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Article

Assessing the Connections between COVID-19 and Waste Management in Brazil

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Abstract: In addition to the health crisis caused by the coronavirus pandemic, several countries—particularly in developing regions—faced serious additional challenges in the economic, social and environmental areas. In Brazil, one of these challenges refers to the changes in consumption caused by the lockdowns, and the environmental impacts caused by new patterns of waste generation. Against this background, this paper investigates the changes in consumption and waste generation in Brazil during the COVID-19 pandemic. It provides a technical contribution to the topic by comparing the perception of survey respondents on the amount of household waste produced before and during the pandemic, and cross-checking these with information on current aspects of policymaking, the findings suggest that the amount of some specific types of household waste has noticeably increased, challenging even more the local waste management systems. The data instrument was validated by a pre-test, prior to deployment. According to the respondents, packaging (both plastic and paper/cardboard) was the type of waste that reported the highest increase in generation during the lockdowns, which is in line with the results of increased consumption of food delivery within this period. The results also suggest that current waste management policies make Brazil ill-equipped to deal with one of the non-intended effects of the COVID-19 pandemic, which has severely impacted Latin America's largest country.

Keywords: household waste; waste generation; consumer behaviour; waste policies; environmental policies; environmental impact

1. Introduction

Coronavirus Disease 2019 (COVID-19) was first diagnosed in Wuhan, China, at the end of 2019 [1], and quickly spread to other countries [2]. By the middle of May 2022, more than 523 million cases were already diagnosed worldwide, causing more than 6.27 million deaths [3]. Since this disease is mainly transmitted through contact between people [4] and some people may not present any symptoms, social distancing and travel restriction measures to reduce the transmission rate were recommended by authorities [5].

In Brazil, the first diagnosis was made in February 2020. After that, the number of cases increased quickly [6]. In addition to the characteristics of high transmissibility of the virus, this increase can be related to government measures. The Brazilian government has been ill-prepared to deal with the pandemic, including the lack of a national plan to control the number of cases, and the difficulties faced by the government to distribute vaccines, among other problems. Additionally, although it is observed that countries such as USA and United Kingdom are prioritizing social measures, in Brazil these measures are secondary, receiving much fewer resources than measures to support the financial sector [7]. It is important to mention that the Latin America countries presented serious problems, aggravated during the COVID-19 pandemic (income inequality, informal work and poverty). These problems aggravated the challenges already faced by the region that is impacted by social-economic issues due to historical roots [8].

The extent of the pandemic and its consequences worldwide have aroused a need for anti-contagion protocols, protective measures, and policies such as social distancing, home-schooling, work from home, and lockdowns [9,10]. For example, the Brazilian Government published on 23 March 2020 provisional measures altering some labour regulations such as the adoption of remote working, anticipation of vacations, and the possibility for collective vacation concessions. In addition, through the provisional measure 936/20 created to maintain employment and income conditions, it was also possible to reduce working hours or temporary suspension of the employment contract [11].

Consequently, these restrictions and measures impacted families' daily lives, suggesting that people had to start coping with the new pandemic context by changing their lifestyles, behaviours, routines [12], and work modality [13,14]. One significant change is related to the new consumption behaviours [15–18] imposed by the restriction measures and the subsequent household waste production changes in quantity and quality [19].

Within this context, the literature underlines the importance of tracking this new consumption behaviour and its subsequent domestic waste production. Regarding the waste management, the development level of the country [20] and the area of waste generation (e.g., medical waste) [21] should be considered. An example of difference on countries strategies of waste management, it can be mentioned the initiative of some nations to improve safety measures for waste management to deal with the increase in contaminated waste in domestic trash [22]. As a positive manner to learn with the experience of the COVID-19 pandemic, it is possible to mention the better understanding that the waste management should be considered in the context of a circular economy [23]. Indeed, Sharma et al. [24] mention that the circular economy approach focused on solid waste management should be prioritized in the post-COVID-19 scenario, with an active engagement of policy makers, that can create green jobs.

Considering the COVID-19 pandemic outbreak context in Brazil, consultancy groups such as McKinsey & Company, Ernst & Young, and PwC identify similar changes as the academic community regarding the changes in Brazilians' consumption behaviours. These studies performed by these companies went in the same direction, underlining four main trends shaping consumption preferences and behaviours since the beginning of the COVID-19 pandemic:

- The first is related to the economic dimension in which the reduction in families' income and the rising unemployment rate made people, on average, change preferences and reduce costs by buying only essentials, opting for cheaper brand products, and supporting the local economy.

- The second main drive is connected to people's health and well-being, generating increased purchasing of personal hygiene products, cleanliness, and preference for essential and healthy food at grocery stores.
- Thirdly, the rise of digital and online shopping brought comfort and safety, providing a way that people could buy and stay protected from COVID-19 in their homes
- Finally, the fourth trend is related to the fact that most Brazilians are spending more time at home and spending more on home improvements, and developing other skills and habits such as home cooking [25–27].

