THE IMPORTANCE OF SELECTED DEMOGRAPHIC FACTORS IN MUNICIPAL WASTE MANAGEMENT

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Abstract: The publication presents the possibilities of using selected demographic variables as a source of knowledge to predict the amount of municipal waste. This may be important in the adaptation process of selecting the optimal technology for recycling and waste disposal. Therefore, the study aimed to determine the relationship of selected demographic variables with the generation of municipal waste based on the example of a pilot proprietary survey conducted in the Czech Republic. Advanced statistical methods were used in the pilot study to verify the research hypotheses. The presented research results clearly show that many parameters characterizing socio-demographic factors, such as age, disposable income or type of inhabited real estate, may be of great importance, affecting the amount of municipal waste and the effectiveness of its selective collection. In addition, the use of multivariate statistical analysis based on the CATPCA method made it possible to show in more detail the relationship between the age of the respondent and their approach to waste management.

Key words: waste management, demographic factors, statistical analysis

Introduction

Initial research work on the issue of factors important for municipal waste management appeared in the early 1990s and was concerned mainly with the efficiency of separate collection (Floz, 1991; Platt et al., 1991). This topic additionally gained importance after 1992, and more precisely after the world conference in Rio de Janeiro, during which the ideological foundations of the concept of sustainable development were created. The issues related to segregation then became very important from the point of view of the success of the waste management and recovery programs implemented around the world at that time. Therefore, most of the works created at that time focused mainly on the issue of recycling, in particular on the attitude of people to it, and on the characteristics of residents who segregate and separate waste (Everett and Pierce, 1993; Coggins, 1994). A breakthrough work that significantly influenced the way of thinking in

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municipal waste science was a 1996 study in Dublin (Dennison et al, 1996). They focused not so much on the effectiveness of separate collection but were devoted to the general quantitative and qualitative analysis of household waste. Another change in the way of thinking about municipal waste could be observed at the turn of the 20th and 21st centuries. It was then that people began to consider not only the effectiveness of separate collection and the factors determining the behaviour of residents in this matter but also the issue of limiting the amount of waste generated by residents (Chung and Poon, 1999; Ebro and Vining, 2001; Curtis et. al., 2011, Hazuchova et al., 2020). Subsequent legislative changes introduced in the European Union, related to the resolution of the New Waste Directive [2008/98 / EC], placed even greater emphasis on the appropriate hierarchy of waste management (first reduction of the amount of generated waste, then recovery and disposal other than landfilling, and only finally storage). As a result, understanding the key factors influencing the amount of generated and recovered waste becomes one of the most important challenges of the modern science of waste management, which is characterized by quite significant differences in both the amount and composition of waste generated and the degree of implementation of waste recovery and transformation technologies before storage (Nitsenko et al., 2018; Dunjic et al., 2019; Jakubus and Stejskal, 2020; Rajca et al. 2020). These differences are observed at various levels of data aggregation, ranging from clear differences between European Union countries, through differences in individual regions, to smaller territorial units (Wendimagegn, 2019). It seems, however, that the main problem in municipal waste management is breaking the simple correlation between, for example, economic growth and the increase in the amount of waste generated. This problem concerns mainly highly developed countries with a high level of economic development. The approach used so far in forecasting missing data, consisting of a simple extrapolation of trends based on historical data, has devalued in a situation of rapidly changing socio-economic conditions, and above all demographics. However, many studies indicate that the list of potential variables that may affect the amount of waste generated may be quite diverse, depending, for example, on the area of the study (Wysocka, 2012; Skibiński and Poskart, 2021; Handayani et al., 2018,). An example can also be the research of P.C. Calabro and D. Komilis who point out that the success of separate collection of municipal solid waste, the efficiency of the other connected services and the justification of a large cost assumed by an authority, depends on the level of service provided to customers as well as the citizens' attitude towards waste management (Calabro and Komilis, 2019; Ginevičius, 2022). In turn, the work (Bach et al. 2004) developed a multivariate regression model providing valuable insights into the relationship between demographic parameters and the amount of collected waste paper. At present, most scholars mainly focus on two aspects of municipal solid waste. On the one hand, factors affecting the generation of municipal solid waste are analyzed, and different factors have different effects on municipal solid waste. For example, Zhao Yan selected five influential factors, such as urban population, GDP, urban built-up area, per capita disposable income, and

per capita consumption expenditure, as the factors to analyze the amount of municipal solid waste in 31 provinces of China (Zhao, 2016). Therefore, knowledge of the socio-economic factors, including, in particular, the demographic factors determining the amount of municipal waste generated, may help use it in decision-making processes in the field of waste management (Mota Freitas et al., 2016; Babaei et. al., 2015). The more so because according to publicly available demographic forecasts prepared by Eurostat, the ageing of the population is a long-term trend that started in Europe several decades ago (Eurostat database, 2022). This trend is visible in the transformation of the age structure of the population and is reflected in the increasing share of the elderly combined with the decreasing share of the working-age population in the total population. This is of great importance for the waste management process (Rybova et.al., 2018, Rybova and Slavik, 2017). Thus, the quantity and quality of waste generated in a household are related to the various characteristics of its inhabitants. Table 1 presents selected factors that may affect the quantity and quality of municipal waste generated in the city.

