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Selective collection: Factors guiding the process based on the case study of a medium-sized city in Minas Gerais

Coleta seletiva: fatores norteadores do processo a partir de um estudo de caso de cidade de médio porte em Minas Gerais

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ABSTRACT: One of the crucial elements that determine the success or failure of Selective Collection Programs (SCPs) in the municipalities consists of popular participation, as this process depends directly on source separation. For this reason, studies that identify favorable or unfavorable conditions for this participation are of utmost importance for SCP planning. However, there is a gap in this type of research in the Brazilian context. In this scenario, this study aimed at identifying, based on the residents' perceptions, the demographic, motivation and barrier factors that influence the decision to separate solid waste at source in the urban area of a medium-sized city and, taking these perceptions into account, propose alternatives to increase SCP efficiency. To achieve this goal, a questionnaire survey was conducted, with the sample defined by a random probability method of three-stage cluster sampling. A total of 850 questionnaires were considered valid, with 95% confidence interval, 3% error margin and 78% maximum variability. It was found that the main determinants for the decision to separate waste at source were age group, schooling level, environmental quality, domestic and public area infrastructures, lack of time and amount of solid waste generated. It was also observed that 82% of the population already carry out some type of solid waste segregation and that 86.82% are willing to participate in SCPs. Therefore, it is recommended to adapt the language and communication means used in the programs according to the target audience, considering accessibility and understanding of each one. The current study corroborates the future applicability of selective collection programs as a sustainability tool for solid waste management, encouraging further research in this area and as a basis for structuring environmental education programs focused on selective collection.

Keywords: solid waste; selective collection; recycling; source separation; adherence by the population.

RESUMO: Um dos elementos cruciais que definem o sucesso ou fracasso dos Programas de Coleta Seletiva (PCS) nos municípios consiste na participação popular, já que esse processo tem dependência direta da segregação na fonte geradora. Por essa razão, estudos que identifiquem condições favoráveis ou desfavoráveis a esta participação apresentam grande relevância no planejamento do PCS. Entretanto, há uma lacuna desse tipo de pesquisa no contexto brasileiro. Nesse cenário, este estudo visou identificar, com base na percepção dos moradores, os fatores demográficos, de motivação e de barreira que influenciam na decisão quanto à segregação na fonte dos resíduos sólidos na área urbana de uma cidade de médio porte, para, fundamentado neles, propor alternativas para aumento da eficiência dos PCS. Para tanto, foi realizada pesquisa quantitativa, com aplicação de questionário estruturado, sendo a amostra definida por método probabilístico de amostragem aleatória. Foram consideradas 850 entrevistas válidas, com nível de confiança de 95%, probabilidade de 3% de erro e variabilidade máxima de 78%. Constatou-se que os fatores mais significativos para a tomada de decisão quanto à segregação dos resíduos sólidos nas residências consistem na faixa etária, escolaridade, qualidade ambiental, infraestrutura da residência e das áreas públicas, falta de tempo e quantidade de resíduos sólidos gerada. Observou-se ainda que 82% da população já realiza algum tipo de segregação dos resíduos sólidos e que 86,82% está disposta a participar do PCS. Assim sendo, recomenda-se a adequação da linguagem e dos meios de comunicação utilizados no programa conforme público-alvo, tendo em vista a acessibilidade e entendimento de cada um. O presente estudo corrobora a aplicabilidade futura de programas de coleta seletiva como um instrumento de sustentabilidade para a gestão de resíduos sólidos, incentivo a novas pesquisas na área e base para estruturação de programas de educação ambiental com foco na coleta seletiva.

Palavras-chave: resíduos sólidos; coleta seletiva; segregação na fonte; reciclagem; adesão da população.

1. Introduction

Unlike the regular solid waste collection practiced in Brazil, whose centrality is cleaning and removal of solid waste from the generating sources, the focus of selective collection consists in valuing and increasing the useful life of the materials collected (Eigenheer & Ferreira, 2015). Thus, this collection modality aims at collecting solid waste in a differentiated way for their reinsertion in the productive cycle.

And it is based on this solid waste segregation that the different materials can be properly destined, maximizing leverage and minimizing the environmental impacts. It is recognized that, to render these different destinations economically viable, in addition to making the work of people who deal with Urban Solid Waste (USW) more humane, it needs to be separated at source and collected in a different way, according to the destination (Gallardo *et al*., 2010).

Having recognized the importance of selective collection, the question remains as to why between 2010, the year when the National Solid Waste Policy (*Política Nacional de Resíduos Sólidos*, PNRS) was enacted in Brazil, and 2019 there was progress in regular USW collection (from 88% to 92%); however, there was almost no change in the percentage of materials sent for recycling, which is directly related to SCPs (ABRELPE, 2020).

On the other hand, a 19% increase was observed in the generation of urban solid waste during this period (ABRELPE, 2020). With the effective implementation of the PNRS, it was expected that there was at least a respective increase in the rates of materials destined to recycling. However, data

from the National Sanitation Information System (*Sistema Nacional de Informações sobre Saneamento*, SINIS) shows that, of the 3,172 municipalities surveyed in 2019 (66.6% of the total), only 38.7% had selective collection, resulting in 1.04 million tons of solid waste recovered (SINIS, 2019). In general, the selective collection rates do not exceed 4% in the country (ABRELPE, 2020).

Of the total solid waste collected in 2019 (72,748,515 tons), 59.5% had landfills as final destination, 23% controlled landfills, and 17.5% ended up in dumps (ABRELPE, 2020). Considering the amount of solid waste that is diverted through collection, 5,281,070 tons (1.3%, considering the difference between generation and collection) are still disposed of in waterways and spillways, among others.

Conke (2018) emphasizes that selective collection programs can present obstacles at several points, such as separation, collection, treatment or disposal, in addition to proper management that can account for stagnation. Gallardo (2010) asserts that success of a selective collection program largely depends on the population, as it represents a contact between generators and managers. According to the author, meeting the expectations of both parties, that is, a convenient program for the population and good quality materials for efficient management, will make the system work properly.