Considering the mentioned context, the present study aims to analyse the changes observed in the consumption of the Brazilians citizens due to the COVID-19 pandemic. In addition, this paper analyzes Brazilians perception regarding waste management public policies. The development of this study is justified due to the differences in the consumer behaviour and the public management of the pandemic in each country. It should be noticed that according to Fan et al. [28], the waste management has not been receiving enough attention, and their aspects vary according to the country analysed.

Besides this introduction, this paper presents an overview of the state of the art in Section 2. The methodological procedures used to conduct the research are presented in Section 3. Section 4 focuses on the results and discussions. The conclusion is shown in Section 5.

2. COVID-19, Household Consumption and Waste Production

Throughout the world, the COVID-19 pandemic led to restrictions on movements and access to facilities. It also influenced the frequency and scale of shopping.

Table 1 summarizes this dynamic by identifying how the COVID-19 anti-contagion policies [9,29,30] resulted in changes in household consumption and waste production patterns. Additionally, it showcases three categories of domestic waste that were most impacted during the COVID-19 pandemic: food waste, packaging waste and, potentially COVID-19 infected waste.

Table 1. Impact of COVID-19 policies on household consumption and waste production.

Dimensions	Implications	Main References
COVID-19 Outbreak Measures and Policies	Quarantine measures; Social Distancing/protective facial masks; Lockdowns/Stay at home directives; Homeschooling/work from home; Restaurant closures	Bennett [10]; Crokidakis [29]; Hsiang et al. [9]; Qiu et al. [30]
Changes in Household Consumption	Increase in delivery services; Increase in online purchasing; Acquisition of prepared food outside/takeaway; Increase in packaged meals; Increase in packaged products' consumption; Better Food management/Cooking at home; Rise in health concerns in food choices; Changing in shopping frequency and routines; Increase in single-use products; Stockpiling non-perishable food and other supplies	Aldaco et al. [31]; Amicarelli & Bux [32]; Burlea-Schiopoiu et al. [33]; Cosgrove et al. [34]; Leal Filho et al. [19]; Pappalardo et al. [35]; Patrício Silva et al. [36]; Rodgers et al. [16]; Roe et al. [17]; Sarkodie & Owusu [37]; Vanapalli et al. [38]
Impacts on the household waste production	Scaled-up domestic waste volume; Decrease in food waste generation; Increase in packaging waste (e.g., paper/plastic boxes, bags, and sacks). Raising in COVID-19 potentially infected waste (e.g., protective facial masks, tissue paper, hygiene products).	<p><i>Packaging Waste references:</i> Adyel [39]; Leal Filho et al. [19]; Hantoko et al. [40]; Patrício Silva et al. [36]; Sarkodie & Owusu [37]; Vanapalli et al. [38]</p> <p><i>Food waste:</i> Amicarelli & Bux [32]; Burlea-Schiopoiu et al. [33]; Cosgrove et al. [34]; Hantoko et al. [40]; Pappalardo et al. [35]; Principato et al. [41]; Rodgers [16]; Roe et al. [17]</p> <p><i>Potentially COVID-19 infected waste references:</i> Behera [42]; Dharmaraj et al. [43]; Di Maria et al. [44]; Sarkodie & Owusu [37]; Unicef [45]</p>

In general, there is a common sense in the literature that food waste has decreased during the pandemic, possibly due to the fact that as people start spending more time at their homes, they have engaged in more home-cooking and became more conscious about what (and how much) food they should purchase and prepare; therefore, a better household food management might be in place [16,17,32–35,40,41]. However, this pattern of reducing waste does not stand true for the other household waste categories. Several studies have drawn attention to the surge of packaging waste (e.g., paper/plastic boxes, bags, and sacks) as a result of the intensification the single-use product purchasing, and the increasing online buying and delivery services [19,36–40]. Additionally, among these studies, there is a particular concern about the consequences of household plastic waste, where issues related to the impacts of plastic on terrestrial and marine ecosystems are addressed, as well as possible policies and strategies to enhance plastic waste management [38,46,47]. Finally, the literature also calls attention to the potentially COVID-19 infected household waste such as medical masks, tissues, and other personal use products, which started being consumed since the onset of the COVID-19 and offer a significant risk of environmental pollution and contagion [37,42–45].

According to the Ernst and Young's report [25] about the impacts of COVID-19 on Brazilian consumer behaviour, Brazilians' new main concerns were about meeting their basic needs during the pandemic. According to the study, 71% of the respondents reported they were prioritizing personal hygiene and home cleanliness to contain contamination. Additionally, as people avoided activities outside, they were rediscovering their lives in their homes (47% of the respondents reported they depend less on hired help, 69% of the respondents started to cook often in their homes, and 41% are connecting more with friends and family). This also challenged usual consumer behaviour as people began to go less to stores, use more meal delivery services, and order assorted products online.

In sum, the rises in e-commerce were a significant trend in 2020 as the number of new consumers grew, and e-commerce revenues presented higher levels than the same periods in the previous years, due to the stay-at-home effect caused by the COVID-19 pandemic. In this context, it is estimated that the first semester of 2020 achieved an e-commerce sales record of BRL 38.8 billion (around USD 7.6 billion), approximately 47% higher when compared to the first semester of 2021. Additionally, studies point out that a large percentage of Brazilian consumers started using or increased their frequency of purchasing through delivery apps, especially grocery shopping, ready-to-eat meals, pharmacy items, and clothing [48].

