [H(4) = 11.06, p = 0.026]. The mean rank shows that respondents from one-member households particularly prioritized their water reserve more for WASH practices than drinking and cooking. In contrast, respondents from households with at least five members had the lowest scores. Having more household members significantly increased the need for water for drinking and cooking, especially when everybody was confined to their house due to the lockdown. This is consistent with [6–15].

The respondents' concern about the imposition of rationing during the pandemic was also significantly influenced by the districts they resided in [H(2) = 6.08, p = 0.048]. The mean rank demonstrates that the residents residing in Jasin were the most concerned, while those in Melaka Tengah were the least concerned. On the other hand, the respondents' gender, ethnicity, level of education, and monthly income had no statistically significant influence on how they perceived the impact of rationing on their WASH practices.

Table 5. Respondents' perceptions regarding water rationing's impact on personal hygiene measures, based on demography (n = 73).

Demographic Profile		Concern about Water Rationing during the Pandemic		Water Rationing Hindrance of Ability to Perform WASH Practices		Prioritization of Water Reserve for WASH Practices over Drinking and Cooking during the Rationing	
		Mean Rank	Test Statistics	Mean Rank	Test Statistics	Mean Rank	Test Statistics
Gender [1]	Male	39.63	482.00	38.66	481.50	40.11	454.00
	Female	36.43		36.42		35.91	
Age [2]	18–20	21.17	15.51 ***	26.63	11.63 **	30.21	3.384
	21–30	28.00		29.50		34.13	
	31–40	43.37		40.79		40.63	
	41–50	38.29		36.06		35.75	
	51–60	49.71		50.50		44.57	
	61 and above	44.00		50.50		41.17	
Ethnicity [2]	Malay	39.31	4.05	38.15	5.17	38.77	1.87
	Chinese	38.69		40.33		38.52	
	Indian	30.79		28.54		30.61	
	Others	10.00		19.00		32.00	
Level of education [2]	Secondary school and below	32.67	2.11	38.83	2.57	39.89	1.51
	Undergraduate	38.47		38.54		38.88	
	Postgraduate	38.52		36.29		33.79	
	Professional qualification	27.20		25.00		31.00	
Employment status [2]	Self-employed	36.67	17.63 ***	34.50	11.88 **	40.00	7.97
	Full-time employee	42.02		39.80		38.05	
	Part-time employee	10.00		2.50		3.00	
	Retired	54.00		50.50		58.50	
	Unemployed	24.00		50.50		32.50	
	Student	21.87		27.20		31.13	
Monthly income [2]	Less than RM2500	28.00	10.11	33.00	9.15	36.33	6.33
	RM2500–RM5000	44.68		42.43		42.06	
	RM5001–RM7500	36.93		40.67		32.31	
	RM7501–RM10,000	42.00		37.90		35.40	
	RM10,001–RM12,500	15.20		20.41		17.44	
	RM12,501–RM15,000	13.02		17.49		14.95	
	RM15,001 and above	39.00		19.00		32.00	
Household size [2]	1 member	54.00	8.25 *	50.50	9.14 *	58.50	11.06 **
	2 members	44.00		47.00		52.61	
	3 members	44.43		43.75		42.75	
	4 members	38.30		36.85		34.00	
	5 or more members	29.76		30.28		30.71	

Table 5. *Cont.*

Demographic Profile		Concern about Water Rationing during the Pandemic		Water Rationing Hindrance of Ability to Perform WASH Practices		Prioritization of Water Reserve for WASH Practices over Drinking and Cooking during the Rationing	
		Mean Rank	Test Statistics	Mean Rank	Test Statistics	Mean Rank	Test Statistics
District [2]	Alor Gajah	36.00	6.08 **	37.00	4.40	37.44	1.19
	Jasin	54.00		50.50		44.57	
	Melaka Tengah	34.92		35.07		35.77	

[1] Mann–Whitney U test. [2] Kruskal–Wallis test. * Significant at 10% significance level. ** Significant at 5% significance level. *** Significant at 1% significance level.

Based on the results, H1 was thus empirically supported. There was a significant negative perception among the residents in Melaka of how the water rationing influenced their WASH practices during the pandemic. This study suggests that the mortality levels of COVID-19 at that time had raised the respondents' concern of being infected. In addition to the rampant calls from global health authorities for increased WASH practices, the respondents' inclination to intensify their own WASH practices would naturally deepen. However, the water rationing imposed a significant constraint, mentally as well as physically, on their ability to do so. This is consistent with the findings of published studies conducted in other countries [23,38,39].

