

Prevalence of waste plastic as a household fuel in low-income communities of the Global South

Supplementary Information

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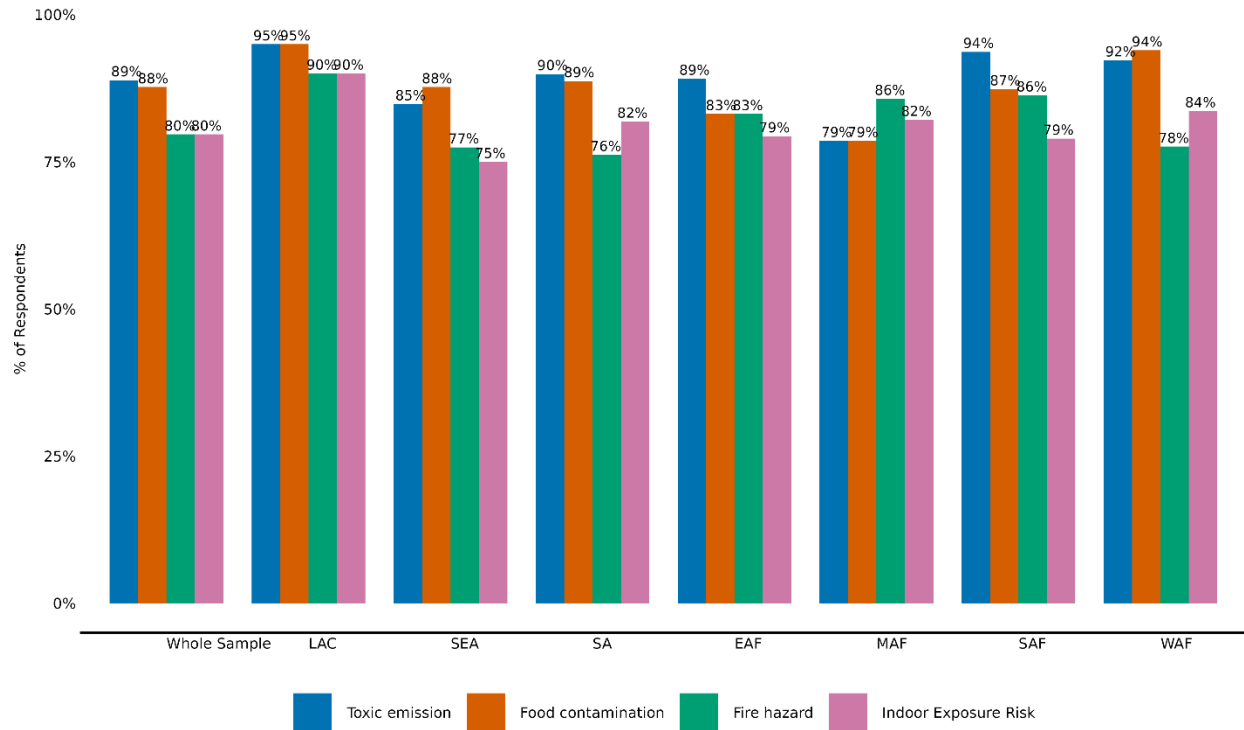
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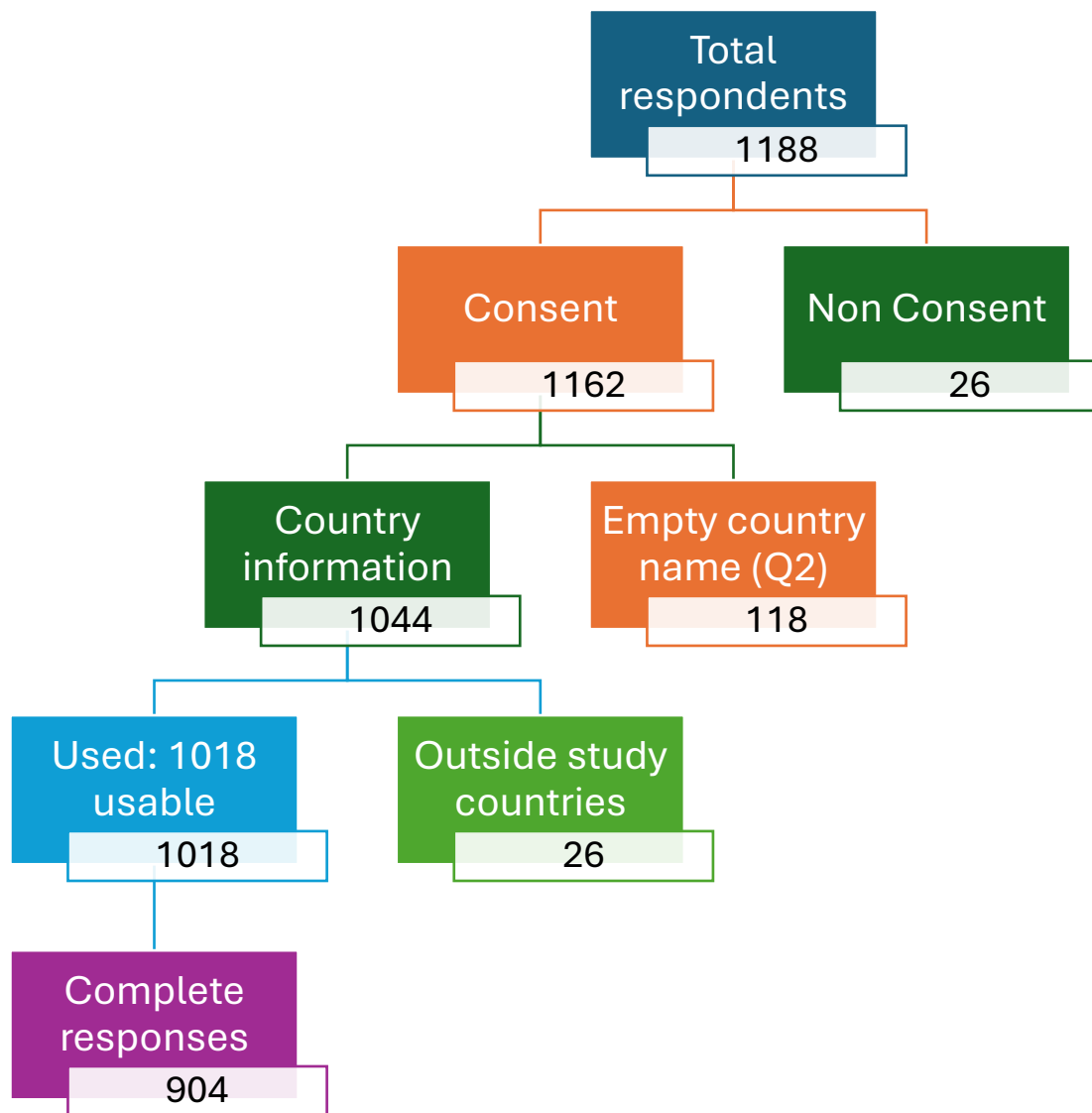
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Supplementary Figure 1 Risk of burning plastic waste as household fuel.