Public policies created from the spread of the pandemic faced urgencies and actions that especially addressed social and economic aspects. Due to these complex problems, public policies developed in this period an action plan that was horizontal and coordinated outstanding circumstances such as suspension of classes, prohibition of face-to-face events, limiting the flow of people in airports, closing of trade, and social isolation.

One of the policies created by the government to reduce waste generation was the incentive for efficient waste sorting, that is, the correct separation between domestic solid waste and those that can be recycled [49]. This incentive does exist, but most of the recycling process in Brazil still occurs manually. During the pandemic, several cities in the country suspended recycling services due to the high risk of contagion, since the virus can remain on materials' surfaces for days, representing a potential risk of contagion among workers [50]. Even so, the remaining municipalities (e.g., S. Paulo) contributed to an increase of around 20% in 2020, in the total of solid waste destined for selective collection, when compared to 2019. The municipal solid waste had a huge increment in the last decade dissociated from the pandemic influence. For example, there was an increase of 30.3% in the quantity of this waste destined for landfills, due to the larger population living in the urban areas. During the pandemic, an increase of 15–25% in household waste generation was projected. It was noticed that there were decentralized decisions about the functioning of the waste management sector during the pandemic [51]. This could be due to the fact that the amount of municipal households' waste depends both on the administrative type of the

municipality and on the factors related to the location and socioeconomic characteristics of the citizens living in the area [52].

This scenario also evidences the importance of the adoption of strategies on the production side to valorise waste through a circular economy perspective. For example, packaging waste could be reduced through product design and manufacturing practices, and companies could put efforts into increasing waste treatment and engage in interindustry waste exchanges [53] or identifying the value of materials found in waste by reusing, recycling feedstock materials or even adopting renewable ones [54,55]. In addition, sustainable practices and innovation toward the adoption of circular business models could support the process of helping organisations implement a circular economy [56].

Finally, issues related to food loss and food wasting also should take into account since there is space for optimising processes and engaging stakeholders involved either on the production or the consumption side to overcome these challenges and reduce negative environmental and social externalities. In this sense, food waste is related to the consumption side of the supply chain and can be reduced in several ways, such as donations to social services or the utilisation of organic material for the production of biofuels. On the other hand, food loss can be tackled by the optimisation of industrial practices, investment in infrastructure, and increased awareness of climatic and environmental issues that could impact food production and transportation [56].

3. Methods

This research, focused on the perception of waste generation in Brazilian households, uses a quantitative approach. By means of an online questionnaire, data were collected from respondents across Brazil. To construct the survey, an extensive review of the literature was carried out and several studies and reports regarding the production of waste within households served as the basis for the questionnaire, e.g., [57–60]. The idea was to gather information on perceptions on attitudes and behaviours from individuals during the COVID-19 pandemic. The authors based this study on the approach proposed by Leal Filho et al. [19], adding a new section on public waste management and policies. Thus, the final version of the survey included four main sections:

- Section 1: demographic data and information regarding the type of household, family composition, and lockdown stage: as in Leal Filho et al. [19], this section intended to characterise the study respondents;
- Section 2: level of consumption (changes in the consumption of certain categories of products—packed food, fresh food, takeaway/online food delivery);
- Section 3: waste generation in the household (changes in the quantity of waste generated during the lockdown, reasons for those changes and types of waste more generated—including food waste, non-recyclable waste, and plastic packaging);
- Section 4: waste management and formulation of politics (municipalities procedures, challenges to the waste management systems, measures to better deal with the problem of waste during pandemic events, national politics for the waste management, and satisfaction with the waste management in Brazil).

The questionnaire was validated with ten sustainability researchers by means of a pre-test, resulting in minor adjustments for clarity—including number, order and reorganisation of sections and how options were described. The findings from the data collected during the pre-test indicated the survey instrument was satisfactory, with the applied minor changes. The final version is presented in Appendix A.

After revision, the online survey was then applied through Google Forms, in Portuguese, and shared with scientific mailing lists to which the co-authors have access and the network of the Inter-University Sustainable Development Research Programme (IUS-DRP), characterising a convenience sampling strategy. The survey collected 170 responses between March and May 2021, which were examined using descriptive statistical analysis.

The gender distribution of the studied group of respondents (57.6% female and 41.2% male) roughly follows the overall Brazilian gender distribution for those over 18 years

old (52% female and 48% male). In terms of age distribution, the groups between 18–29 and 30–39 years old formed the largest share of respondents, reaching 36.5% and 34.7% of the total, respectively. The age groups of 40–49, 50–59, and over 60 years old represented 15%, 11%, and 3% of the respondents, respectively. The overall Brazilian age distribution above 18 years old is, for the same age groups, 30%, 22%, 18%, 14%, and 15%, meaning that the group of respondents was able to reproduce well the Brazilian age distribution in all groups except for a slightly over the participation of age group 30–39 years-old and smaller participation of the people over 60 when compared to the national values. Over 70% of the respondents were postgraduates, whereas 4.7% completed high school and 24.7% completed higher education. Differences between the respondents and national averages are significant when considering the educational level, with higher education respondents being overrepresented when compared to the national averages (10% of the population).