4.3. Change in Respondents' WASH Performance over Varying Periods

Figure 1, below, presents the respondents' WASH performance frequencies in three separate periods: (i) before the pandemic and water rationing (pre-December 2019); (ii) during the pandemic and rationing (January 2020 to March 2020); and (iii) after the rationing, but with the pandemic still ongoing (April 2020 onwards). The WASH practices measured were their daily hand-washings, daily bathing, daily clothes-changing, weekly laundry, and weekly household surface cleaning.

The changes in these frequencies were examined using Friedman's ANOVA, the results of which are in Table 6. The results from the Friedman's ANOVA test were then validated using the Wilcoxon signed-rank test, the results of which are presented in Table 7.

The Friedman's ANOVA results indicate that the respondents' daily hand-washing had significantly changed over the periods [$\chi^2(2) = 8.20$, $p = 0.017$]. The follow-up Wilcoxon signed-rank test shows that the daily hand-washing frequency during the rationing did not significantly change from the pre-rationing period [$Z = -0.18$, $p = 0.860$]. However, it had significantly increased after the rationing ended as compared to during the exercise itself [$Z = -3.29$, $p = 0.001$]. The results suggest that as the water supply recovered, the respondents were able to wash their hands more frequently, as recommended.

Meanwhile, the respondents' daily bathing [$\chi^2(2) = 15.36$, $p = 0.000$] and clothes-changing [$\chi^2(2) = 19.83$, $p = 0.000$] activities had significantly changed over the three periods when examined using Friedman's ANOVA. The Wilcoxon signed-rank test further affirms these results. The respondents had bathed significantly more frequently in a given day, even during the rationing, compared to beforehand [$Z = -2.42$, $p = 0.016$]. There was also a significant rise in their daily bathing frequency after the rationing ended, in comparison to when it was ongoing [$Z = -2.13$, $p = 0.033$]. Likewise, the number of times the respondents changed their clothes in a day had also significantly increased during the rationing as opposed to before it [$Z = 3.09$, $p = 0.002$]. It had further increased after the rationing ended, in contrast to during the exercise itself [$Z = 2.50$, $p = 0.012$]. These significant changes could be attributable to the public health guidelines indicating that a person should shower directly after returning home from outside to cut down the risk of COVID-19 transmission to family members. This had especially been the case when

the Malaysian government began to gradually loosen the lockdown from June 2020 [70], resulting in both more people returning to their workplaces and resumed travelling.

Moreover, the Friedman's ANOVA test shows a significant change in the respondents' weekly household surface cleaning over the periods tested [$\chi^2(2) = 8.87$, $p = 0.012$]. The Wilcoxon signed-rank test result demonstrates that while no significant change was present after the rationing ended as compared to during the rationing, the weekly household surface cleaning had significantly risen during the rationing as compared to before it. This highlights the respondents' growing awareness and concern for ensuring their residence's cleanliness to reduce COVID-19 transmission risk in their households.

Table 6. Friedman's ANOVA analysis of the respondents' WASH performance over different periods ($n = 73$).

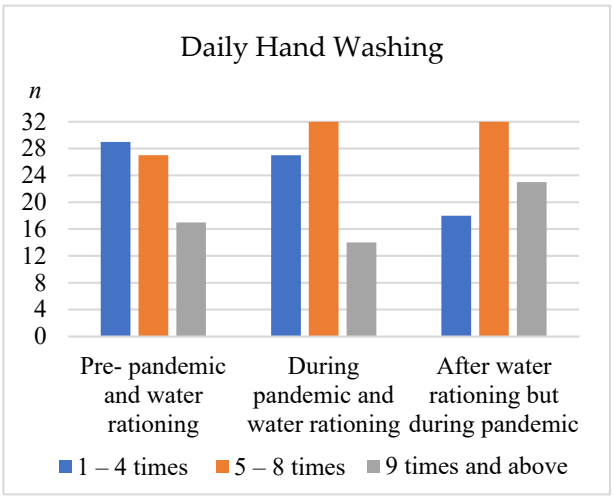
WASH Practice	Period	Mean Rank	χ^2	Df	*p*-Value
Daily hand-washing	PPR	1.90	8.20	2	0.017
	DPR	1.90			
	ARDP	2.20			
Daily bathing	PPR	1.82	15.36	2	0.000
	DPR	2.00			
	ARDP	2.18			
Daily clothes-changing	PPR	1.76	19.83	2	0.000
	DPR	2.04			
	ARDP	2.20			
Weekly laundry	PPR	1.97	3.12	2	0.201
	DPR	1.94			
	ARDP	2.10			
Weekly household surface cleaning	PPR	1.84	8.87	2	0.012
	DPR	2.05			
	ARDP	2.11			