Understanding in depth both the barriers and motivational factors that interfere with citizens' willingness to segregate their solid waste at source will make a difference in the development and implementation of a successful SCP. Therefore, although several research studies point to some paths to be followed, the fact is that the programs implemented lose strength quickly and are not long-lasting, as expected. Thus, studies seeking to identify decisive factors in the process are important for USW management in Brazil.

Considering that solutions cannot always be replicated due to local specificities, especially those linked to the population's habits, considering a case study carried out in the city of Uberaba, Minas Gerais, it was sought to identify key elements that interfere with choosing solid waste source segregation, based on the residents' own perceptions about the program. The municipality in question was chosen because it portrays the reality of medium-sized cities[1], which welcome industries from large urban centers and a consequent population increase, although without major advances in USW management.

2. Bibliographic review

2.1. Selective collection

Defined by the PNRS as the "collection of solid waste previously segregated according to its constitution or composition", selective collection, in accordance with Article 8 of Decree 10,936 dated 2022, which regulates Law No. 12,305 of 2010, must be "implemented by the holder of the public urban cleaning service and should establish, at a minimum, the separation of dry and organic solid waste and, progressively, be extended to the separation of dry solid waste in its specific parcels, according to goals established in the respective

[1] According to the IBGE, cities with between 100,000 and 500,000 inhabitants are considered medium-sized (Gomes, 2015. p. 517).

plans" (Brazil, 2010. Art 3, V; Brazil, 2022. Art 8 §1). Eigenheer & Ferreira (2015, p. 677) understand selective collection as "differentiated collection of materials already separated at the generating sources, aiming to ease their reuse as well as ensuring their quality".

More broadly, selective collection comprises a series of actions that comprise a chain with the involvement of different agents, such as those who collect the materials and transport them, those responsible for incorporating these materials back into the production cycle and the consumers, who are responsible for separation and disposal of the materials (Conke, 2018). Thus, from the management point of view, this set is considered as SCPs. Each stage of this system consists in leverage or obstacles for their operation.

The following can be mentioned among the benefits of differentiated collection of discarded materials: final disposal cost reductions, with remediation of degraded areas and public cleaning; increased useful life of landfills; reduction of the solid waste to be transported and stored until final disposal; increased the amount and improved quality of the materials recovered, which results in rational use of natural resources; improved working conditions and income for collectors; and encouraging citizen participation in solid waste management and in reducing consumption (Vilhena, 2014; Conke, 2018; Pivetti *et al.*, 2020).

Aiming at the aforementioned objectives, the PNRS initially stipulated the proper environmental destination of all garbage until 2014. Thus, it was understood that, by that date, there should be maximum solid waste use, only sending to landfills materials for which no processing was possible due to technical or financial limitations; however, data from 2019 show that 40.5% of the solid waste collected was sent to landfills or controlled landfills. Law No. 14,026 was enacted in 2020, extending the deadline to 2024 (Brazil, 2020).

Among the barriers to implementing SCPs in Brazil, we can mention people's lack of knowledge regarding the operational aspects of the program, including recyclability of the materials and collection schedule, aversion to the presence of disposal devices, incorrect sizing and illusory expectations about human behavior and SCP results on the part of public managers; disputes with independent collectors, low financial returns and lack of regulation in the recycling chain, among others (Conke, 2018).

It is known that, when planning selective collection programs, factors such as time spent for separation, space required in homes, incentives and fees, among others related to people's behavior, should be considered and, sometimes, even mentioned in the initial SCP planning phase. However, the system's technical information, such as costs, collection vehicle travels and amount of solid waste generated, for example, have greater weight in the final decision, resulting in low popular adherence. Thus, elements aiming at increasing participation only start to be emphasized after achieving results below the expected in the programs implemented (Gallardo, 2010; Bringhenti & Günther 2011; Eigenheer & Ferreira, 2015; Ibáñez-Forés *et al*., 2018; Meng *et al*., 2019; Cudjoe *et al*., 2020).

Considering the importance of SCPs in solid waste management, the low implementation rate for this type of program and the fact that public participation is indispensable in this process, the reasons for people's participation should be taken into account.

2.2. Adherence by the population

According to a study presented by Miranda & Mattos (2018), the process to implement an SCP has five phases: diagnosis, planning, implementation, operation, and analysis of the benefits. In all these stages, it is essential to understand the population preferences and needs for a program to be successful.

The concept of rationalist administration prevailed until the 1980s, which, according to Takahashi (2020), neglected people's participation conferring emphasis to technical decisions. However, this procedure proved to be inefficient to deal with the environmental issues, with emergence of the concept of economic rationalism and extended responsibility to the producers. In this new model, the costs of the products' entire life cycle must be paid by the producer, who passes them on to the consumer and also seeks alternative solutions for more sustainable production. Consequently, the consumers' attitude, and therefore that of solid waste generators, gains more relevance for decision-making.

In this sense, one of the significant advances of the PNRS was the inclusion of the generators' accountability in solid waste management. Thus, the entire society is somehow involved in the final destination of the materials disposed of. Regarding household solid waste, its generators are responsible for its proper availability for collection or return, in case of reverse logistics (Brazil, 2010).

Considering the large amount of solid waste generated in urban areas, source segregation becomes essential to reduce contamination in recyclable materials and ensure their better leverage. Consequently, public policies will only be effective if there is a change in the population behaviors and voluntary adherence to the practices proposed, understanding personal accountability (Eigenheer & Ferreira, 2015; Conke, 2018; Knickmeyer, 2020).

When analyzing studies in several countries on the reasons for the population's adherence or not to selective collection systems, Struk (2017) summarizes the most cited factors to be considered by decision-makers when choosing a methodology in terms of distance and convenience; in other words, availability and distance of places for solid waste disposal and separation ease.

A similar result was found by Xiao *et al*. (2017). In addition to that, depending on the context, factors such as income, schooling level, age and presence of incentives can exert an influence on the population behaviors (Struk, 2017). However, the cost-benefit analysis carried out when deciding whether or not to participate in an SCP should be highlighted; as stated by Escario *et al.* (2020): people's attitude can be based on this analysis in an individual way. For this reason, demographic factors such as income may not show significance in the analysis, as separation may not be compensating or due to the low return associated, or even to the high cost involved.