4. Results and Discussion

This section presents the analysis of the survey data in two subsections: respondents' attitudes on consumption and waste generation, covering an overview of the characteristics of food consumption and waste generation, and Waste Management and Policies, exploring the respondents' views in terms of satisfaction with the national and local policies on waste management.

4.1. Respondents' Attitudes on Consumption and Waste Generation

The respondents were asked about any changes in consumption of packed food, fresh or organic food (e.g., vegetables), and takeaway (or home-delivered food) during the lockdown in 2020. The consumption of food at home during the pandemic increased from 38% to 66% of the respondents, as expected, since during the lockdown people spent more time at home and children are also at home instead of at nurseries or school. However, the increase depended on the type of food. Although the consumption of packed food increased for 38% of the respondents, more than half (55%) of the respondents increased their consumption of fresh food, and almost two-thirds (66%) increased food delivery. This is in line with some studies reporting the increase in food packaging waste motivated, in part, by the increase in the takeaway food and delivery services [19,57]. In comparison to the international study of Leal Filho et al. [19], the Brazilian respondents have higher percentages of increase in consumption of packed food and food delivery, and also increased generation of food waste. The summary of the answers is shown in Table 2.

Table 2. Summary of changes in the consumption of food and overall waste generation ($n = 170$).

Food Category	Consumption Change	Responses (%)	Distribution of Responses (%)				
			Blanks	Up to 10%	10–20%	20–30%	Over 30%
Packed food	No change	39.4%	100%	-	-	-	-
	Increased	38.2%	-	25%	43%	18%	14%
	Decreased	22.4%	3%	13%	32%	26%	26%
Fresh food	No change	31%	100%	-	-	-	-
	Increased	55%	-	22%	31%	27%	20%
	Decreased	14%	-	33%	21%	4%	42%
Food delivery	No change	26%	100%	-	-	-	-
	Increased	66%	0	28%	21%	16%	35%
	Decreased	8%	8%	23%	31%	-	38%
Waste generation	No change	16%	-	-	-	-	-
	Increased	75%	-	24%	29%	24%	23%
	Decreased	6%	-	50%	20%	20%	10%
	Do not know	3%	-	-	-	-	-

Smaller shares of respondents indicated a decrease in food consumption in the studied categories (packed, fresh, delivered), which may indicate that some groups could have engaged in healthier diets or taken advantage of the possibility of preparing meals at home.

Overall, 76% of the respondents indicated an increase in waste generation in the household during the lockdown period, 16% reported no changes and 6% reported a decrease in waste generation, as also shown in Table 2. The changes in the generation of different types of waste are explored further in Figure 1.

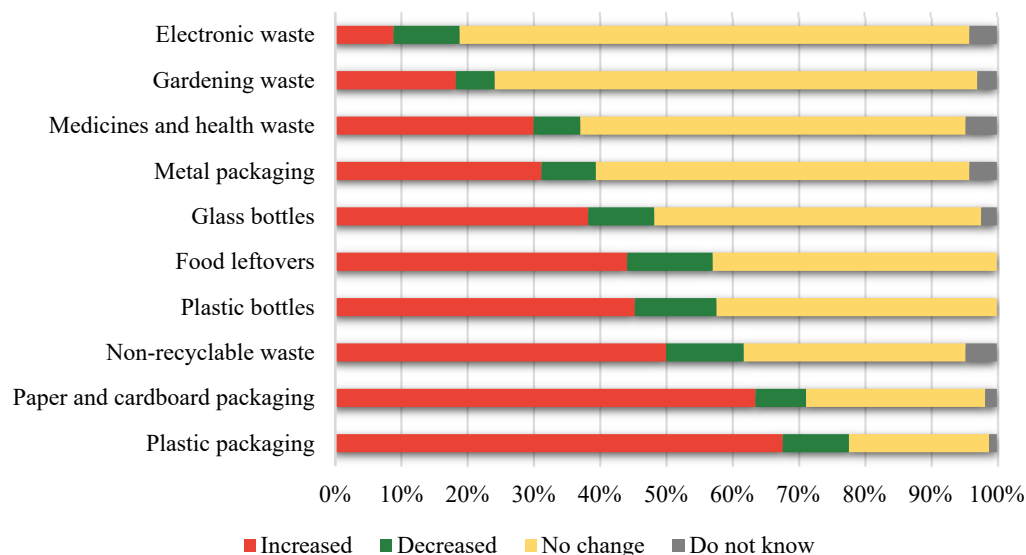


Figure 1. Changes in the generation of waste types in the households during the pandemic.