Percentage of respondents who indicated that the risk associated with burning plastic waste as household fuel is somewhat likely or extremely likely for the whole sample and by region. Responses measured as 1 = extremely unlikely to 5 = extremely likely are converted to a binary variable that takes the value for respondents selecting somewhat likely or extremely likely. (N= 832). LAC = Latin America and the Caribbean; SEA = South Asia SA = South Asia; SAF = South Africa; WAF = Western Africa; EAF = Eastern Africa; MAF = Middle Africa. The MAF and LAC numbers are based on responses from a single country, the Democratic Republic of the Congo and Peru, respectively.



Supplementary Figure 2 Consort style diagram showing the number of respondents who participated in the survey.

The figure shows the flow of respondent who started the survey to number of respondents who completed the survey. Total respondents indicate the total number of respondents who started the survey. Used indicates the number of responses that were included in the analysis. Complete responses indicate the respondents who completed the survey.

Supplementary Table 1 Number of responses from study countries.

Country	# useable response	% of response	# of complete responses	% of useable responses
Bangladesh	16	1.57	15	93.8
Botswana	17	1.67	17	100.0
DR Congo	44	4.32	21	47.7
Gambia	17	1.67	17	100.0
Ghana	37	3.63	37	100.0
India	37	3.63	29	78.4
Indonesia	132	12.97	103	78.0
Kenya	18	1.77	18	100.0
Lao PDR	17	1.67	14	82.4
Malawi	40	3.93	40	100.0
Malaysia	31	3.05	31	100.0
Maldives	37	3.63	33	89.2
Namibia	53	5.21	41	77.4
Nepal	65	6.39	64	98.5
Nigeria	49	4.81	46	93.9
Pakistan	80	7.86	79	98.8
Peru	23	2.26	19	82.6
Rwanda	93	9.14	93	100.0
South Africa	15	1.47	15	100.0
Sri Lanka	20	1.96	20	100.0
Swaziland	23	2.26	19	82.6
Thailand	48	4.72	47	97.9
Togo	26	2.55	16	61.5
Uganda	17	1.67	17	100.0
Viet Nam	47	4.62	37	78.7
Zimbabwe	16	1.57	16	100.0
No of observations(N)	1018		904	