As a priority, for higher people's participation levels to be attained, investments should be made to provide information to the potential participants in the collection process, at the disposal loci, in marketing and in regulation (Xiao *et al*., 2017).

Wilson & Williams (2007) recommend that annual research studies should be carried out by the bodies responsible for solid waste management so that indicators can be surveyed to improve the services provided, an understanding shared by Knickmeyer (2020), when he emphasizes the im-

portance of preliminary research to characterize the population and adapt the system to be implemented, such as identifying results and costs by monitoring behavioral changes.

Tong *et al*. (2018) noticed that 70% of the people receptive to participating actually become participants in the programs; therefore, it is concluded some factors that can encourage or discourage solid waste separation in homes, that is, conditions that will or will not help turn intention into action (Wang *et al*., 2020b).

Consequently, this study aims at contributing to filling the knowledge gap about people's participation and interest in the solid waste source separation, considering the reasons that lead residents to carry out segregation or not. As a result, decision-makers will be able to consider effective tools to stimulate people's participation in SCPs.

3. Methodology

3.1. Study area

The study object consisted of urban households from the head district of the municipality of Uberaba, Minas Gerais, excluding both building and house condos. The municipality is located in Triângulo Mineiro (Figure 1) and, according to the IBGE 2010 Census, its total population in that year was 295,988 inhabitants. Of this total, 285,662 lived in urban areas (IBGE, 2010).

Uberaba has a privileged geographic location, approximately 500 km equidistant from cities such as São Paulo, Belo Horizonte, Goiânia and Brasília and connected to them through state and federal highways. Its development is linked to people and shopping circulation across these cities (Gomes, 2015).

As explained by Gomes (2015), the municipality is among the cities that have been receiving investments due to economic and industrial decentralization. Approximately 93% of all 4,523,957,000 km^2 of the municipality are considered rural areas (Uberaba, 2006; IBGE, 2010). However, agriculture is last in terms of contribution to the municipality's GDP (4.7%), with the service sector ranking first (53.2%), industry second (30.7%) and public services third (11.4%), according to data from 2018 (IBGE, 2021).

In relation to solid waste management, the municipality presents modest numbers, even in terms of documentary records. In 2005, the municipal landfill came into operation and, until then, the solid waste collected had been landfilled in a controlled manner. In 2012, a private landfill was installed to receive hazardous solid waste and civil construction waste (*DRZ Gestão Ambiental*, 2013). Also focusing on hazardous solid waste, there are two non-energy-using incinerators in the municipality, one installed in 2015 and the other the following year. At least two companies that receive and process solid civil construction waste, returning it as raw material to the production cycle, also operate in the city.

A total of 11 Ecopoints for the disposal of civil construction solid waste were implemented in 2007. Despite the existence of these places, the population still deposits solid waste in Permanent Protection Areas (*Áreas de Proteção Permanente*, APPs), vacant lots, on the sides of highways and even close to recycling bin facilities, at times when they are closed, or even solid waste that is not received, such as electronics (Silva & Teixeira, 2012).

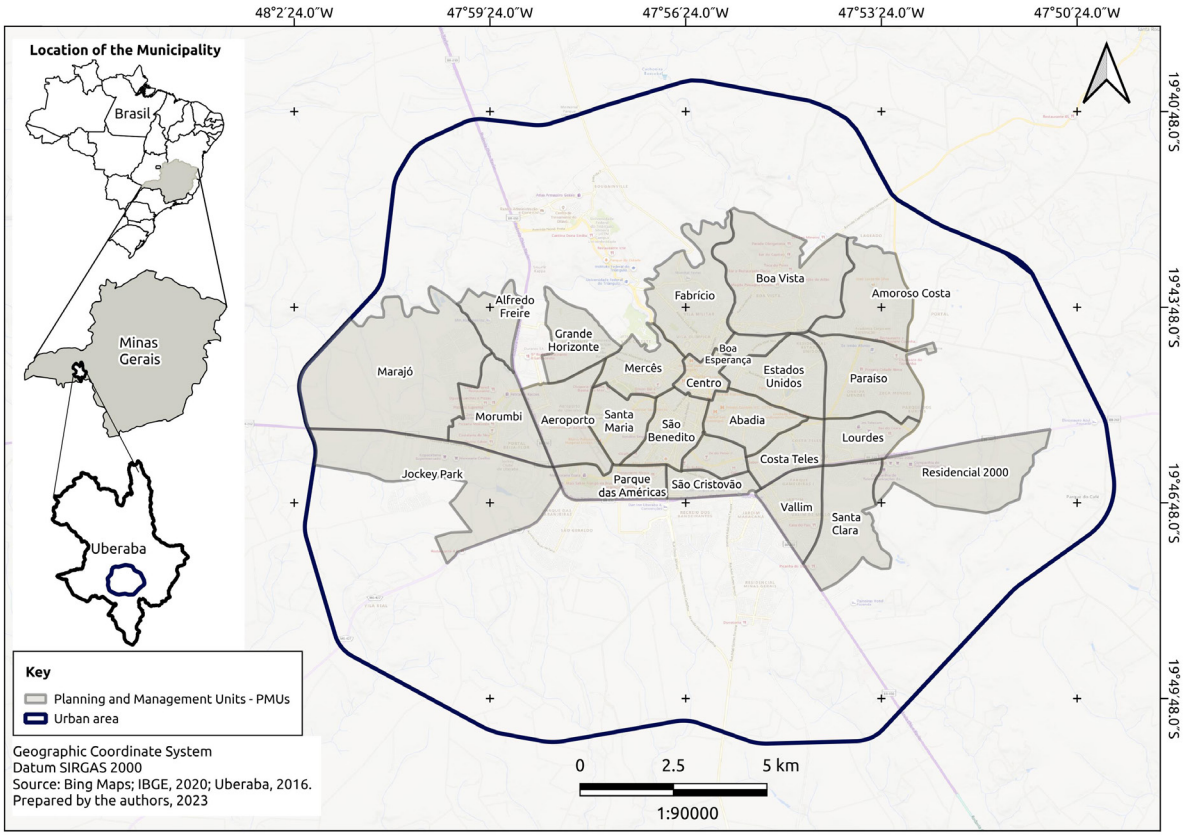

FIGURE 1 – Location of the municipality of Uberaba and the PMUs selected.
SOURCE: Prepared by the authors based on Bing Maps (maps database), IBGE 2020 and Uberaba 2006.