According to the information provided by the respondents, packaging waste in their households increased during the pandemic by 68% for plastic packaging and by 64% for paper/cardboard packaging. This finding is in line with other previous studies that call attention to the surge of packaging waste (e.g., paper/plastic boxes, bags, and sacks) as a result of the intensification of the single-use product purchasing, and the increasing online buying and delivery services [19,22,36–40]. In comparison to the international investigation [19], similar patterns of responses are observed; nevertheless, Brazilians indicated higher percentages of increase for paper/cardboard waste and non-recyclable waste—which is aligned with the result of increased consumption of food delivery (that is commonly distributed with plastic and paper/cardboard materials and might also lead to the increase in non-recyclable materials due to contamination). The increase in food delivery stated by 66% of the respondents (Table 2) likely contributes to the surge in packaging waste reported in this study as Sharma et al. [61] have previously linked the increase in the demand for food delivery options during the pandemic to an increase in packaging waste, especially plastic. Therefore, it is important to adopt sustainable packaging, such as reusable or biodegradable containers, to balance this increased demand. However, only 18% of the respondents looked for sustainable packaging options when ordering food during the pandemic, whereas 40% of the respondents never considered this issue and the remaining 43% only rarely took sustainable packaging into consideration when ordering food.

Less than one-third of the respondents (30%) reported an increase in medicines and health waste. The literature calls attention to the potential of infections by COVID-19 through household waste such as medical masks, tissues, and other personal use products [37,42–45]. Although one could expect a higher increase rate of health waste (e.g., due to the use of masks), this might indicate that the respondents engaged in alternative options for health protection, such as reusable cloth masks [47] instead of disposable ones.

The amount of food waste increased in 44% of the households according to the respondents. This is a new finding as the literature shows a tendency for decreased generation of

food waste during the pandemic, possibly due to the fact that as people had to spend more time at their homes, they engaged in more home cooking and could better control how much food they should purchase and prepare, therefore resulting in a better household food management [16,17,32–35,40,41]. This was not the case in this studied group of respondents and the results in Figure 2 bring some light to the possible reasons for this trend.

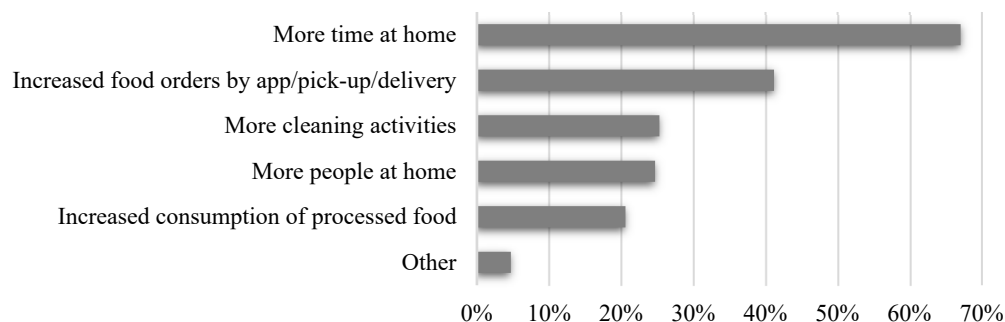


Figure 2. Reasons for changes in waste generation during the pandemic.

For the most part of the respondents (67%), spending more time at home is among the main reasons for changes in waste generation, followed by increased food orders by app, pick-up, or delivery (41%). Although “more time at home” was also indicated as a reason by the respondents who reported a decrease in waste generation, their other reasons included engaging in waste composting and the possibility of cooking at home. Analysing the reasons reported only by respondents who indicated an increase in waste generation, the importance of spending more time at home increases to 83% and online food orders to 51%.

In comparison to the international study, in which results were more balanced across options (with all reasons receiving between 75–95% of responses) [19], Brazilians were more assertive in proving the reasons for change, with cleaning activities, more people at home and increased consumption of processed food being perceived as having less impact in the changes. Although the post-pandemic scenario might reduce the contribution of being more time at home to the increased consumption and waste generation, it is important to reflect on the impact caused by changed consumer behaviour for safety reasons and how it impacts long-term efforts to reduce consumption of different types of packing, for example.

4.2. Individual and Public Waste Management Practices

This section aims to present the individual and municipalities’ procedures to deal with the increased amount of waste generation. The challenges to the waste management systems, the measures to better deal with the problem of waste during pandemic events, the national politics for waste management, and the satisfaction with the procedures of waste management in Brazil were also covered.

Regarding waste separation (e.g., between organic and recyclable), 83.5% of the respondents indicated following separation procedures in their households, demonstrating a concern with this issue. When asked if their efforts to separate waste changed during the lockdown, the majority of the respondents said that no changes were observed (66.5%). A positive outcome of this investigation is that, of the respondents who indicated a change in efforts (33.5%), almost all of them (93%) said that the efforts to separate waste increased.

The survey was also interested in understanding the main challenges associated with waste management during the lockdowns. Among the options offered, the most selected ones were the increased amount of packaging waste (65%) and Personal Protective Equipment—PPE (e.g., gloves, masks) (36%), keeping or developing efforts to separate waste (32%), and dealing with food waste (21%). 5% of the respondents indicated no challenges associated with the pandemic and the procedures of waste management in their households. The options also included challenges associated with the frequency of public waste collection, but the results were not so expressive (8% of the respondents indicated

that the increased frequency of waste collection was a challenge, whereas 13% indicated as challenge the reduced frequency). The high percentage of increased packaging waste reinforces the findings explored in the previous section and brings the new component of consumers being aware of this problem. As policy recommendations around plastic waste management under the pandemic situation call for prioritising citizen-science approaches—in addition to better links between research, policy, and industry [36], these results could be considered promising. It is also necessary to consider the specificity of the municipality, the population density, the use intensive of energy, etc. [52].