PPR = Pre-pandemic and before water rationing; DPR = During pandemic and water rationing; ARDP = After water rationing, but with the pandemic still ongoing.

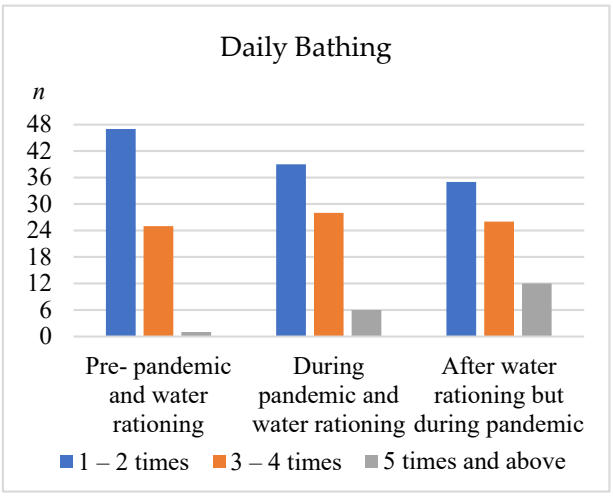
Table 7. Wilcoxon signed-rank test for the respondents' WASH performance over different periods ($n = 73$).

WASH Practice	Period	Negative Ranks [1]			Positive Ranks [2]			Test Statistics	
		n	MEAN RANK	Sum of Ranks	*n*	Mean Rank	Sum of Ranks	Ties	*Z*-Score
Daily hand-washing	DPR–PPR	19	22.21	422.00	21	18.95	398.00	33	−0.18 [a]
	ARDP–DPR	5	13.50	67.50	22	14.11	310.50	46	−3.29 [b] ***
Daily bathing	DPR–PPR	6	11.00	66.00	17	12.35	210.00	50	−2.42 [b] **
	ARDP–DPR	4	11.88	47.50	15	9.50	142.50	54	−2.13 [b] **
Daily clothes-changing	DPR–PPR	6	13.50	81.00	22	14.77	325.00	45	−3.09 [b] ***
	ARDP–DPR	3	8.50	25.50	13	8.50	110.50	57	−2.50 [b] **
Weekly laundry	DPR–PPR	13	12.50	162.50	13	14.50	188.50	47	−0.34 [b]
	ARDP–DPR	4	10.13	40.50	13	8.65	112.50	56	−1.86 [b] *
Weekly household surface cleaning	DPR–PPR	6	11.00	66.00	18	13.00	234.00	49	−2.62 [b] ***
	ARDP–DPR	7	9.50	66.50	12	10.29	123.50	54	−1.28 [b]

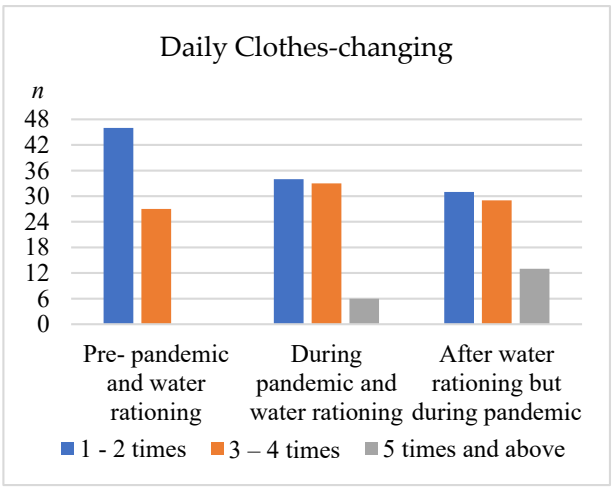
PPR = Pre-pandemic and before water rationing; DPR = During pandemic and water rationing; ARDP = After water rationing, but with the pandemic still ongoing. [1] A negative rank was assigned to data pairs that represented decreases in WASH performance over the periods. [2] A positive rank was assigned to data pairs that represented growth in WASH performance over the periods. [a] Based on positive ranks. [b] Based on negative ranks. * Significant at 10% significance level. ** Significant at 5% significance level. *** Significant at 1% significance level.