The municipality also has disposal points for batteries and fluorescent lamps from domestic users as part of the reverse logistics system for these sectors, respectively operated by *Green Eletron* and *Reciclus*, in addition to the *Agronelli* Institute, which periodically receives these materials, and the *Black and Decker* Company, which participates in reverse logistics of batteries. To collect pesticide packaging, there is a unit at the National Empty Packaging Processing Institute (*Instituto Nacional de Processamento de Embalagens Vazias*, INPEV) (Green Eletron, 2021; INPEV, 2021; Reciclus, 2021).

There is a collectors' cooperative in the municipality and several companies that buy and sell recyclable materials from urban and industrial solid waste, which negotiate them directly with independent collectors and with productive sectors. However, no formal SCP is implemented. Consequently, this research aims at contributing to the im-

plementation of this program, as it is indispensable to know the motivations and barriers for adherence by the population.

Sample quantification was performed after surveying the general information of the municipality, which characterize the city as medium-sized. Considering that collection is carried out by homes and the researchers' access, the sampling space was delimited. The detailed calculations are shown in item 3.2.

3.2. Sample calculation

To calculate the sample, the number of properties registered for payment of the Urban Property Tax (*Imposto Predial e Territorial Urbano*, IPTU) was considered: 157,411 residences, according to data from the Uberaba Municipal Finance Department (2019, unpublished data), as well as the probabilistic method of random sampling by clusters in three stages, the last of which is systematic sampling.

The cluster sampling method consists in dividing the population into N groups, then "x" number of these groups are included in the sample. Each population element corresponds solely to a single cluster. When in one stage, all elements of the clusters selected are sampled. When it occurs in two or more stages, as in this research, a subgroup of elements within the conglomerates selected is randomly drawn (Stat Trek, 2019).

In systematic sampling, only the first element is chosen at random and the others are selected according to a predefined criterion, for example, one in every two; the umpteenth individual will be included into the sample set according to the standard adopted (Ochoa, 2015).

The following was also considered: 95% confidence level (p=0.95), 3% margin error (E=0.03) and 78% maximum variability (Z=0.78), according to Equation 1 (Santana, 2013).

$$n0 = (q.p.Z^2) / E^2 \text{ (Equation 1)}$$

Where:

n0 = Initial sample and q = 1-p

As refinement, considering that the target population has a defined number, Equation 2 was applied, where N is the total number of homes to be studied, resulting in 730 households to be sampled. 5% above this result was adopted as safety margin, totaling 767 households.

$$N = n0/ (1 + ((n0+1) / N)) \text{ (Equation 2)}$$

Based on Decree No. 80 of October 15th, 2009, which regulates Articles 375 and 376 of the Master Plan (Uberaba, 2009), the neighborhoods were grouped into subdistricts, according to the urban Planning and Management Unit (PMU) to which they belong. Therefore, within cluster sampling, the subdistricts assembled the groups.

Thus, a random draw of samples was carried out for 25 subdistricts (Figure 1) of all 33 occupied residentially; the sample size for each one was rounded considering a 5% safety margin, resulting in a total of 863 interviews to be conducted.

In the last stage of this method, the blocks from each PMU were numbered based on the images available on *Google Earth*® and were randomly drawn to assemble subgroups; subsequently, syste-

matic sampling was applied to choose the homes to be included in the sample. After random collection in the first house, the neighboring one was excluded, thus interviewing alternated homes. When the chosen household was unable to participate in the research due to any impediments, the one immediately following was included.

For safety reasons, during data collection, additional interviews were carried out considering the engagement level shown by the interviewee as an exclusion factor. In case of lack of interest, for example, inattention to the questions, answers given in a hurry or incomplete answers, the interview was excluded from the sample. Consequently, individual interviews were conducted with people living in 874 houses, excluding 24 forms due to the aforementioned, with 850 valid questionnaires remaining.

3.3. Questionnaire

The research instrument used was developed based on several similar studies (Bringhenti & Günther, 2011; Santana, 2013; Conke, 2018; Wang *et al*., 2020a), having been submitted to and approved by the competent Ethics and Research Committee[2]. The questionnaire was divided into three parts: the first one refers to demographic data such as age, schooling and income; the second one, to questions related to current participation (Q1) and willingness to participate in solid waste source segregation into three types: organic, recyclable and garbage, that is, SCP (Q2); finally, the third part consisted of the motivation factors and barriers for solid waste source separation.

3.4. Interviews

The field work was carried out in the first half of 2020. An electronic questionnaire via the *Google Forms*® platform was used, which was substituted with a printed form in case of lack of Internet devices or signal. The interviews were carried out door-to-door, choosing the person responsible for solid waste management in the home environment, when possible and, when not, the individual receiving the researcher, was the interviewee, as long as they were over 18 years old. Before starting asking the questions, the Free and Informed Consent Form (FICF) was read and the interviews were conducted after due agreement.

3.5. Data analysis

To perform the statistical calculations, the answers were numerically qualified, with double-checking, to validate the results. For question Q1, any separation procedure performed in the household was considered, with the exception of used cooking oil. Thus, the answers given by residents who reported separating organic solid waste for feeding domestic animals or separating plastics and aluminum cans for self-employed collectors were considered a "Yes".

In the case of the questions about items motivating and demotivating participation in SCPs

[2] Ethics Committee for Research involving Human Beings of the Federal University of Triângulo Mineiro (Protocol No. 27850620.1.0000.5154), including the Free and Informed Consent Form (FICF).

(Q3 and Q4), the answers were different from the predetermined ones. In these cases, the information provided was grouped in three ways: included in already existing categories; included in the "others" category; or a new category was created. This last case occurred when such answer was obtained repeatedly.

The SPSS® software was used to calculate the answer percentages. When identifying associations between answers, demographic factors and participation, for example, contingency or cross tables were calculated, that is, the answers to one question were compared in relation to another. *Fisher*'s Exact or *Pearson*' Chi-square tests were used to identify the association between two variables.

