Analysis on the influencing factors of residents dispose of discarded masks base on Probit regression model

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Abstract. Objective Understanding the influencing factors of discarded masks disposed by residents in Dongguan City during the period of COVID-19 epidemic, so as to provide basis for avoiding the environmental pollution caused by discarded masks in the future. Methods Using random sampling way to make an Internet questionnaire survey among 1042 permanent residents in Dongguan city and using Probit regression model to analyze the current situation and influencing factors of disposing the discarded masks. Results The installation of disposal bins, residents’ environmental concern level and education level positively influenced the residents’ disposal behavior, while the residents’ age and total household size negatively influenced the residents’ willingness to dispose. These influencing factors are basically consistent with those derived from other scholars’ studies on residents’ willingness to dispose of household waste, it shows that residents do not treat the disposal of discarded masks differently from other household waste and ignore the potential environmental hazards of discarded masks. Conclusion In order to motivate residents to properly dispose of discarded masks, it is necessary to clarify and standardize the requirements for discarded mask disposal and increase publicity to enhance the public’s awareness of environmental concerns and hygiene. To avoid environmental problems such as microplastics brought by discarded masks, disposable masks should be replaced by reusable elastic respirators; the use of polypropylene in masks should be reduced; new mask materials should be developed.

1. Introduction
By the end of December 2019, COVID-19 pneumonia broke out, and masks became a necessary material for people’s lives; according to statistics, the daily demand for masks is estimated to be as high as 530 million masks nationwide [1]. The rapid increase in masks demand has brought about a large number of discarded masks, which, if not handled properly, will not only cause the spread of the COVID-19, but also bring about environmental problems. According to statistics, in 2020, at least 1.56 billion masks will be thrown into the ocean, which has become a new type of pollution in the ocean, and many studies have shown that discarded masks will release microplastics into the environment [2-5]. After use, the average release amount of mask micro plastics is 682.7-1918 / piece. These micro plastics can enter the human body through food, drinking water, air and other ways [6]. This poses a great potential threat to the health of organisms and ecosystems. Therefore, the problem of recycling and disposal of waste masks should be taken seriously. This study analyzes the factors influencing the disposal of discarded masks by Dongguan residents during the period of COVID-19.
epidemic based on the data of a web-based questionnaire on the disposal of masks by permanent residents in Dongguan city from March 5th to 20th, 2020, and provides a basis for the development of disposal measures of discarded masks at a later stage.

2. Objects and methods

2.1. Objects
A web-based questionnaire survey was conducted on March 5-20, 2020 among the permanent residents of Dongguan City, and a total of 1042 questionnaires, 951 valid questionnaires, with an effective rate of 91.27%. Among the respondents, the majority of them were under 40 years old, accounting for 67.82% of the sample size; the number of family members was diversified; the gender ratio was close to 1:1 between men and women; and the average years of education were more than 13 years.

2.2. Methods
A self-designed questionnaire, in the form of a questionnaire star, was filled out by the respondents through WeChat and web links. Considering that factors such as "economic rationality", "education level" and "cognitive level" all affect the willingness of dispose garbage [7-9]. The contents of the questionnaire include gender, education level, age, household size, occupation, whether garbage bins are set, environmental concern, awareness of environmental pollution of discarded masks, dispose behavior and willingness of discarded mask, etc. In the questionnaire, "Is your community equipped with a discarded mask dustbin or a household garbage sorting box", those who answered "yes" were counted as residents of the area where the discarded mask dustbin was installed, and those who answered "no" were counted as residents of the area where the discarded mask dustbin was not installed. "For environmental concerns, the question "I think improper disposal of discarded masks will affect residents' health and spread diseases" was set, and the options for the question were "strongly agree ", "agree", "unclear", "disagree" and "strongly disagree". which are assigned as 5, 4, 3, 2 and 1 respectively, and the average value of all survey samples is calculated to calculate their environmental concern. The higher the score, the more concerned about the environment. If the score is higher than the average, the sample is considered as "high environmental concern sample", otherwise, the sample is considered as "low environmental concern sample".

2.3. Statistical analysis
SPSS 25.0 statistical software was used for statistical analysis of the data, including general descriptive analysis, t-test, and binary Probit regression model analysis. Independent sample t-test was used. All test directions were bilateral, and the difference was statistically significant at P < 0.05.