Table. 1 The most important factors that may affect the quantity and quality of municipal waste generated in a given city based on a literature review

Factor	On the scale of one city
Average size of a household (number of people/household	negative correlation with the amount of generated waste (Dyson and Chang, 2005)
Age	- age range 16 - 19 years - more produced plastic waste (Dennison et al., 1996) - older - more waste generated (Tonglet et al. 2004)
Type buildings residential	different amounts of generated waste (Skalmowski 1992) and their factions (Dennison et al., 1996)
Affiliation to a given unit administrative	visible impact on the social perception of the adopted system of waste collection (Purcell and Magette, 2010)
Employment status	students/retirees/disability pensioners - strong negative correlation with the quantity generated waste

Source: Own elaboration based on: Wysocka, 2012

The motivation to undertake this research topic was primarily the observed changes in the demographic structure of the population in the Czech Republic, the lack of ideas for effective waste management, the so-called Covid and global interest in the recovery of materials towards their energy use in the face of the energy crisis. Even though waste management in the Czech Republic is one of the most developing sectors of the economy, there are still areas where action should be taken to meet EU requirements in this area. In addition, an analysis of the literature from the years 2018-2022 based on keywords and restrictions introduced to the advanced search in the Scopus database made it possible to generate a map using the VOSviewer program (ver.1.6.18). As part of an attempt to interpret keywords (demographic

factors, waste management, municipal waste), the type of analysis "co-occurrence" was selected - "counting method: Full counting" and the analysis unit of all keywords - "unit of analysis - all keywords".
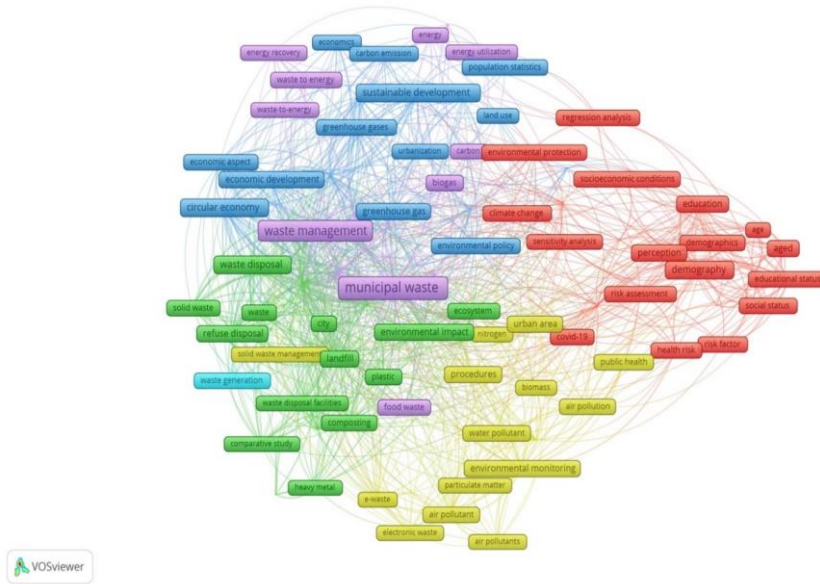

Figure 1: VOSviewer term map visualization for level 1
Source: Own analysis in VOSviewer

To determine the leading keywords, it was assumed that the minimum number of occurrences of a given word is 5. This assumption was adopted to intensify the weight of words and to enable the identification of elements on the map. Analyzing all the results obtained based on the created map, it should be stated that the issues related to the demographic aspect in municipal waste management are up-to-date and are constantly developing, which is confirmed by emerging publications dealing with the demographic aspect, especially in the context of climate change. However, it seems that there is still a need to expand knowledge on the impact of demographic factors on municipal waste management. Taking the above into account, this study aims to determine the relationship of selected demographic variables with the generation of municipal waste on the example of a pilot proprietary survey conducted in the Czech Republic. To verify the research goal, set in this way, the following research hypotheses were adopted:

main hypothesis:

H0. Demographic factors determine the amount of municipal waste generated and affect the effectiveness of its selective collection.

detailed hypotheses:

H1. Determining the share of individual population groups by age in the total population helps to predict consumption behaviour trends.

H2. The behaviour of individual groups of consumers in terms of age affects the amount of municipal waste generated and changes its morphological composition.

H3. The effectiveness of the selective collection of municipal waste depends on the age of the population.

H4. The effectiveness of municipal waste management depends on the financial situation of the local community.

H5. The effectiveness of municipal waste management depends on the level of education of the local community.

H6. The effectiveness of the separate collection of municipal waste depends on the number of people in the household.

Research Methodology and Materials

The pilot study was conducted on a sample of the Czech population. The design of the survey was based on a combination of two methods: quota random selection (a proportional number of randomly chosen respondents in different age groups, regions and types of housing) and snow sample selection (respondents were asked to fill in the questionnaire also from colleagues). The pilot study was conducted between November 2022 and January 2023. Respondents were asked to fill in the questionnaire via e-mail and social networks. A total of 300 respondents aged 18-65 were contacted. The structure of the questionnaire can be briefly described as follows. The first group of questions focused on general waste sorting tendencies (questions 1-5 and 9: Do you sort waste at home? Do you sort regularly? What types of waste do you sort? waste management during the COVID pandemic, reasons for possible negative attitudes towards waste sorting, the suitability of the current waste management system). The next part of the questioning focused on possible future attitudes (Q6-14: If you do not currently sort, would you be willing to sort in the future? What would motivate you to do so? Do you pay attention to the materials from which the packaging of products is made? What can be done to mobilize society to sort waste more effectively attitudes towards waste incineration, which of the waste management practices should prevail according to the respondents). The last part of the questionnaires consisted of identification questions (age, gender, education, number of household members, place of residence, type of housing and income), necessary for testing the hypotheses. The influence of the individual characteristics of the respondent on the waste management process was analyzed in detail. Taking into account the fact that most of the data obtained in the survey are categorical, appropriate methods were selected for statistical evaluation (Tang et al., 2012). Statistical analysis of the survey results was performed with the SPSS software. In the first stage of the evaluation, the analysis of dependencies in the contingency tables was mainly carried out (Dorofeev, Grant, 2006). The dependence of two categorical features is a chi-square test of independence (Nolan, Heinzen, 2007, Řezanková, 2007). If the precondition for applying the chi-square test in the contingency table is not met, the so-called exact tests (Mehta and Patel, 2006) or Monte Carlo method (Mehta and Patel, 2013) were used. For a more detailed insight