The objective of all tests was to show the significance corresponding to the association between the data in the analysis, which is evidenced when the result is lower than 0.05. The first test was developed for small samples, although it can be used in larger samples and provides an exact p-value, whereas the *Pearson* test is done by approximation and is best applied to larger samples (AGRESTI, 1992). In the current research, preference was given to the *Fisher*'s Exact result; if this test did not produce results due to computational limitations, the value shown by *Pearson*'s Chi-square was used. The data are presented graphically in plotting charts made in the Canva® platform.

4. Results and discussion

4.1. Characterization of the population sampled and socioeconomic factors

The characterization of the population living in the sampled households showed that there was predominance of female respondents (61.88%), aged over 50 years old (52.35%), income up to two minimum wages (58.00%) and schooling up to High School level (72.83%), as can be seen in Table 1.

In relation to the predominance of female respondents, this can be explained because women are in charge of household chores. The highest proportion of women corresponds to data from IBGE (2010); however, in the census the proportion of women corresponds to 52.1% and 47.95% of men.

In addition to that, the IBGE data show that 24% of the population is aged over 50 years old. The difference in the values can be explained by fact that the sample cutoff point is over 18, whereas the IGBE data are related to the total population.

Regarding income, according to IBGE, the municipality's mean income through wages is close to the one found in the research (2.8 minimum wages), and the schooling level of the residents sampled is close to the national mean: 21.8% with Higher Education (IBGE, 2021), representing 19.77% of the sample.

According to the studies carried out by Aprile & Fiorillo (2019) and Geiger I. (2019), the likely elements that act towards greater or lesser participation of the population in selective collection programs can be grouped into socioeconomic factors, intrinsic or individual, and extrinsic or contextual.

TABLE 1 – Characteristics of the population living in the households sampled (n=850).

Characteristic	Result (%)	Characteristic	Result (%)
Age group		*Gender*	
18-29 years old	15.30	Female	61.88
30-39 years old	16.82	Male	38.12
40-49 years old	15.53	*Schooling*	
50-59 years old	19.76	Less than one year/No formal education	3.88
60 years old or more	32.59	Incomplete Elementary School	20.24
Income (Minimum wages)		Complete Elementary School	12.47
Up to 1	32.82	Incomplete High School	6.71
1-2	25.18	Complete High School	29.53
2-3	17.41	Incomplete Higher Education	7.41
3-5	13.64	Complete Higher Education	16.59
5-10	4.35	Graduate Studies	3.18
10-15	2.71	*Participation*	
More than 15	2.47	Separates in some way	82.00
Not reported	1.41	Would separate into three types, if there was an SCP implemented	86.82

SOURCE: Prepared by the authors

Four socioeconomic factors were considered in this study, as shown in Table 1. In order to identify the influence of these factors, the characterization of the population was compared to the answers to the following questions: “Separates in some way at home” (Q1), with the objective of identifying current participation and “Would separate into three types” (Q2), to identify the propensity for future participation in more complex SCPs (solid waste separation into dry, damp and garbage).

Table 2 shows the *Fisher*'s Exact and *Pearson*'s Chi-square test values resulting from the comparisons. Considering that values greater than 0.05 (5%) mean no association between the variables, two characteristics among the demographic factors deserve to be highlighted: “age group” and “schooling”. According to the data, the age group is correlated to the population current participation (Q1), whereas age group and schooling are not relevant for future engagement (Q2).

In Figure 2 it can be seen that people aged over 40 years old are more engaged in solid waste separation (Q1). Similar results were found by Ibáñez-Forés *et al*. (2018) and by Wadehra & Mishra (2018). Escario *et al*. (2020) argue that older people have a deeper sense of urgency in relation to

TABLE 2 – Factors influencing participation for the households sampled.

Factors	Q1		Q2	
	Fisher	Pearson	Fisher	Pearson
Demographic				
Gender	0.052		0.358	
Income	0.675		0.113	
Age group		**0.022**		**0.003**
Schooling		0.099		**0.026**
Barriers (Q5)				
Intrinsic				
Lack of habit	0.111		0.400	
No interest in participating	0.550		0.800	
No interest in participating[2]	0.116		**0.000**	
Extrinsic				
Insufficient space in the house	**0.003**		0.343	
Lack of time		**0.001**	**0.000**	
No place to separate solid waste	0.110		0.800	
No results with selective collection programs	1.000		1.000	
Little recyclable waste is produced	0.192		**0.000**	
Little recyclable waste is produced[2]	0.600		**0.000**	
No program is implemented	0.258		**0.002**	
Others	0.850		1.000	
Motivations (Q4)				
Intrinsic				
Improving environmental quality	0.100		**0.005**	
No reason for not participating	**0.000**		**0.000**	
Not incentive-dependent	0.188		0.417	
Extrinsic				
IPTU reduction	0.276		0.477	

Discounts in public services	0.426	0.913
Shopping discounts	0.198	0.262
Presence of specific collectors	0.258	**0.000**
Others	0.676	0.441

KEY: [2] They did not identify any motivation and reiterated the barrier to participation.
SOURCE: Prepared by the authors

environmental issues, whereas younger individuals believe that any and all problem will be solved in the future; in turn. Fan *et al.* (2019) advocate that lack of resources and time are reasons for non-participation of the younger population.

On the other hand, younger people showed greater willingness to participate in collection separated into three categories (Q2), while there was a small reduction in the participation of the population over 60 years of age. One of the possible analysis that can be made from these data is the correlation to the difficulty engaging in the task and in changing habits, especially among the aged population (Struk, 2017; Setiawan *et al*., 2019). As they already separate waste, older people are aware of the obstacles, such as lack of time, space and disposal structure, among others.