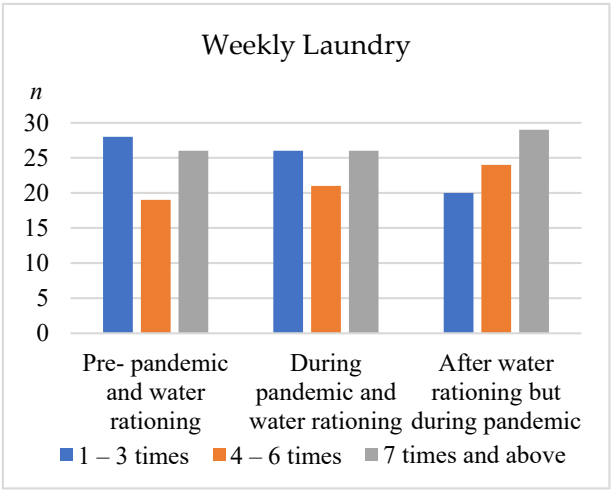
(**a**)



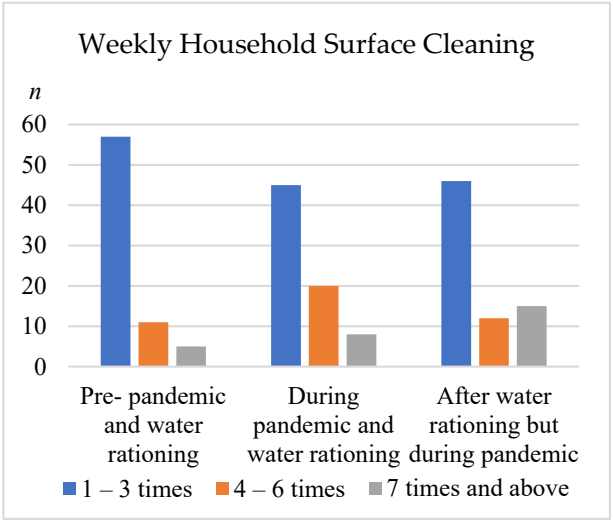
(**b**)



(**c**)



(**d**)



(**e**)

Figure 1. Respondents' WASH performance over different periods (n = 73): (**a**) frequency of daily hand-washing; (**b**) frequency of daily bathing; (**c**) frequency of daily clothes-changing; (**d**) frequency of weekly laundry; and (**e**) frequency of weekly household surface cleaning.

In view of the above, H2 was empirically supported. There had been a significant rise in the respondents' WASH practices during the pandemic, even with the rationing at that time. The results are harmonious with the WASH practices during pandemic in other countries [15–26]. They signify the success and effectiveness of the global health authorities' extensive WASH advisories and campaigns during the pandemic. People worldwide are now much more cognizant of how pivotal proper WASH practices are in mitigating infections and disease outbreaks.

In addition, the respondents' WASH practices had continued to significantly increase after the rationing ended. Consistent with the earlier findings on H1, this observation upholds the pivotal role of access to adequate and uninterrupted water supply for individuals' ability to perform WASH practices. It conforms with the mainstream theories of behavioral change, which collectively underscore that a behavior performance requires a facilitative setting [23,71–73]. Additionally, such steady growth can be indicative of the formation of a new habit among the respondents. It implies a possibility that their heightened WASH practices might have persisted even after the pandemic had ended [14,74].

4.4. Effect of Water Collection Activity on Social Distancing Performance during the Pandemic

Figure 2 shows that a total of 27 (36.99%) respondents had to collect water externally during the rationing. They had been collecting water from a water tanker and/or local collection point (n = 8) or a family member's/relative's/friend's house (n = 7), as well as both sources (n = 12). While a majority of them had been making water collection trips once or twice in a week (n = 11), there were also respondents who had made at least seven such trips in a week (n = 3). More than half of the affected respondents only had to travel less than 2 km from their residences (n = 16), with one (n = 10) or two (n = 10) household members accompanying them.