into the dependency structure, a sign test was used in significant cases to help examine in more detail the extent to which sort results can be expected in the base file (Howitt and Cramer, 2014, Rabušic et al., 2019). The sign pattern can be used to detect statistically significant differences between the observed and expected frequencies. Significance levels for such differences are given in the text (e.g., α= 0.01 - observed frequencies are higher than expected and significant at the significance level of 1%- the risk of error max. 1%, α= 0.05; α= 0.001). Principal methods of data reduction are principal component analysis (PCA) and factor analysis (FA). These methods allow many variables to be replaced with a smaller number of latent variables, with the original variables assuming linear relationships with one another. Since the PCA method was designed to analyze quantitative continuous variables, other methods are needed for categorical variables. One of them is CATPCA (Categorical Principal Component Analysis). When using the CATPCA method, the use of optimal scaling enables the variables to be scaled at different levels. Categorical variables are optimally quantified within a defined dimensionality. It is also possible to model nonlinear relationships between variables. The scales of individual variables may differ. This method also does not require compliance with the assumption of multidimensional normality of data (Šulc and Řezanková, 2015). The choice of the measurement scale of a given variable is very important because it affects the structure of the correlation matrix. The authors choose the appropriate scale. Details of the selection are described, for example, in Linting (2007), and full use of the methods in Meulman and Heiser (1993). The CATPCA method was used separately to reduce dimensionality, and then cluster analysis was performed. Cluster analysis is a collective name for a series of computational procedures aimed at dividing a given population into several relatively homogeneous subsets (clusters), so that the units (objects) within each cluster are as close as possible, and the units (objects) belonging to different clusters are more distant as possible. In this way, each unit is described by a group of features (more, e.g., Affifi and Clark, 1997).

Research Results and Discussion

As expected, women were much more likely to respond, representing 73% of the respondents. The age structure of respondents is shown in Figure 2.
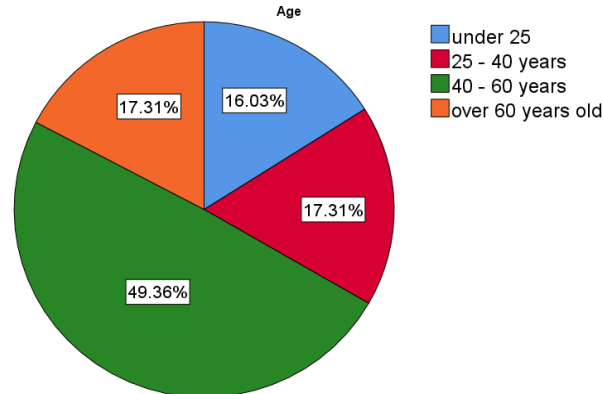
**Figure 2: Age structure of respondents**
Source: Own study in SPSS

Almost two-thirds (64%) of the respondents reported secondary education, one-third higher education (35%), and only 1 % indicated primary education. The proportions of the respondents in the two proposed housing categories were almost equal (multi-family building – 48%, single-family house – 52%). Households with two (29%), three (26%) and four (26%) members are relatively evenly represented in the sample. Data on respondents' incomes appear to be underestimated, with 43% of respondents reporting an income between EUR 500 and EUR 1,000. Figure 3 shows the structure of respondents according to the size of the place of residence.
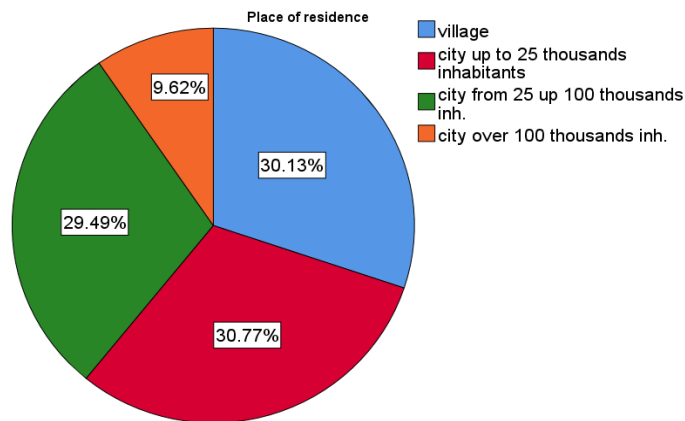
Figure 3: Place of residence
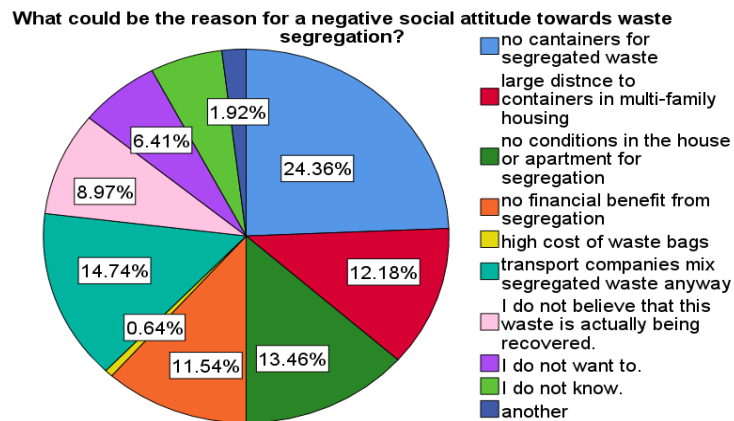**Source:** Own study in SPSS