3. Results

3.1. Descriptive analysis of individual and household characteristics of the sample residents
Existing studies have shown that environmental concern is the degree to which people are aware of environmental problems and support solving them, and individuals with high environmental concern are more willing to participate in household waste drop-off [10], so the level of environmental concern positively influences residents' participation in dispose of discarded masks. At the same time, in the setting area of discarded mask dustbins and the pilot communities for domestic waste disposal, the discarded mask dustbins and other equipment are complete and the publicity is sufficient, which will have a positive impact on Residents' participation in discarded mask disposal. Therefore, in this paper, whether to set up discarded mask dustbin and the level of environmental concern are considered as important influencing factors of discarded mask dispose behavior and willingness.

From Table 1, the high environmental concern sample has higher education years than the low environmental concern sample, the high environmental concern sample is younger than the low
environmental concern sample, and the total household size of the high environmental concern sample is smaller than the low environmental concern sample, which shows that the higher education level, younger age, and smaller total household size also have higher environmental concern. According to the statistical results, in terms of the overall sample, there are significant differences in individual characteristics, years of education and total household size between the area where the discarded mask dustbin is installed and the area where the discarded mask dustbin is not installed; For the environmental concern sample, there is a significant difference in age in the high environmental concern sample and a significant difference in total household size in the low environmental concern sample.

**Table 1.** Descriptive analysis of individual and household characteristics of sample residents.

|                         | Total Sample | High Environmental Concern Sample | Low environmental concern sample |
|-------------------------|--------------|-----------------------------------|---------------------------------|
|                         | Average value of dustbin setting area | Average value of non-setting area of dustbin | t-value | Average value of dustbin setting area | Average value of non-setting area of dustbin | t-value |
| Gender (male=1, female=0) | 0.469 | 0.473 | 0.521 | 0.478 | 0.475 | 0.518 | 0.417 | 0.462 | 0.432 |
| Age (years)             | 2.728 | 2.602 | -1.432 | 2.623 | 2.438 | 0.254** | 3.333 | 3.615 | -2.564 |
| Years of education (years) | 13.519 | 13.978 | 1.465** | 14.058 | 14.588 | 0.719 | 10.417 | 10.231 | 1.135 |
| Occupation category     | 2.222 | 2.140 | 6.432 | 2.232 | 2.05 | 4.325 | 1.867 | 1.777 | 3.432 |
| Total number of family members (persons) | 4.778 | 4.987 | 1.741** | 4.710 | 4.925 | 2.165 | 5.167 | 5.462 | -0.123** |

* Note: ** and *** indicate passing significance tests at 5% and 1% statistical levels, respectively; Age was assigned as follows: under 20 years old = 1, 20 (inclusive) - 30 years old = 2, 30 (inclusive) - 40 years old = 3, 40 (inclusive) - 50 years old = 4, 50 (inclusive) - 60 years old = 5, over 60 (inclusive) years old = 6. Years of education (years) were assigned as follows: elementary = 6, middle school = 9, high school = 12, junior college student = 15, undergraduate = 16, postgraduate = 19. The assignment of occupational categories was assigned as follows: medical personnel = 5, security personnel = 2, others = 1. The assignment of total family size was assigned as follows: 1 person = 1, 2 people = 2, 3 people = 3, 4 people = 4, 5 people = 5, 6 people = 6, 7 and above = 7

3.2. **Analysis of the differences in dispose behavior and willingness of the sample residents**

From Table 2, there are significant differences in the dispose behavior and willingness between the residents in the non-setting area of discarded mask dustbin and the setting area of discarded mask dustbin in the overall sample. Residents' dispose behavior and willingness of discard masks were both higher in the setting area of discarded mask dustbin than those in the non-setting area of discarded
mask dustbin, in which the dispose behavior and willingness of the overall sample are 13.14% and 9.60% higher. Similarly, residents with high environmental concern had higher dispose behavior and willingness than those with low environmental concern, in the setting area of discarded mask dustbin, the residents with high environmental concern have 10% higher dispose behavior and 32.97% higher dispose willingness. In the non-setting area of discarded mask dustbin, the residents with high environmental concern have 11.36% higher dispose behavior and 36.30% higher dispose willingness.