Correspondingly, the survey asked the respondents to indicate whether they observed changes in public waste collection. Only 14% indicated that changes were observed (whilst 57% reported no changes and 29% did not know). It might indicate that perceived impacts on public waste management in Brazil during the lockdown were not so significant.

Despite the environmental problems aggravated by the lockdown, there were also some “positive” aspects mainly related to a higher green consciousness such as the increased efforts to eat healthier (56%), control food waste (50%), to be more aware of waste generation and separation (25%) and a major interest in recycling options (21%). However, 25% of the respondents reported no change in their behaviour as a result of the lockdown.

Brazilian respondents were extremely critical regarding the national policies for waste management, as seen in their opinions summarised in Table 3. In all statements, more than 60% of the respondents indicated either total or partial disagreement. The statement on “appropriate government-led efforts to promote citizen engagement in reducing waste generation and separating waste, and on the selective collection” observed the highest percentages of disagreement. Less than 10% of the respondents believe that national or municipal waste management policies in place are adequate to deal with the changes in waste generation caused by the pandemic.

Table 3 also presents a set of aspects of waste management policies (e.g., selective waste collection and environmental education) to which respondents should indicate their level of satisfaction. Following the results explored in the previous paragraph, around half of the respondents indicated the option “not at all satisfied” in all aspects. Among the list and the negative results, the selective waste collection and the support to collectors of recyclable waste seem to be the aspects that gather more level of satisfaction regarding the government’s performance. On the other hand, ‘support for the recycling industry’ has not received any positive feedback (“extremely satisfied”), which is worrying especially considering the recycling potential in Brazil and how this industry is seen as fundamental for the waste management sector [51,62].

Table 3. Type of policy measures related the waste management and level of satisfaction regarding public policy on waste management.

Statements on Waste Management Policies	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
The national waste management policies in place are adequate to deal with the changes in waste generation caused by the pandemic.	37.1	38.8	18.2	4.7	1.2
The waste management policies in your city are adequate to deal with the changes in waste generation caused by the pandemic.	33.5	41.2	17.1	7.1	1.2
Current operating procedures for manual collection of waste during the pandemic are adequate.	24.1	38.2	25.9	10.6	1.2

Table 3. Cont.

Statements on Waste Management Policies	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
Current operational hygiene procedures in handling waste collection during the pandemic are adequate.	24.7	38.2	27.6	8.8	0.6
Government-led information campaigns on waste management are adequate.	47.6	25.3	17.6	6.5	2.9
Government-led efforts to promote citizen engagement in reducing waste generation and separating waste, and selective collection, are appropriate.	51.8	30.0	12.9	2.9	2.4
Aspects of Waste Management Policies	Not at All Satisfied	Slightly Satisfied	Moderately Satisfied	Very Satisfied	Extremely Satisfied
Regularity and universalization of public service provision in waste management	42.9%	34.7%	14.1%	7.6%	0.6%
Adequate selective waste collection	42.9%	29.4%	19.4%	7.1%	1.2%
Support for the recycling industry	45.3%	36.5%	11.8%	6.5%	0.0%
Support to collectors of recyclable waste	46.5%	31.8%	13.5%	7.1%	1.2%
Pursuit of more sustainable management and final destination options	50.6%	30.0%	12.9%	5.9%	0.6%
Promotion of Environmental Education	50.6%	32.4%	13.5%	3.5%	0.0%

On the other hand, it is important to highlight that this observed dissatisfaction is not totally related to the pandemic. The survey investigated if the level of satisfaction with the aspects above changed during the pandemic; for 68% of the respondents, there was no change in their opinion, and 31% indicated that the overall situation reduced their satisfaction.

Finally, the respondents could also point out which measures should be intensified for better waste management procedures, especially in situations related to disasters or pandemics. The most indicated measures were increased communication between municipal authorities and the community (73%) and the provision of tax incentives/deductions by local governments to encourage responsible waste management practices (72%). Higher percentages were also observed for improved product design to use less packaging (65%) and improved product design to increase recyclability (63%). Improved design to increase the life cycle and more regular/frequent waste collection were the least indicated among the options provided (42% and 34%, respectively). Other individually indicated measures include educational and awareness-raising efforts and increased dissemination of the schedules for selective/recycle waste collection. Even though these educational aspects were mentioned to a lesser extent, they have a great impact on the success of the other investigated initiatives, as they rely on citizens' awareness and engagement [60].