167

When asked if they segregate waste, 98% of the respondents answered yes, and 88% of the respondents regularly sort waste. Figure 4 shows that the respondents most frequently sort plastics (PET bottles) (67%). The second most frequently reported category of sorted waste is organic waste, which corresponds to the percentage of respondents living in rural areas (30%).
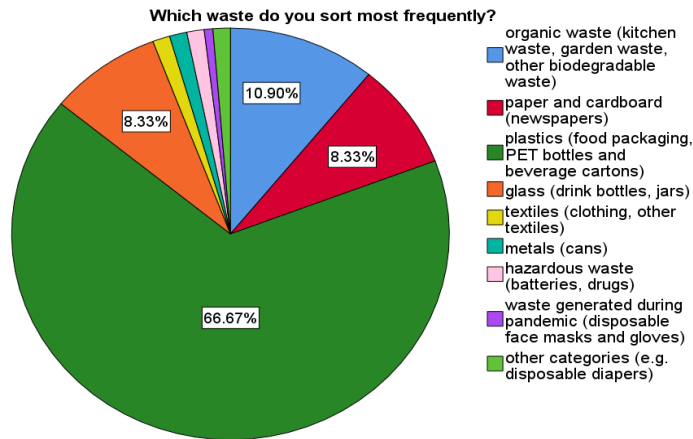
Figure 4. The most frequently segregated type of waste
Source: Own study in SPSS

In question Q4, respondents were asked what may have an impact on the negative attitude of people towards sorting waste. The results are shown in Figure 5. Almost a quarter of respondents (24%) do not have sorted waste containers. Other respondents indicated insufficient sorting conditions (13%) or too-distant containers (12%). It can be assumed that the lack of education makes some respondents (15%) believe that transport companies mix sorted waste anyway, and another 9% do not believe that waste is recovered.

Figure 5: Structure of respondents' attitudes to possible causes of negative attitudes towards waste segregation
Source: Own study in SPSS

The attitude of respondents toward waste generated during the COVID-19 pandemic may have something to do with it. Over three-quarters of respondents (77%) throw this waste into the same containers as other waste. One-fifth of the respondents separated it into other baskets. Respondents were also asked what would motivate them to sort waste in the future (question 7). More than one-third found that a sufficient motivation is the lower fee for the collection of segregated waste. Structured answers are presented in Figure 6.
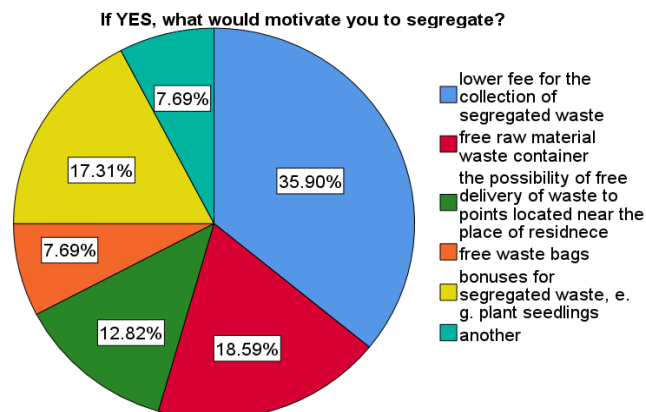
Figure 6. Future motivations for segregating waste
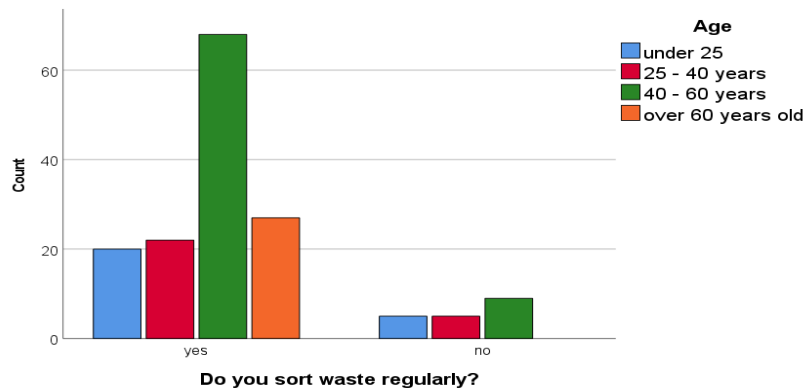**Source:** own study in SPSS

The following views may be useful in future waste management planning. More than half of the respondents (53%) believe that the current waste management system is unsatisfactory, 19% of respondents are satisfied and 28% have no opinion. More

than two-thirds of the respondents (67%) answered question 11 negatively, 11% positively, and 21% did not have an opinion. This also corresponds to the structure of the answer to question Q12 whether the respondents believe that waste incineration plants are the only correct direction of municipal waste management. Two-thirds of respondents think not, 10% agree and 24% have no opinion. Half of the respondents are concerned about the impact of incinerators on the environment, and 42% about the impact on human health (Q13). In the case of other responses, both effects repeat simultaneously, 5 respondents showed no concern. The opinions of Czech respondents to question Q14 (Which of the following waste management practices do you think should prevail in your country?) seem to be positive: 87% of respondents believe that recycling should be dominant in the Czech Republic, 11% choose thermal disposal (e.g., incineration).