Thus, when urged to separate into more than two types, these barriers may have constituted an impediment to change. On the other hand, younger individuals, especially those who are not familiar with household solid waste management, may have placed greater weight on environmental issues,

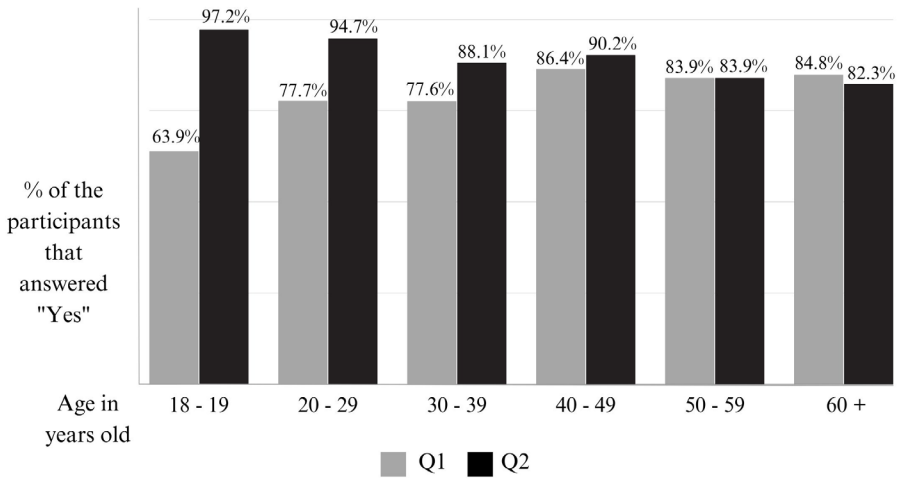

FIGURA 2 – Comparativo faixa etária e participação para os domicílios amostrados.
FONTE: elaborada pelos autores

which may have been drivers for adhering to the new segregation modality suggested.

Based on the above, it is worth assuming that communication actions aimed at younger audiences need to be devised to ensure that the intention is transformed into effective participation and that these individuals have sufficient knowledge to overcome obstacles that may arise in the solid waste segregation process. Therefore, for this age group, promoting environmental education in schools and universities in an interdisciplinary way emphasizing the importance of selective collection and the impacts of inadequate USW management on the environment presents itself as an essential tool. In addition to that, short and objective messages via social networks can serve as reminders for the theory to turn into practice.

On the other hand, in order to avoid loss of engagement, it is necessary to inform older citizens, in addition to implementing a simple system, at least until everyone is familiar with the innovations. Therefore, all the information intended to this population group should be simple and practical, aiming at clarifying the separation stages. Meetings can be held in neighborhood associations and religious communities, among other places, in addition to information leaflets and notes on Water/Energy/Internet bills, SMSs and social networks.

Considering that this factor was associated with current and future willingness to participate in selective collection programs, it should be carefully observed.

When it comes to "income and schooling", the results for Q1 showed no correlation with participation in selective collection (*Fisher*'s Exact and *Pearson*'s Chi-square values greater than 0.05). It is incoherent for these two factors to show this behavior since, in general, people with higher schooling levels earn higher incomes, as these aspects are interrelated.

Other studies indicate that the economic and educational elements present no direct relationship with household solid waste management (Gallardo *et al*., 2010; Wadehra & Mishra, 2018; Wang *et al*., 2018; Valenzuela-Levi, 2019). This result can be explained by the opportunity cost embedded in the separation action. As the time and effort spent on this task are more costly for the individual than turning to outsourcing, the tendency is for less willingness to participate (Kirakozian, 2016). In addition to that, as pointed out by Rousta *et al*. (2015), habit (identified in Q1) outdoes other demographic factors.

However, it is worth noting that, in their research studies, Ibáñez-Forés *et al* (2018); Sorkun (2018); Aprile & Fiorillo (2019); Fan *et al*. (2019) and Escario *et al*. (2020) identified a positive correlation between income/schooling levels and solid waste segregation, whereas Cudjoe *et al*. (2020) and Wang *et al*. (2020a) found a negative relationship; in other words, people with lower income and schooling levels were more prone to solid waste source separation.

These variations indicate that other factors more relevant to the local population may be overriding the influence of income and schooling; for example, the need to earn income through the sale of recyclables leads the population with lower incomes and study times to separate more frequently. This conclusion is supported by the fact that, for question Q2, there was a correlation with willingness to participate for the "schooling" factor. In this case, as complexity of the activity increases and there is no immediate monetary return, cost-benefit once

again exerts an influence and schooling can play a more predominant role.

With this in mind, as advocated by Kirakozian (2016), elements that increase the benefit must be introduced into the equation to offset the costs. In the case of the higher-income population, one of the options would be to adopt punitive monetary measures, whereas for those with lower purchasing power, economic incentives are an alternative. However, caution is recommended when implementing these practices, as experts on the topic warn about adverse effects, as will be discussed later.

From the analysis presented it is inferred that the socioeconomic factor which showed an association with people's participation in a selective collection program was "age group", indicating that greater attention should be given to it in terms of intervention measures. Schooling level proved to be relevant for future participation; therefore, this information needs to be considered when preparing an SCP.

As shown in the aforementioned studies, these elements begin to exert less influence when intrinsic (individual) and extrinsic (contextual) factors are present. These two groups of factors are addressed below, based on the results obtained in this paper.

4.2. Intrinsic and extrinsic factors

By applying the contingency table method between the participation questions (Q1 and Q2) and those related to the barriers (Q3) and motivations (Q4), it was possible to identify the associated factors (*Fisher*'s Exact test < 0.05), as already shown in Table 2.

For current participation (Q1), only three factors were identified as relevant to such behavior, two of which were contextual and one individual. Among the interviewees who stated that they had already performed some sort of separation (Q1), 40.3% did not list any reason for not participating in the program (Figure 3).

Regarding a possible selective collection program to be implemented in the municipality with source segregation into dry recyclable solid waste, organic waste and garbage (Q2), the number of factors associated with the population's decision was higher, three of which were motivational and four were barriers. Two of the motivation factors are intrinsic, whereas the extrinsic ones appear in higher numbers among the barriers (Figure 3).

Of the respondents who said that they would not participate in the program (Q2), nearly 20% did not list a specific reason for their answer (no interest/reasons). These participants indicated "improving environmental quality" and "presence of specific collectors" as possible motivators for participation.