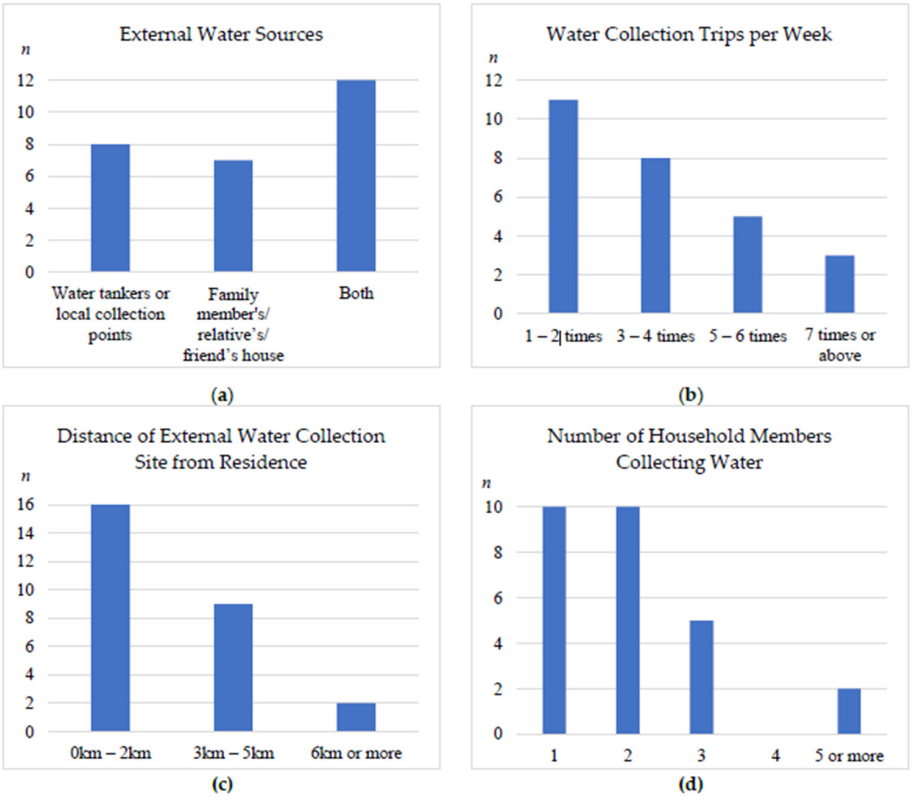


Figure 2. Respondents' external water collection activity during water rationing exercise (n = 27): (**a**) sources of external water supply; (**b**) water collection trips made per week; (**c**) distance of external water collection site from residence; and (**d**) number of household members accompanying respondents during water collection trips.

Table 8 below presents the frequency analysis for how external water collection affected the respondents' social distancing performance during the pandemic. A total of 81.48% of them found that crowds were present at the water collection sites. Contact with non-sanitized surfaces at these sites had been unavoidable for the 85.19% of the respondents confirming such an occurrence. Moreover, while 77.78% of the respondents had observed compliance with the mask-wearing requirement among the crowds present at the location, 51.85% found that it had been very difficult to comply with the one-meter social distancing requirement. Finally, 85.18% of them agreed that external water collection activity during the pandemic was indeed inappropriate.

Table 8. Effect of external water collection on respondents' performance of social distancing measures during the pandemic (n = 73).

Social Distancing Measure		*n*	%	Mean (Std. Dev.)	Median
Crowd presence at collection site	Yes	22	81.48	1.19 (0.396)	1.00
	No	5	18.52		
Contact with non-sanitized surfaces	Yes	23	85.19	1.15 (0.362)	1.00
	No	4	14.81		
Compliance with mask-wearing requirement among the crowd	Yes	21	77.78	1.22 (0.424)	1.00
	No	6	22.22		
Compliance with one-meter social distancing requirement among the crowd	Very difficult	14	51.85	1.63 (0.742)	1.00
	Difficult	9	33.33		
	Easy	4	14.81		
	Very easy	0	0.00		
Appropriateness of external water collection during the pandemic	Very inappropriate	12	44.44	2.04 (1.192)	2.00
	Inappropriate	7	25.93		
	Slightly inappropriate	4	14.81		
	Slightly appropriate	3	11.11		
	Appropriate	1	3.70		
	Very appropriate	0	0.00		

Std. dev. = Standard deviation.