Descriptive statistics and hypothesis testing

By analyzing the data and testing the dependencies on the age of the respondents, the following facts were found:

-   Q1 *"Do you sort waste in your household?"*- 98.1% of respondents sort their waste. The highest percentage of people sorting waste (fig. 7) is between 40 and 60 years old (43.6 %). Other people sort less (under 25 years old – 16%, 25-40 years old - 14.1%, seniors over 60 years old - 17.3%).
-   Q2 *"Do you sort waste regularly?"*- among those sorting waste, 89.5% of the respondents answered positively, and 10.5% negatively. The age structure of respondents is in Figure 7.

Figure 7: Age structure of respondents who
regularly and irregularly segregate their waste
Source: Own study in SPSS

In line with the hypotheses, the relationships between categorical variables (respondents' answers) and the value of identifying features were tested. There is a statistically significant relationship between attitudes towards regular sorting and age (χ^2 = 7.894, 2-sided 99% confidence interval: (0.034, 0.044) - Monte Carlo Sig.). There were also statistically significant differences in views on the motivation of

respondents to sort waste in the future (question 7, χ^2 = 31.076, 2-sided 99 %confidence interval: (0.005, 0.010) - Monte Carlo Sig.). Respondents aged 40-60 much more often prefer a free container for raw material waste (α= 0.01), respondents over 60 years of age prefer a lower fee for the collection of segregated waste (α= 0.05), young people up to 25 years old prefer premiums for segregated waste, e.g. seedlings (α= 0.05) and people aged 25-40 years reported other options significantly more often (α= 0.05), e.g. saving the planet, containers for everything (oil, glass, paper, plastic, place for electronic waste, a large-capacity container for other waste). Different age groups also pay statistically significantly different attention to the materials from which the product packaging is made (question 8, χ^2 = 15.057, 2-sided 99% confidence interval: (0.017, 0.024) - Monte Carlo Sig.). The use of the sign test allows us to identify the differences between the categories in more detail: people over 60 years of age significantly more often answered this question in the affirmative (α= 0.01), and young people under 25 years of age more often chose it occasionally (α= 0.05). Also views on question 9 "Is the current waste management system satisfactory?" differed significantly depending on age (χ^2 = 31.370, p = 0.000). People aged over 60 significantly more often answered this question in the affirmative (α= 0.001), and people aged 25-40 disagreed much more often (α= 0.05). Respondents were also asked "Would you consent to the construction of a municipal waste incineration plant?" (question 11). Again, there are significant differences in opinion by age (χ^2 = 23.059, 2-sided 99% confidence interval: (0.000, 0.001) - Monte Carlo Sig.). Seniors over the age of 60 agree much more often (α= 0.001), while those under the age of 40 disagree much more often (α= 0.05). The respondents' attitudes towards various aspects of waste segregation do not differ statistically significantly concerning the level of education. However, they differ slightly depending on the number of household members. The respondents' attitudes do not differ significantly in terms of the size of the place of residence or the place of residence. Nevertheless, the type of apartment influences the respondents' attitude to possible further sorting in the future (question 7, χ^2 = 14.124, 2-sided 99% confidence interval: (0.011 0.017) - Monte Carlo Sig.). People living in single-family houses (compared to those living in multi-family houses) would be much more inclined to sort waste (α= 0.001), especially by being able to deliver waste free of charge to points close to where they live. The respondents' income also significantly influences their motivation to sort waste in the future (χ^2 = 41.184, 2-sided 99% confidence interval: (0.002 0.005) - Monte Carlo Sig.). People with incomes below EUR 500 would be much more motivated by bonuses for segregated waste, e.g. plant seedlings (α= 0.01) and free waste bags (α= 0.05), while respondents with incomes between EUR 500 and EUR 1,000 want a reduced fee for collection of segregated waste (α= 0.01), respondents with an income between EUR 1,500 and EUR 4,000 want a free waste container for raw materials (α= 0.05), and respondents with the highest incomes (over EUR 4,000) indicated other incentive options (α= 0.001).