Classified as barrier factors, lack of time proved to be relevant in both situations studied (Q1 and W2), whereas the lack of space in the house was only highlighted when considering the current context (Q1; Figure 3). These extrinsic factors are also related to convenience to participating in the SCP. In the study conducted in China by Wang *et al*. (2020a), where most of the respondents were aged between 18 and 40 years old, one of the most relevant reasons for non-participation was the effort required.

In a research study carried out in Turkey, with most of the sample population aged over 40 years old, Sorkun (2018) includes lack of space as a factor that affects convenience, therefore negati-

vely influencing the intention to participate. Also corroborating the results herein shown, among other convenience factors, lack of time was cited as a reason for not participating in SCPs in Espírito Santo (Bringhenti & Günther, 2011), as well as in a meta-analysis carried out by Knickmeyer (2020). These studies show that, in different contexts and even in different age groups, the difficulty separating waste, especially when considering the time and space elements, can be limiting for the implementation of an SCP.

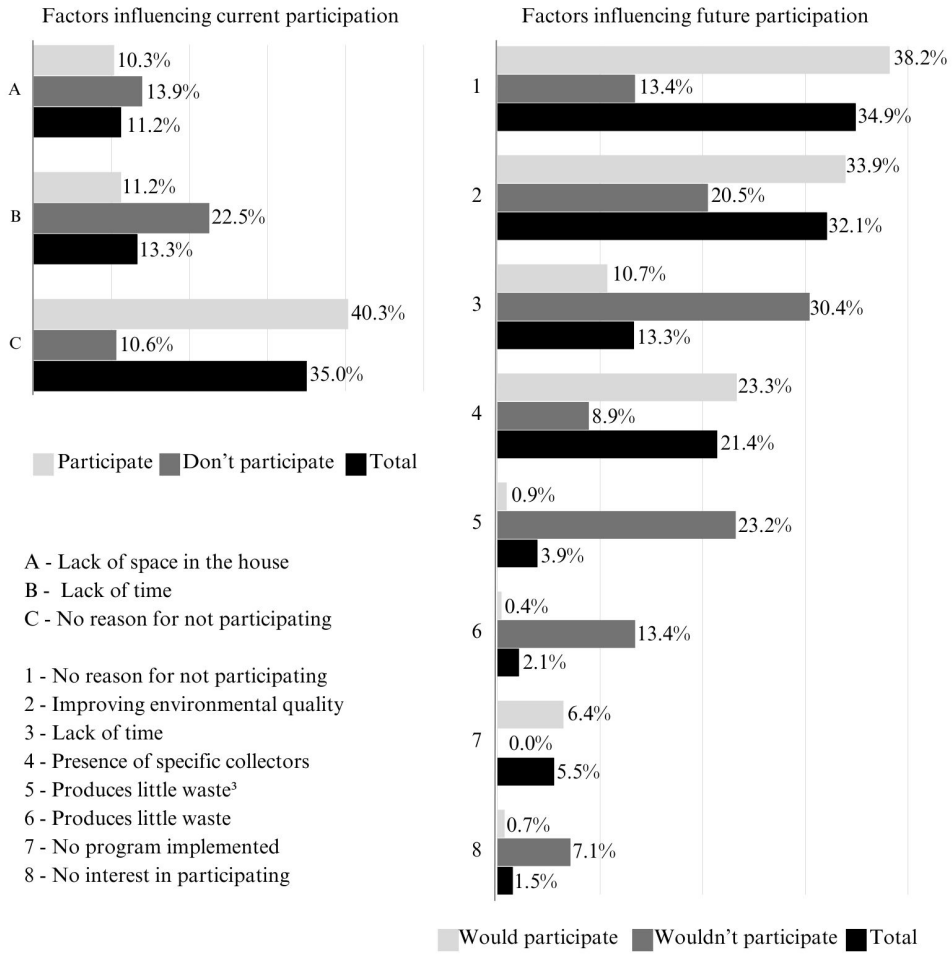

FIGURE 3 – Factors versus current and future participation for the households sampled.

KEY: [3] They did not identify any motivation and reiterated the barrier to participation.

SOURCE: Prepared by the authors

In order to minimize the effect of these hindering factors, one of the solutions to be adopted is to render the program simpler (Sorkun, 2018). Segregation into three types of solid waste meets this criterion, as it allows greater use of the materials with lower costs in terms of convenience for home residents.

Both for the current situation and in the hypothesis of implementing the SCP, some intrinsic factors proved to be preponderant in the respondents' decision to participate. "I have no reason not to participate" and "improving environmental quality" appear with significant percentages among the motivations for solid waste source segregation. Several studies, such as the ones conducted by Wang *et al*. (2020a) in China and by Geiger *et al*. (2019), who carried out a meta-analysis of surveys conducted around the world on the subject matter, show intrinsic factors as important motivators for adherence to SCPs. In a study carried out in Singapore, environmental concerns are the main drivers for adhering to the segregation of recyclables (Shan *et al*., 2020); the same conclusion reached by Aprile & Fiorillo (2019) in a research study in Italy, also appearing in the list presented by Meng *et al*. (2019) among the five most significant factors to participate in selective collection in China.

Consequently, it is considered indispensable to raise awareness among the population in relation to environmental issues. To participate, the residents must understand the importance of environmental components, how maintenance or destruction of these components directly affects their lives, the impact of inadequate management and, above all, the effectiveness of their actions to improve environmental quality, that is, solid waste segregation as a tool for active participation in environmental protection (Cudjoe *et al*., 2020; Wang, 2020a).

The "no program implemented" barrier factor and the "presence of specific collectors" motivation factor are related to the existence of public policies and infrastructure for selective collection. No matter how great the intention to segregate is, obstacles beyond the potential for an individual solution may make such attitude unfeasible. As pointed out by Knickmeyer (2020) and Wang *et al*. (2018), lack of proper infrastructure can constitute a relevant limiting factor for people's participation. On the other hand, the existence of such structure will serve as a driver for solid waste segregation in households, in addition to affecting convenience, a factor that exerts a strong influence on adherence to SCPs, as previously shown. Knickmeyer (2020) cites examples from the United Kingdom, Canada and Sweden of how adopting infrastructure policies and standards, such as providing strategies for leveraging space within homes, resulted in an increase in the rates of solid waste correctly disposed of for recycling.