The Spearman's correlation analysis for the effects of external water collection on the respondents' performance of social distancing measures are presented in Table 9. The results demonstrate that the frequency of external water collection was significantly and negatively correlated with the size of the crowd present at the collection sites, $rs = -0.394$, 95% BCa CI [−0.619, −0.124], $p = 0.042$. This indicates that the respondents performed more external water collections when there were smaller crowds at the collection sites, which was a safer approach, as compared to repeated visits to crowded sites.

The crowd size at the collection site meanwhile had a significant positive correlation with the respondents' contact with non-sanitized surfaces during water collection, $rs = -0.606$, 95% BCa CI [−0.063, 1.000], $p = 0.001$. This correlation holds true, in that as more people converged in a place, they would inevitably touch the same surfaces. Without sanitation, the surfaces would have served as perfect Petri dishes for bacteria and viruses, which would then have led to COVID-19 spread in the community. Handling of non-sanitized, common surfaces also defeated the purpose of the one-meter social distancing requirement.

Similarly, the respondents' contact with non-sanitized surfaces during water collection was significantly and positively correlated to their compliance with the one-meter social distancing requirement; $rs = 0.391$, 95% BCa CI [−0.137, 0.651], $p = 0.044$. Their compliance with the one-meter social distancing requirement also had a significant positive correlation with their opinion on the appropriateness of collecting water from external sources during the pandemic; $rs = -0.674$, 95% BCa CI [−0.063, 1.000], $p = 0.001$. Since such activities required the respondents to venture out and be around others, they were not conducive

to the performance of effective social distancing measures. In consequence, the more the respondents were unable to properly distance themselves from the crowds, the more inappropriate they considered it that this activity was taking place during the pandemic.

Table 9. Spearman's correlation analysis of external water collection's impact on respondents' performance of social distancing measures during the pandemic (n = 27).

	Collection Frequency	Crowd Presence	Contact with Non-Sanitized Surfaces	Mask-Wearing Compliance	Social Distancing Compliance	Appropriateness
Collection frequency	−1.000	−0.394 (0.042)	−0.035 (0.861)	−0.042 (0.834)	0.010 (0.961)	0.119 (0.555)
Crowd presence	−0.394 (0.042)	−1.000	0.606 (0.001)	−0.025 (0.900)	0.270 (0.173)	0.149 (0.458)
Contact with non-sanitized surfaces	−0.035 (0.861)	0.606 (0.001)	1.000	−0.223 (0.264)	0.391 (0.044)	0.269 (0.174)
Mask-wearing compliance	−0.042 (0.834)	−0.025 (0.900)	−0.223 (0.264)	1.000	0.025 (0.901)	−0.024 (0.905)
Social distancing compliance	0.010 (0.961)	0.270 (0.173)	0.391 (0.044)	0.025 (0.901)	1.000	0.674 (0.000)
Appropriateness	0.119 (0.555)	0.149 (0.458)	0.269 (0.174)	−0.024 (0.905)	0.674 (0.000)	1.000

Full category definitions: Collection Frequency = Water collection frequency; Crowd Presence = Crowd presence at collection site; Mask-Wearing Compliance = Compliance with mask-wearing requirement among the crowd; Social Distancing Compliance = Compliance with one-meter social distancing requirement among the crowd; Appropriateness = Appropriateness of external water collection during the pandemic. The *p*-values are presented in parentheses.

These results collectively corroborate the fact that the external water collection had not been a suitable activity to be carried out during the pandemic, as it exposed people to crowds. By forcing people into closer physical contact with one another, this activity had defeated the very purpose of social distancing. In addition, it caused them to come into contact with non-sanitized surfaces of shared objects touched by many, such as water buckets, hoses and taps. This ultimately increased the risk of COVID-19 transmission in the community. H3 is therefore supported. The respondents' external water collections during the rationing had a significant negative impact on their social distancing performance. This study's findings are also in conformance with other similar studies conducted in different countries [5,6,35,52].

5. Conclusions, Limitations, and Future Research Directions

Prior to the COVID-19 pandemic, WASH practices were not given much emphasis, even though they are crucial and effective in preventing the spread of communicable diseases [39]. However, the pandemic has changed that. Numerous studies conducted in various countries have reported improvements in individuals' WASH performance, above all, hand washings [15–26]. This development thus makes access to appropriate WASH infrastructure, especially clean and uninterrupted water supply, more vital.