Multidimensional statistical analysis - respondent profiles

When looking for different profiles of respondents concerning waste management, CATPCA and cluster analysis were used. Using the multivariate scaling approach allows us to scale the variables at different levels. Categorical variables are optimally quantified within a defined dimensionality. It is also possible to model nonlinear relationships between variables. In the case of attitudes towards waste management, CATPCA led to a reduction in the dimension in the data when the original 21 nominal or ordinal variables received 4 main components, which account for 59.5% of the total variability of the set. The component loads of particular variables are presented in Table 2. Individual components - dimensions - can be seen as specific personality types or traits, which can be roughly described as follows: 1 - future motivation for waste management, 2 - individual attitudes towards separation, 3 - general attitude towards separation, 4 - household (characteristics). Table 2 shows that dimension 1 called "future motivation for waste management" is the most saturated with the variables (questions) that examined the respondents' opinions on the most frequently sorted waste (Q3), the willingness to sort waste in the future (Q6), the attitude to the possible construction of an incineration plant in the place of residence (Q11) and the importance of incineration plants for waste management (Q12), as well as the dominant method of waste disposal in the country (Q14). Dimension 2 "individual attitudes towards segregation" is most saturated with attitudes (motivations) towards sorting waste in the future (Q7), the level of care for the packaging of goods (Q8), and the view on the efficiency of waste management (Q9 - this dimension is very strongly saturated by age identification variables) and income, which, among other things, also confirms the hypothesis H4. The first question (Q1) about whether the respondents sort their waste and if they sort it regularly (Q2) saturates dimension 3 the most. The third dimension "general attitude towards separation" is also negatively saturated with the education of the respondents. This confirms hypothesis H5. The fourth dimension "household (characteristics)" is most saturated with the variables identifying; the size of the household; the size category of the place of residence and the type of dwelling. The views of the respondents on possible tools for mobilizing the population to sort waste are partially reflected here.

Table 2. Component loads (varimax rotation)

Question	ingredients			
	1	2	3	4
1) Do you sort waste in your household?	-0.041	-0.085	**0.545**	-0.031
2) Do you sort waste regularly?	0.103	0.339	**0.612**	0.013
3) What kind of waste do you sort the most?	**0.706**	0.071	0.213	-0.008
4) What may be the cause of a negative social attitude to waste segregation?	-0.109	-0.180	**0.487**	-0.279
5) How do you deal with the waste generated during the pandemic (masks, disposable gloves, disinfection packaging)?	-0.060	-0.388	-0.220	0.173

6) If you don't sort your waste regularly now, would you like to sort your waste in the future?	**0.651**	0.073	0.071	-0.135
7) If YES, what would make you segregate?	-0.026	**0.620**	-0.163	0.024
8) Do you pay attention to the materials from which the product packaging is made?	0.134	**0.434**	0.367	0.145
9) Is the current waste management system satisfactory?	-0.244	**0.337**	0.300	0.081
10) What do you think can be done to mobilize society for the most effective waste segregation?	0.156	-0.220	0.381	**0.383**
11) Would you consent to the construction of a municipal waste incineration plant near you?	**-0.551**	0.253	0.378	0.142
12) Do you think that waste incineration plants are the only correct direction of municipal waste management?	**-0.657**	0.135	0.252	-0.089
13) What are your concerns about building a waste incineration plant?	-0.078	-0.009	**0.484**	-0.029
14) Which of the following methods of waste management should, in your opinion, be dominant in your country?	**0.735**	-0.033	0.007	0.112
Age	0.263	**-0.778**	0.034	-0.095
sex	-0.185	0.142	-0.077	0.156
Number of people in the household	-0.102	0.129	0.127	**0.682**
Education	-0.142	0.039	**-0.334**	-0.140
Place of residence	0.017	-0.018	-0.046	**-0.750**
Residential facility	0.006	0.012	-0.178	**0.746**
Your income (EUR)	-0.009	**-0.719**	0.156	-0.062

Source: Own study in SPSS

The object-oriented values of all the dimensions obtained were then used as input variables for the subsequent cluster analysis to identify typical groups of respondents according to their attitudes towards waste management (respondent profiles). Using the K-means method, the respondents were divided into 4 clusters. The number of clusters was estimated using the Ward method. The fact that all four components are statistically significant in the distribution of respondents to clusters is shown in Table 3.

Table 3. Grouping of component results - analysis of variance

changeable	Variance Analysis (Object Ratings)					
	group mean Square	df	Mistake Mean square	df	F.	Signal
dim1	33.96161	3	122.0538	152	14.09806	0.000000
dim2	91.27156	3	64.7470	152	71.42302	0.000000
dim3	58.36788	3	97.6701	152	30.27850	0.000000
dim4	92.46876	3	63.7494	152	73.49221	0.000000

Source: Own study in SPSS
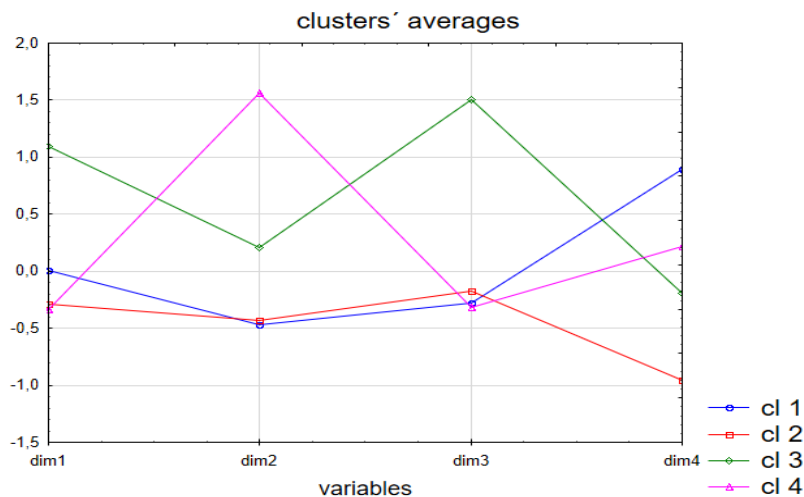
Figure 8: Comparison clusters – average dimensions
Source: Own study in Statistica