For Dongguan residents with a high level of environmental concern, there was a significant difference in the dispose behavior of residents in the non-setting area of discarded masks dustbin and the setting area of discarded masks dustbin. The dispose behavior in the setting area of discarded masks dustbin being 12.10% higher than that in the non-setting area of discarded masks dustbin. Although the willingness to dispose masks was also higher in the setting area of discarded masks dustbin than in the non-setting area of discarded masks dustbin (6.30% higher), the t-test was not significant. Residents with a high level of environmental concern have a stronger awareness of disposing discarded masks, and the establishment of waste classification pilot has a certain promotion effect on their willingness and behavior to dispose discarded masks.

For Dongguan residents with low level of environmental concern, the willingness to dispose discarded masks in the setting area of discarded masks dustbin is 9.63% higher than that in the non-setting area of discarded masks dustbin, while the behavior of dispose discarded masks in the setting area of discarded masks dustbin is 13.46% higher than that in the non-setting area of discarded masks dustbin. The difference is relatively significant, which shows that the setting up of disposal mask dustbin has a strong driving effect on the dispose willingness and behavior of residents with low environmental concern level.

Compared with the non-setting area of discarded masks dustbin, whether it is the overall sample, high environmental concern sample or low environmental concern sample, the dispose behavior and willingness of residents in the setting area of discarded masks dustbin are relatively high, which may be due to the complete dropping equipment, publicity, and effective management and operation of the setting area of discarded masks dustbin, which helped to raise residents' awareness and promote the development of separate dropping behavior.

Table 2. Differences in the dispose willingness and behavior of residents in areas with and without discarded mask dustbin.

|                        | Willingness and behavior to dispose | Non-setting area of discarded mask dustbin | Setting area of discarded mask dustbin | Differences | t-value | P  |
|------------------------|------------------------------------|------------------------------------------|----------------------------------------|-------------|--------|----|
| Overall                | Dispose behavior                    | 71.33%                                   | 84.47%                                 | 13.14%      | -3.273 | 0.001|
|                        | Willingness to dispose              | 79.90%                                   | 89.50%                                 | 9.60%       | -2.114 | 0.036|
| High environmental concern | Dispose behavior                   | 72.90%                                   | 85.00%                                 | 12.10%      | -2.907 | 0.005|
|                        | Willingness to dispose              | 85.00%                                   | 91.30%                                 | 6.30%       | -1.431 | 0.154|
| Low environmental concern       | Dispose behavior                   | 61.54%                                   | 75.00%                                 | 13.46%      | -0.417 | 0.683|
|                        | Willingness to dispose              | 48.70%                                   | 58.33%                                 | 9.63%       | -0.72  | 0.483|

3.3. Analysis on influencing factors of disposal behavior and willingness of the sample residents

A binary Probit regression model was used to analyze the influencing factors in dispose behavior and willingness. The expression of the Probit model is as follows [11].

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P(Y = 1|X_1, X_2, \cdots X_n) = \Phi(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)
\]  

(1)
where: Y =1 indicates that residents are willing to sort discarded masks or have the disposal behavior, and Y =0 indicates that residents are not willing to sort discarded masks or do not have the disposal behavior; X1, X2, ..., Xn are the explanatory variables affecting residents' willingness to dispose and disposal behavior; β0 is the intercept term; β1, β2, ..., βn are regression coefficients.

The explanatory variables included dispose willingness and behavior, and the questions on disposal willingness were set as three questions: "Are you willing to dispose of discarded masks after sorting", "Are you willing to sort household waste (including discarded masks) at home", and "Are you willing to dispose the discarded masks at home every day from now on". The answers to the questions were set as yes and no, with the values of 1 and 0. The questions on disposal behavior were set as three questions: "Do you put the discarded masks together with domestic waste in your home ", "Do you put the discarded masks in the designated garbage bin (or 'other garbage' bin)", "Do you put the discarded masks in your home after treatment (such as using a separate bag)". The answers to the questions were set as yes and no, with the values of 1 and 0. The explanatory variables include whether there is a discarded masks dustbin or a waste separation dustbin, the degree of environmental concern, personal characteristics and household characteristics, with gender, age, education, and occupation selected for personal characteristics and total household size selected for household characteristics.

3.3.1. Descriptive analysis of residents' individual characteristics on the disposal willingness and behavior. From Table 3, we can see that residents' age has a significant negative influence on their willingness and behavior of disposing discarded masks, and the older the age, the lower their willingness and behavior of disposing discarded masks. This is because age is negatively correlated with education level, and the older people are generally less educated and less cognitive and receptive to new things [12-13], so their willingness and behavior to dispose discarded masks are relatively low.