The safety initiatives taken by the population during the pandemic, although necessary, negatively impacted sustainability efforts such as reducing consumption of plastic packaging and single-use products. The results investigated in this study pointed out how the Brazilian respondents perceive the change in household waste generated before and during the pandemic, and their views regarding policy measures. As presented by Ranjbari et al. [23], research on post-COVID-19 initiatives in terms of waste management should include a system-thinking approach, a circular economy model and development of informal sectors and local capacity. Based on the views of the Brazilian respondents, particularly

on the need for information campaigns and citizen engagement, those research [23] needs also apply to the analysed national context, as supported by other investigations [60,62]. Given the reported increase in generation of waste associated with plastic, paper and cardboard packaging, more importance should be paid to waste prevention and reduction in policy recommendations [60], as well as with the great investments needed in the recycling sector's infrastructure [62].

5. Conclusions

This study aimed at reporting on the changes in consumption and in the amounts of waste produced in Brazil during the pandemic, in addition to exploring aspects of waste management policy and the views of Brazilians around these issues, based on responses provided by those who took part in the survey.

The increase in consumption of food delivery was quite prominent among the respondents, in comparison to packed or fresh food. Accordingly, three in four respondents have also observed an increase in waste generation in their households. The main reasons reported for this change were spending more time at home and ordering more takeaway/delivery food. According to the respondents, packaging (both plastic and paper/cardboard) was the type of waste that reported the highest increases in generation during the lockdowns, also in line with the scenario of increased consumption of food and delivery options. An additional finding of this study was the reported increase in food waste in the households, as other researchers have been showing tendencies of decrease. This might be connected to the high consumption of takeaway food, which may lead to higher amounts of waste.

In terms of waste management policy, the respondents were extremely critical of the ways waste is being currently handled, reflecting on how the waste management infrastructure in Brazil is under pressure to cope with the different patterns of waste generation. Overall, the respondents were not satisfied with the policies in place to handle aspects of waste management, such as citizen engagement, selective collection, and support to the recycling industry. Nevertheless, this dissatisfaction does not seem to be a direct result of the pandemic and the problems associated with the lockdowns, as over two-thirds of the respondents reported that their opinion has not changed during the pandemic—indicating issues that the population has been struggling with for years.

To improve waste management procedures, the respondents support measures such as increased communication between municipal authorities and the community, and the provision of tax incentives/deductions by local governments to encourage responsible waste management practices. There is also a good potential for the development of improved product design to use less packaging and increase recyclability, indicating important research-industry opportunities, as well as consumers' interest in these options.

This study has some limitations. Firstly, the small sample size does not allow it to make definitive conclusions. Secondly, the networks within which communication about the survey was circulated suggest that only people with a certain level of education took part in it. Despite these constraints, the study provides a contribution to the literature since it presents an overview of trends of the perception of respondents on consumption and household waste in association with the pandemic. Among several international studies on this topic, the scientific novelty of this paper consists of (a) the data generated for the Brazilian scenario, (b) the possibility of replication in other countries, and (c) the new insights on consumer perceptions and waste generation patterns.

Future and complementary studies can deepen the knowledge of the long-term impact of the pandemic in the waste management sector, and how the redistribution between different waste sources has occurred.

Even though waste management systems were not substantially affected by the pandemic, the observed redistribution in waste generation is likely to last for years to come, which will probably put the country's waste management system under greater pressure.

Thus, it is strongly suggested that waste management policy makers take into consideration some lessons learned. These are:

- Lesson 1: Whereas the green behaviour of the Brazilian population shows signs of pro-waste management initiatives, the increased consumption of households will require a re-calibration of urban waste management systems so that they may better cope with increased demands.
- Lesson 2: Government's initiative is perceived as a missing link in improving waste management in Brazil, which will require a strong commitment from public bodies to regain the confidence of the population about the legitimacy of the government in waste management initiatives
- Lesson 3: New types of waste such as medicines and PPE—which were less prevalent before the pandemic—should receive attention from public authorities to assess the impacts of these types of waste on the Brazilian waste management system.

Finally, it is important that multiple stakeholders—mainly companies—engage in the design of food products that require less packaging and, inter alia, lead to reduced environmental impacts.

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Appendix A. Questionnaire—COVID-19 and Household Waste Production in Brazil

Section 1: Background

1. Country

2. Gender
 - Female
 - Male
 - Prefer not to say
3. Age
 - 18–29
 - 30–39
 - 40–49
 - 50–59
 - 60+
4. Level of Education
 - Post Graduate
 - Graduate
 - High School complete
 - Incomplete primary/secondary education
5. Occupation
 - Upper Management
 - Middle Management
 - Junior Management
 - Administrative Staff
 - Trained Professional

- Skilled Laborer
 Consultant
 Temporary Employee
 Self employed/Partner
 Student
 Retired
 Unemployed
6. Net monthly household Income
- Below EUR 500
 EUR 500 to EUR 1000
 EUR 1001 to EUR 1500
 EUR 1501 to EUR 2000
 EUR 2001 to EUR 2500
 EUR 2501 to EUR 3000
 Above EUR 3000
 Prefer not to say
7. Type of housing
- Flat
 Semi-detached house
 Detached house
 Other: _____
8. Number of persons or individuals in the household
- | | 0 | 1 | 2 | 3 | 4 or More |
|---|---|---|---|---|-----------|
| Number of Adults Other | | | | | |
| Number of Children (less than 18 years old) | | | | | |
9. Area of living place
- Urban
 Rural
10. Stage of lockdown at the height of the COVID-19 pandemic
- Full Lockdown
 Partial Lockdown
 No Lockdown
11. Current stage of lockdown:
- Full Lockdown
 Partial Lockdown
 No Lockdown
- Section 2: Level of Consumption**
12. Has the consumption of packed food in your household changed during the lockdowns in 2020?
- Yes, it has increased
 Yes, it has decreased
 No change
- 12.1. If it has increased or decreased, to what extent?
- Up to 10%
 Between 10% and 20%
 Between 20% and 30%
 Over 30%