Figure 8 shows that concerning sorting waste, four separate groups of respondents (clusters) were distinguished. Clusters I and II are similar in terms of the average values of dimensions 2 and 3, i.e., the general and individual attitudes toward waste sorting. These groupings differ significantly in dimension 4, i.e., the characteristics of households. Cluster III shows the highest values for dimensions 1 (future motivation for waste management) and 3 (general attitude to segregation), while Cluster IV shows the highest value for dimension 2 (individual attitudes to segregation). However, a more detailed picture of the differences between clusters (respondent profiles) should be obtained through analysis at the level of background variables. Cluster I includes 54 respondents, mostly aged 40-60, living in larger (4 or more members) rural households, or single-family houses. All respondents from this cluster sort waste, most often plastics (70.4%), and partly also organic materials (13%). According to the respondents from this cluster, the lack of containers for sorted waste (33%) and the fact that sorting waste does not bring financial benefits

(18.5%) may cause negative attitudes people towards sorting waste. Although no significant differences in waste management were found between the clusters during the COVID pandemic (most respondents threw masks, disposable gloves and disinfectant containers into the bin with other waste), respondents in this cluster can be described as the most disciplined, mixing COVID waste with other waste in "only" two-thirds of cases (compared to clusters II-IV: 75%, 91%, 89%, respectively). Out of 96% of respondents from this cluster who would like to sort waste in the future, 41% would be motivated by lower fees for collecting sorted waste, and almost a fifth (24%) would be motivated by free waste containers. In this respect, the respondents from cluster I do not differ significantly from the attitudes of the respondents from groups 2 and 3 (see Table 4). The respondents in clusters I and II also pay much more attention to the materials from which the product packaging is made (70%, 79%), compared to the respondents in clusters III and IV (32%, 39%). This corresponds to lower levels of non-compliance for unsatisfactory waste management (Q9 - half of the respondents in clusters I and II think it is inappropriate) compared to clusters III and IV (where the proportion of dissatisfied respondents is higher).

Table 4. Modal responses and the corresponding proportions
of respondents in clusters (%)

Question	Cluster I	Cluster II	Cluster III	Cluster IV
Q2 (yes)	100	100	40.9	78.6
Q3 (separated material)	plastic (70.4), organic (13.0)	plastic (76.9)	glass (31.8), plastic (22.7), paper (13.6)	plastic (75), organic (10.7)
Q4 (insignificant differences here)	no containers (33.3), no financial benefits (18.5), mixed waste segregation (13)	no containers (17.3), no conditions (15.4), waste segregation (15.4), long distance (13.5)	mix segregated waste (27.3), no conditions (31.8), long distance (13.6)	no containers (32.1), do not believe (14.3), long distance (17.9)
Q5 (negligible) - with other wastes	66.7	75.0	90.9	89.3
Q6 (future) Yes	96.3	98.1	77.3	96.4
Q7 (Future Motivation)	lower fee (40.7), free container (24.1), free shipping (14.8)	lower fee (42.3), free containers (19.2), bonuses (17.3)	lower fee (40.9), free containers (18.2), bonuses (18.2)	free bags (17.9), bonuses (28.6), free shipping (25.0)
Q8 (product packaging material) - yes	70.4	78.8	31.8	39.3

Q9 (satisfactory management) - no	50.0	50.0	54.5	60.7
Q10 (mobilization)	lower tuition fees (40.7), universal education (13.0), financial savings (31.5)	mainstream education (42.3), lower fees (25), higher fines (15.4)	lower fees (59.1), financial savings (18.2), universal education (13.6)	mainstream education (32.1), financial savings (25), lower fees (21.4)
Q11 (approval for waste incineration plants) - no	59.3	59.6	72.7	92.9
Q12 (waste incineration = right direction) - no	61.1	69.2	50.0	82.1
Q13 (concerns about waste incineration)	envi - effects (50), health (37)	jealousy (50), health (44.2)	jealousy (31.8), health (68.2)	envi (64.3), health (28.6)
Q14 (dominant methods) - recycling	81.5	98.1	59.1	100
Age	40 - 60	above 60	40-60	under 25
Household members	4 and more	1 - 2		
Education			secondary	
Place of residence	village	city up to 25,000		
Residential facility	Single-family house	multi-family	multi-family	
Income			1000 - 1500	less than 500

Source: Own study in Statistica

According to the respondents from cluster I, it would be advisable to mobilize the society to segregate waste through lower fees for waste disposal (41%) or financial savings (32%). The greater awareness of the importance of waste segregation in clusters 1 and 2 is also evidenced by the lower level of non-compliance of respondents in these clusters on the possibility of building waste incineration plants (Q11: 59%, 60%) compared to clusters III and IV (73%, 93%). Cluster 1 and 2 respondents also have somewhat similar concerns about a potential incineration plant, with half of the respondents in each cluster expressing concern about the environmental impact and a smaller proportion with concern about the impact on public health (37%and 44%). Cluster II included 52 respondents, mostly aged over 60, living in smaller households (1-2 members) in cities with more than 25,000