Education level has a significant positive impact on residents' willingness and behavior of disposing masks. The higher the level of education, the higher the willingness to dispose discarded masks. The reason for this is that the higher the level of education, the better the understanding of environmental knowledge, and thus the better the understanding of the potential health hazards of discarding discarded masks and the importance of putting them out [14].

The total household size had a significant negative effect on the willingness and behavior of Dongguan residents to dispose masks. The larger the total household size, the lower the willingness and behavior of disposing discarded masks. The reason is that the larger the household size, the more household waste and discarded masks are produced, which is relatively troublesome to handle [15], so their willingness and behavior to dispose the masks will also be lower.

Table 3. Descriptive analysis of residents' individual characteristics on disposal willingness and behavior.

| Parameters            | Coefficient | Standard deviation | Z-value | Significance |
|-----------------------|-------------|--------------------|---------|--------------|
| Gender                | -0.184      | 0.127              | -1.446  | 0.148        |
| Age                   | -0.155      | 0.069              | -2.261  | 0.024        |
| Education level       | 0.087       | 0.051              | 1.707   | 0.048        |
| Total family size     | -0.257      | 0.111              | -2.318  | 0.020        |
| Occupational category | 0.327       | 0.176              | 1.857   | 0.163        |

3.3.2. Differential analysis of residents' individual characteristics on disposing behavior. From Table 4, among the analyses exploring the possible effects on residents' disposing behavior, only the setting of discarded mask dustbin, environmental concern and education level have effects on residents' disposing behavior (all significant at P<0.05), Among them, the setting of discarded mask dustbin, the
level of environmental concern and the increase of education will help residents improve their disposal behaviour.

The disposal behavior of residents in the setting area of discarded mask dustbin is 0.390 percentage points higher than that in the non-setting area of discarded mask dustbin. It can be seen that residents who in the setting area of discarded mask dustbin will have better disposal habits; The disposal behavior of residents with high environmental concern is 0.812 percentage points higher than that of residents with low environmental concern. This means that the higher the environmental concern, the stronger the implementation of the behavior of disposing; the disposal behavior of residents with high education is 0.359 percentage points higher than that of residents with low education, which means that the higher the education, the stronger the awareness of environmental protection and the more willing to implement the behavior of disposing.

Table 4. Differences in residents' disposal behavior.

| Parameters                        | Coefficient | Standard deviation | Z-value | Significance | 95% CI       | Marginal effects |
|-----------------------------------|-------------|--------------------|---------|--------------|--------------|-----------------|
| Whether to set the discarded mask dustbin | 0.395**     | 0.155              | 2.548   | 0.011        | 0.091~0.700  | 0.390           |
| Level of environmental concern    | 0.712***    | 0.173              | 4.117   | 0.000        | 0.373~1.051  | 0.812           |
| Gender                            | -0.070      | 0.149              | -0.473  | 0.636        | -0.362~0.222 | 0.0239          |
| Age                               | -0.067      | 0.074              | 911     | 0.362        | -0.212~0.077 | 0.102           |
| Education level                   | 0.237***    | 0.056              | 4.233   | 0.000        | 0.127~0.347  | 0.359           |
| Total household size              | 0.241       | 0.127              | 1.893   | 0.058        | -0.009~0.490 | 0.309           |
| Occupational category             | 0.391       | 0.212              | 1.846   | 0.165        | -0.024~0.806 | 0.759           |
| Intercept distance                | -0.837      | 0.498              | -1.681  | 0.093        | -1.334~0.339  |                 |

3.3.3. Differential analysis of residents' individual characteristics on the disposal willingness. From Table 5, it can be seen that among the analyses exploring the possible effects on residents' disposing willingness, only the setting of discarded mask dustbin, age, and total household size affect residents' disposing willingness (all significant at P<0.05). The setting of discarded mask dustbin will help residents to have a willingness to dispose masks, while age and total household size will have a negative impact on residents' willingness to dispose masks with the value increases.