Nevertheless, the residents of Melaka, Malaysia had to weather the pandemic and water rationing concurrently in early 2020. Seizing the opportunity in these simultaneous real-time occurrences, this study aims to analyze the impact of water rationing on the WASH practices and social distancing performance of the state's residents. Most of all, it focuses on examining any shifts in their WASH practices as a result of both the pandemic and water rationing.

The results showed that a considerable majority of the respondents had significant negative perceptions on the impact of water rationing on their WASH practices during the pandemic. Yet, their WASH performance had significantly grown after the pandemic started, even when the rationing was in effect. This study also found that a significant

majority of the respondents who collected their water externally during the rationing viewed such activity as detrimental to their social-distancing performance.

The findings are essentially in agreement with prior studies in other countries. On the whole, these studies' conclusions underscore the fact that the increase in individuals' WASH practices during the pandemic was a global phenomenon, evident even among the residents of a state undergoing water rationing. People during that time were much more concerned about the severity of COVID-19 when there wasn't yet a vaccine or cure. In consequence, they were more receptive to the extensive WASH advisories and campaigns by the global health authorities. Now, they have become much more cognizant of how pivotal proper WASH practices are in mitigating infections and disease outbreaks.

Furthermore, this study reported increases in individuals' WASH performance, even during the rationing itself. This is indicative of a new but enduring hygiene habit among residents in Melaka, Malaysia. It is vital that the new habit be sustained to build community resilience against future disease outbreaks [23]. Accordingly, the extensive WASH campaigns and public education programs should be continued by health authorities to ensure that the message is ingrained in the populace. At the same time, a facilitative setting should be provided for this new habit to flourish further.

In respect of the provision of a facilitative setting, this study's findings particularly emphasize the critical necessity of an adequate and uninterrupted supply of clean water. Therefore, appropriate provision of WASH facilities and infrastructure should be made available to all households. Indeed, Target 6.1 of the SDG6 aspires to universal and equitable access to safe and affordable water for everyone by 2030 [1]. This, however, will require considerable financial commitment by the government, especially when the country's existing WASH infrastructure is aging and impaired by a weak maintenance culture.

This study contributes towards addressing the existing research gap in relation to the implication of water rationing on individuals' WASH practices and social distancing performance during the pandemic. Yet, it is also limited in certain ways. Firstly, this study focuses on a specifically targeted population i.e., the residents of Melaka, Malaysia. In consequence, its results may not be able to be directly extrapolated to populations in other locations. Moreover, it should be noted that the water rationing exercise in Melaka was only enforced for two months, i.e., from 29 January 2020 to 1 April 2020. Should the rationing have been any longer, its impact on the affected individuals' WASH practices and social distancing performance might have been different.

This study also recognizes the limitations of its survey approach. Its use of a web-based questionnaire as well as recruitment methods due to the lockdown made the survey more attractive to educated and computer-literate respondents with access to the Internet. This could have alienated the residents with lower education levels, those living in areas with no access to the Internet, and/or those who were not computer-savvy. The self-reported nature of the responses makes them vulnerable to reporting bias. As the questionnaire concerned personal hygiene practices, it is expected that some respondents might have over-reported their own performance, potentially impacting the data. Moreover, despite the researchers' efforts in reaching out, this study's final sample was small relative to the state's population. This study attributes its small sample size to the possibility of the residents of Melaka being apathetic due to the stress of the prolonged pandemic and subsequent lockdown they had been subjected to.

Accordingly, this study suggests that future research be conducted in areas that suffered much longer water shortages during the pandemic. This will provide a platform for comparative analysis of how prolonged water shortages affect individuals' WASH practices. This study also suggests future research on the personal motivations behind the increase in individuals' WASH practices during the pandemic. The effectiveness and success of the WASH advisories and campaigns by health authorities in boosting individuals' WASH practices during the pandemic should also be further examined. In particular, the cultivation effect from the widespread WASH advisories and campaigns among the public should be analyzed. Additionally, it is imperative for analysis to be

performed on the question of whether the habit of WASH practices among individuals persists now that the pandemic has significantly abated. The findings from such an analysis would have important public health implications, notably in building community resilience towards existing communicable diseases, but also in future disease outbreaks.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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