inhabitants residents, i.e., mainly in residential buildings. As in the case of Cluster I, all respondents segregate their waste - more than three-quarters of them are plastics. These city dwellers are much less determined in their views on what may be the cause of negative social attitudes towards waste segregation (Q4) than respondents from other clusters. They also express the highest (98%) level of compliance with future waste sorting. Furthermore, they have the highest (98%) level of consent to sort waste in the future and pay the most attention to the materials that make up the waste (79%). Among the tools mobilizing society to sort waste, they prefer general education (42%). Almost all respondents to this cluster (98%) consider incineration plants to be the only correct direction of municipal waste management. Cluster III respondents can be described as the least aware and least helpful in terms of waste segregation, mainly with secondary education and lower wages and living in multi-family houses. Less than half of them (41%) sort waste, mainly glass (32%), plastics (23%) and paper (14%). More than a third of the respondents from this cluster (32%) indicate a negative lack of conditions for segregation in their home or apartment and the fact that transport companies mix segregated waste anyway (27%) as the main reason for attitudes towards waste segregation. The respondents in this cluster also had little reference to waste management during the COVID pandemic (91%, as did the respondents in the 4 - 89% cluster). This group of respondents also showed the least willingness to continue segregating waste in the future (77%) and the respondents from this group significantly more often did not have an opinion. The main incentive to sort waste in the future would be lower fees for waste treatment (41%). The unfavourable attitude of this group to sorting waste is confirmed by the fact that slightly less than one-third (32%) of respondents from this group pay attention to the materials used to make product packaging. They are also the most sceptical of municipal waste incineration plants (see Table 3 - Q11 - Q14). Respondents from this cluster expressed much more health concerns (68%). According to the respondents, thermal treatment in the Czech Republic is dominant in this cluster. Cluster IV included 28 low-income (mostly students), under 25 years of age respondents who surprisingly approached Group 3 respondents with certain attitudes - not distinguishing between ordinary waste and pandemic waste, and not paying attention to the material used to package the product. The lower share in sorting waste (79%) is mainly due to the lack of segregated waste containers. At the same time, they consider recycling the dominant method of waste management and express the highest level of dissatisfaction with waste management (61%). At the same time, they also express the highest degree of disagreement with the possible construction of a waste incineration plant (93%). To sum up, the respondents from groups 1 and 2 can be described as conscientious and supporting waste segregation, while respondents from group 3 express a more sceptical approach to sorting waste, most often declaring a negative answer to the question of whether they regularly sort waste. Respondents from this group have an average or low salary, which is reflected in their attitude to specific aspects of waste management. Group 4 is represented by young people with a more explicit attitude towards ecology, who, however, do not

yet segregate waste too intensively, e.g., they declared significantly more often that they pay attention to the materials from which product packaging is made only occasionally. Thus, the age of the respondents turned out to be the most important demographic factor influencing the amount of municipal waste generated.

Conclusion

The presented results of the pilot study clearly show that many parameters characterizing the socio-demographic factors influencing the amount of municipal waste and the effectiveness of separate collection may be of great importance. Their identification may turn out to be a very important step that will increase the efficiency of waste management in the Czech Republic and enable the authorities to operate more effectively. There is no doubt that the amount of municipal waste will be increasingly determined by the demographic situation, which in turn will lead to a transformation of the structure of consumption expenditure, and thus the structure of all consumable and durable goods acquired also transforms. Therefore, changes in the morphological composition of the waste (separated components of waste, characterized by specific properties, having a significant impact on technological processes that may be subjected to waste) generated by all households are expected. It seems that an important long-term goal should be to develop a new nature of relations between producers introducing products to the market and the authorities responsible for organizing the municipal waste management system. This would involve shifting the responsibility (mainly financial) for the management of waste remaining after product use from local governments to producers. It seems no less important to create incentives for the later to try to take environmental aspects into account in the product design process. Therefore, targeted research considering demographic factors, especially on the mesoscale (at the level of cities, points and communes), can be very useful in the approach to waste management taking into account predicted changes in the age structure of the population. The issues raised in this article certainly require further in-depth research on the impact of demographic processes on waste management. Therefore, it is planned to survey the countries of the Visegrad group.

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ZNACZENIE WYBRANYCH CZYNNIKÓW DEMOGRAFICZNYCH W GOSPODARCE ODPADAMI KOMUNALNYMI

Streszczenie: W publikacji przedstawiono możliwości wykorzystania wybranych zmiennych demograficznych jako źródła wiedzy do prognozowania ilości odpadów komunalnych. Może to mieć znaczenie w procesie adaptacyjnym wyboru optymalnej technologii recyklingu i unieszkodliwiania odpadów. Dlatego też celem badań było określenie związku wybranych zmiennych demograficznych z wytwarzaniem odpadów komunalnych na przykładzie pilotażowego, autorskiego badania ankietowego przeprowadzonego w Czechach. W badaniu pilotażowym wykorzystano zaawansowane metody statystyczne w celu weryfikacji postawionych hipotez badawczych. Zaprezentowane wyniki badań wyraźnie pokazują, że wiele parametrów charakteryzujących czynniki społeczno-demograficzne, takich jak wiek, dochód do dyspozycji czy rodzaj zamieszkałej nieruchomości, może mieć ogromne znaczenie, wpływając na ilość odpadów komunalnych i efektywność ich selektywnej zbiórki. Dodatkowo zastosowanie wieloczynnikowej analizy statystycznej opartej na metodzie CATPCA pozwoliło na bardziej szczegółowe ukazanie zależności pomiędzy wiekiem respondenta a jego podejściem do gospodarki odpadami.

Słowa kluczowe: gospodarka odpadami, czynniki demograficzne, analiza statystyczna