The willingness of residents who in the setting area of discarded mask dustbin is 0.213 percentage points higher than that in non-setting area of discarded mask dustbin, so setting up discarded mask dustbin will enhance residents' willingness, and relevant departments can appropriately increase the areas with discarded mask dustbin. The disposal willingness of older residents is 0.102 percentage points lower than that of younger residents. This may be because younger residents are more concerned about new things and are more willing to try new behaviors. The relevant departments can increase the propaganda for younger residents about disposing discarded masks and increase their willingness to dispose through the influence of younger residents on older residents; The disposal willingness of residents with large household size is 1.45 percentage points lower than that of residents with small household size. The large difference mainly due to the large household size, the total amount of daily domestic garbage and discarded masks, difficult personal behavior control and large workload of garbage classification.
Table 5. Differences in residents' disposal willingness.

| Parameters                              | Coefficient | Standard deviation | Z-value | Significance | 95% CI         | Marginal effects |
|-----------------------------------------|-------------|--------------------|---------|--------------|----------------|------------------|
| Whether to set the discarded masks dustbin | 0.384***    | 0.134              | 2.868   | 0.004        | 0.121–0.646    | 0.213            |
| Level of environmental concern          | 0.069       | 0.170              | 0.407   | 0.684        | 0.263–0.401    | 0.593            |
| Gender                                  | -0.165      | 0.129              | -1.287  | 0.198        | -0.418–0.087   | 0.101            |
| Age                                     | -0.152**    | 0.070              | -2.191  | 0.028        | -0.289–0.016   | 0.102            |
| Education level                         | 0.089       | 0.052              | 1.691   | 0.091        | 0.192–0.014    | 0.135            |
| Total household size                    | -0.230**    | 0.112              | -2.054  | 0.040        | -0.099–0.610   | 1.45             |
| Occupational category                  | 0.251       | 0.179              | 1.404   | 0.160        | -0.099–0.601   | 0.876            |
| Intercept distance                      | 1.962       | 0.469              | 4.184   | 0.000        | 1.493–2.431    |                 |

4. Discussions
During the period of COVID-19 epidemic, residents, as generators of discarded masks and direct beneficiaries of reducing the spread of COVID-19 epidemic, were influenced not only by external factors but also by internal factors in terms of their disposal behavior and willingness. The results of this paper showed that the installation of discarded mask collection and disposal facilities or the installation of household waste disposal equipment had a significant positive effect on residents' disposal behavior and willingness. The level of environmental concern and the education level of the residents significantly and positively influenced the residents' disposing behavior. This paper also shows that the age of residents and total household size significantly and negatively affect residents' disposal willingness. The results of this study are basically consistent with the research results of Jia Y.J [9], Zhan M.L [16] and Chi S X. et al. [17] on the willingness of rural residents to participate in domestic waste treatment and Yin X. [18] and Xu L. et al. [19] on the willingness of residents to classify domestic waste. It shows that residents do not treat the disposal of discarded masks differently from general household waste, and ignore the special potential dangers of discarded masks, such as bringing new types of pollution to the ocean and releasing microplastics into the environment, endangering the health of organisms and ecosystems.

5. Conclusions
During the period of COVID-19 epidemic, many regions had taken some measures to regulate the behavior of discarded masks, such as setting up special recycling bins for discarded masks in public places, but the placement of the recycling bins was rather arbitrary and there were no mandatory requirements for residents to put them in; publicizing the hazards of disposing of discarded masks at random in public places, but only mentioning that it would help spread the virus, and at once when the epidemic was under control, the warning nature of this slogan has also decreased. Based on this, we propose the following recommendations to promote the proper disposal of discarded masks: (1) Publicize the hazards of discarded masks to the public through public service announcements and brochures, including not only the spread of viruses, but also the new environmental problems brought about by improper disposal of discarded masks, such as marine pollution and potential threats to the ecosphere, in order to strengthen the public's awareness of environmental concerns and hygiene. (2)
Mandatory requirements for the disposal behavior of discarded masks: discarded masks discarded by suspected infected persons, medical personnel and close contacts should be strictly treated as medical waste and recycling is strictly prohibited; discarded masks of the general public should be set up in special discarded mask recycling buckets and be recycled and disposed of by dedicated personnel on the basis of good protective measures.

In addition, in the context of the normalization of the COVID-19 epidemic, the number of masks used remains high, and the improper disposal of discarded masks can increase the residue of microplastics in the environment and have long-term adverse effects on the health of organisms, for which we propose the following recommendations: (1) reduce the use of polypropylene in masks and replace them with recycled water bottles, fishing nets, mosquito nets, etc., thus reducing the potential sources of microplastic pollution; (2) with conditions, flexible respirators with strict cleaning and disinfection devices can be reused, which can reduce the demand for disposable masks; (3) develop new materials for reusable masks.

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