13. Has the consumption of fresh food such as fruits and vegetables changed during the lockdowns in 2020?
- Yes, it has increased
 - Yes, it has decreased
 - No change
- 13.1. If it increased or decreased, to what extent?
- Up to 10%
 - Between 10% and 20%
 - Between 20% and 30%
 - Over 30%
14. Has the consumption of takeaway or online food delivery changed in your household during the lockdowns in 2020?
- Yes, it has increased
 - Yes, it has decreased
 - No change
- 14.1. If it increased or decreased, to what extent?
- Up to 10%
 - Between 10% and 20%
 - Between 20% and 30%
 - Over 30%
15. When purchasing food online, do you look for food options that come in sustainable packaging (e.g., reusable packaging, biodegradable packaging material)?
- Always
 - Seldom
 - Never

Section 3: Waste Generation

16. Has the waste generation in your household changed during the lockdowns in 2020?
- Yes, it has increased
 - Yes, it has decreased
 - No change
 - Do not Know
- 16.1. If it has increased or decreased, to what extent?
- Up to 10%
 - Between 10% and 20%
 - Between 20% and 30%
 - Over 30%
- 16.2. Please point the reasons for this change (if applicable, multiple options possible)
- More time spent at home
 - More people at home
 - More take away food
 - More online orders of consumable goods delivered to home
 - Increased Cleaning Activities
 - Other: _____
17. Which types of waste generation have changed the most in your household during the lockdown?

	Increased	Decreased	No Change	Do Not Know
Food waste				
Non-recyclable waste				
Plastic packaging				
Paper and cardboard packaging				
Plastic bottles				
Glass bottles				
Metal packaging				
Gardening waste				
Electric and electronic waste				
Medical waste				

Section 4: Waste Management and Formulation of Public Policies

18. Do you use different bins for the separation of household waste?
 - Yes
 - No
19. Have local council regulations been changed in your city/district/area in terms of household waste separation during the lockdown?
 - Yes
 - No
 - Do not Know
20. Have your efforts to segregate waste (organic and recyclables) changed in your household during the lockdowns?
 - Yes, they increased
 - Yes, they decreased
 - No change
21. Which were the main challenges regarding waste management at your household during the lockdown? (Multiple answers can be selected)
 - Increased amount of food waste
 - Increased amount of packaging waste
 - Increased amount of health waste (e.g., gloves, masks)
 - Frequency of waste collection increased
 - Frequency of waste collection decreased
 - Keep/develop efforts to segregate waste
22. Which of the following can be considered outcomes of the lockdown in your household? (Multiple options can be selected)
 - Increased awareness regarding waste generation and segregation
 - Increased interest in composting options
 - Increased efforts to control food wastage
 - Increased efforts to eat healthier
 - No change have occurred
 - Increased interest in recycling options
23. Which of the measures below should be intensified for better management of waste during disaster situations? (Multiple options can be selected)

- Greater communication between local council and the community
- Improvement product design to use less packaging
- Improvement product design to increase recyclability
- Improvement product design to extend the lifetime of products, when possible
- More regular/frequent waste collection
- Provision of incentives/tax deductions by local governments to encourage responsible waste management practices
- Other: _____

24. Please indicate your level of agreement/disagreement with the following statements: Use the following scale: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree

	1	2	3	4	5
The national waste management policies in force in your country are adequate to deal with the variations in waste generation caused by the pandemic.					
Waste management policies in your city are adequate to deal with variations in waste generation caused by the pandemic.					
Current operational procedures for manual waste collection during the pandemic are adequate.					
The current hygiene operational procedures in the management of waste collection during the pandemic are adequate.					
Government-led information campaigns on waste management are adequate.					
The efforts led by the government to promote the involvement of citizens in reducing the generation and separation of waste, as well as selective collection, are adequate.					

25. What is your level of satisfaction with the political action in waste management in your country considering the following aspects? Use the following scale: 1 = Not satisfied at all; 2 = Little satisfied; 3 = Satisfied; 4 = Very satisfied; 5 = Completely satisfied

	1	2	3	4	5
Promotion of Environmental Education					
Incentives to the recycling industry (e.g., encourage the use of raw materials derived from recyclable and recycled materials)					
Regularization and universalization of the provision of public waste management services					
Support for collectors of recyclable materials (e.g., creation of cooperatives)					
Adequate selective collection					
Search for more sustainable management and final disposal options					

26. In general, has there been any variation in your level of satisfaction in relation to waste management policy in your country during the pandemic?

- Yes, more satisfaction
- Yes, less satisfaction
- There has been no variation

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