Sorkun (2018) argues that lack of infrastructure can encourage the population to give up on managing their solid waste appropriately; just as when public authorities do not fulfill their role in solid waste management, citizens feel justified in not taking action. So as to mention other studies on the topic that obtained similar results, Miliute-Plepiene *et al*. (2016) found that, for 79% of the Lithuanian citizens who do not segregate their solid waste, the existence of specific containers could ease their participation. In China, Meng *et al*. (2019) observed that the services and infrastructures related to the environment exert the greatest effect on the population behaviors. Wadehra & Mishra (2018)

reported that in New Delhi, India, residents who do not segregate their solid waste claim that it will be mixed again upon collection and that, therefore, the effort is not worthy. A similar reason was pointed out by interviewees in the current study when asked about the current management of household solid waste.

In this sense, in his study comparing the selective collection systems of Brasília and Curitib, Conke (2018) shows a that, in the first city, where the infrastructure is inadequate, only 45% of the population took part, whereas in Curitiba, where the system is more robust, participation was 90%. Among the reasons for non-adherence to the SCP in Brasília is the claim that collection does not take place according to the published schedule, or does not take place at all. This idea is reinforced in the study carried out by Knickmeyer (2020): in addition to the existence of a program suited to the local reality, reliability is indispensable, that is, that it takes place as planned and also in a transparent manner.

Therefore, implementing the program, considering convenience issues such as availability and distance from the collection points, appearance and cleanliness of these locations, ease of the separation method, collection frequency in the case of door-to--door, represents a factor that could encourage the population to segregate their solid waste, also assuming that, even if there is no officially implemented program, 82% of the interviewees state already carrying out some type of segregation (Table 1).

7.1% of those that stated that they would not participate when answering Q2, pointed out lack of interest as a reason. In relation to the total sample, this accounts to 1.5%, which means a very low number of people who showed no willingness to segregate household solid waste. In the case of SCP implementation, considering the results obtained in the research studies by Escario *et al*. (2020) and Knickmeyer (2020), another element that might cooperate for people's adherence to the program would be social pressure or rules. These researchers point out that the influence of neighbors and family members can be effective in increasing participation, as non-participants start to feel excluded or that they are not respecting social standards.

The amount of waste generated was highlighted by the interviewees and proved to be relevant as a barrier, and also when asked about motivations. However, a reduction of around 42.0% is observed from one question to another; in other words, when asked what the main obstacle is in solid waste segregation, 23.2% of those who would not participate indicated low production of recyclable solid waste. When asked to answer about motivations, nearly 10.0% of these people found some reason relevant enough that, even though they produced little, made them change their attitude and show intention to participate.

This result reinforces the already mentioned thesis about cost-benefit. When observing only the difficulties presented for separation, the interviewee considered that the effort involved would not be worth the small result provided; however, when assuming a gain, motivations outdid barriers for almost half of this group. Therefore, it is worth noting that effective public policies increase awareness about the benefits and reduce the perception of difficulties, therefore contributing to greater effectiveness of source separation.

Another aspect of the results that is worth considering are the monetary incentives, which in the case of this study consisted of discounts on public services (payment for public supply and sewage

collection, electricity and IPTU) and on various purchases (supermarkets, stores, etc.). Unlike the consensus, it was evidenced that these elements exerted no influence on adherence to the SCP in Uberaba. Shan *et al*. (2020) reported a similar conclusion in a behavioral research study conducted in Singapore, which verified non-efficacy of incentives to induce an increase in the rate of solid waste sent for recycling.

Although some studies show that monetary incentives can be positive in relation to solid waste production and segregation (Miliute-Plepiene *et al*., 2016; Struk, 2017; Aprile & Fiorillo, 2019; Wang *et al*., 2020b) and Knickmeyer (2020) point out that economic incentives may result in less lasting results than those provided by education campaigns. Chinese researchers also came to this conclusion in a study on monetary incentives and solid waste separation. At the beginning of implementation, they can encourage participation but, in the long-term, public environmental education policies are vital for continuity of the program. These researchers also warn about possible negative impacts of these incentives on other pro-environmental attitudes, as they might induce actions only through payment, requiring a careful evaluation from the public administration (Xu *et al*., 2018).

A study conducted in New Delhi showed that incentives can be effective when linked to information policies. Some residents refused economic assistance, or in some cases passed it on to domestic workers as motivation, as they considered the responsibility for household solid waste management to be individual (Wadehra & Mishra, 2018). Likewise, in this research there were residents who, when asked about economic benefits, rejected them based on the argument that the generator was responsible for solid waste separation.

Therefore, it is understood that, although there are benefits to using monetary incentives, in addition to showing that this factor does not influence Uberabans' decision, their use must be cautious, for a limited time, and with other long-term policies implemented concomitantly, after a careful cost-benefit study.

In synthesis, the results show that, among the demographic factors, gender was not relevant in the decision to participate and education, only for future participation. The intrinsic factors are the most important ones in terms of motivation, whereas the extrinsic factors are more influential among the barriers. These characteristics should be considered when preparing the SCP to be implemented by actions in an Environmental Education Program.

5. Conclusion

Based on the results, more than 80% of the population is receptive to participating in selective collection. The following is suggested for greater engagement: adopting different communication techniques depending on the age group, in order to shape the environmental education program according to the target audience; simplifying segregation into only three types, so that separation takes place quickly and without the need to reserve large spaces; planning collection considering budgetary issues, but also avoiding excessive accumulation of solid waste in generating households; and, finally, ensuring that participation takes place due to raising awareness, avoiding the use of financial incentives.

In addition to that, a survey of the selective collection chain existing in the municipality should be carried out, highlighting weaknesses and strengths so that efforts can be focused on critical areas that can boost the sector and expand the types of solid waste with a recycling chain.

It is also suggested to carry out a survey research study after implementing the SCP to identify actions that prove to be effective, as well as those that do not produce the expected results, for corrections and improvements in the system.

The work carried out indicates important academic contributions from the point of view of the future applicability of selective collection programs as an instrument for the sustainability of solid waste management, encouragement of new research studies in the area and bases for structuring environmental education programs focused on selective collection.

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