Supplementary Table 2 Summary statistics of variables used in graphs

Description	Obs	Mean	Std. Dev.	Min	Max
Prevalence of burning waste plastic in city (Likert scale)	.	.	.	.	.
Not prevalent at all	931	0.085	0.279	0	1
Slightly prevalent	931	0.224	0.417	0	1
Moderately prevalent	931	0.348	0.477	0	1
Very prevalent	931	0.26	0.439	0	1
Extremely prevalent	931	0.083	0.276	0	1
Plastic fuel used as cooking fuel (Likert scale)	.	.	.	.	.
Strongly disagree	989	0.298	0.458	0	1
Somewhat disagree	989	0.208	0.406	0	1
Neither agree nor disagree	989	0.219	0.414	0	1
Somewhat agree	989	0.191	0.393	0	1
Strongly agree	989	0.083	0.276	0	1
Common practice to burn waste in tradition stove (Likert scale)	.	.	.	.	.
Strongly disagree	985	0.134	0.341	0	1
Somewhat disagree	985	0.159	0.366	0	1
Neither agree nor disagree	985	0.141	0.348	0	1
Somewhat agree	985	0.321	0.467	0	1
Strongly agree	985	0.245	0.43	0	1
Are you aware of burning plastic as fuel?	.	.	.	.	.
No	998	0.266	0.442	0	1
Unsure / maybe	998	0.369	0.483	0	1
Yes	998	0.366	0.482	0	1
Are you aware of the following scenario:					
Plastic waste being burnt and used as fuel for cooking / preparing food (1)	361	3.374	1.219	1	5
No	362	0.122	0.327	0	1
Unsure	362	0.124	0.330	0	1
Yes, I have done	362	0.144	0.351	0	1
Yes, I have seen	362	0.475	0.500	0	1
Yes, I have heard	362	0.135	0.343	0	1
Plastic waste being burnt and used as fuel for heating (2)	361	3.252	1.344	1	5
No	362	0.146	0.354	0	1
Unsure	362	0.185	0.389	0	1
Yes, I have done	362	0.116	0.321	0	1
Yes, I have seen	362	0.373	0.484	0	1
Yes, I have heard	362	0.180	0.384	0	1
Plastic waste being burnt and used as a fuel for cattle feed preparation (3)	361	2.285	1.322	1	5
No	362	0.323	0.468	0	1
Unsure	362	0.409	0.492	0	1
Yes, I have done	362	0.041	0.200	0	1
Yes, I have seen	362	0.116	0.321	0	1
Yes, I have heard	362	0.110	0.314	0	1
Plastic waste is burnt and used by mixing with other fuels like firewood. (4)	361	3.465	1.11	1	5
No	362	0.083	0.276	0	1
Unsure	362	0.102	0.303	0	1
Yes, I have done	362	0.218	0.414	0	1

Yes, I have seen	362	0.459	0.499	0	1
Yes, I have heard	362	0.138	0.346	0	1
Plastic waste being burnt and used to produce smoke that will deter pests e.g. mosquitos (5)	361	2.709	1.486	1	5
No	362	0.262	0.441	0	1
Unsure	362	0.318	0.466	0	1
Yes, I have done	362	0.061	0.239	0	1
Yes, I have seen	362	0.171	0.377	0	1
Yes, I have heard	362	0.188	0.391	0	1
Plastic waste being burnt and used as a fire starter (6)	361	3.551	0.906	1	5
No	362	0.033	0.179	0	1
Unsure	362	0.052	0.223	0	1
Yes, I have done	362	0.378	0.486	0	1
Yes, I have seen	362	0.403	0.491	0	1
Yes, I have heard	362	0.133	0.340	0	1
Plastic material burned for household energy (Ranking: 1 being most frequently used and 7 least frequently used)					
Polyethylene Terephthalate (PET or PETE)	305	2.449	1.63	1	7
High-Density Polyethylene (HDPE)	306	2.444	1.629	1	7
Polyvinyl Chloride (PVC or Vinyl)	306	3.131	1.533	1	7
Low-Density Polyethylene (LDPE)	306	4.546	1.683	1	7
Polypropylene (PP)	306	2.788	1.676	1	7
Polystyrene (PS or Styrofoam)	306	4.288	1.573	1	7
Other large waste plastic items often made from composite materials	306	4.657	1.616	1	7
Source of the plastic waste being burnt (Multiple choice question)					
Food wrappers or bag	365	0.627	0.484	0	1
bag, bottle or wrapper used for packing chemicals	365	0.427	0.495	0	1
Non-food plastic items used in household	365	0.307	0.462	0	1
Construction and furniture materials	365	0.279	0.449	0	1
Other large waste plastic items	365	0.227	0.42	0	1
Other	365	0.041	0.199	0	1
Type of stove used to burn waste plastic					
Three stone (traditional stove)	323	0.3	0.459	0	1
Mud (traditional stove)	323	0.189	0.392	0	1
Improved cooking stoves (ICS)	323	0.136	0.344	0	1
Charcoal stove	323	0.291	0.455	0	1
Other	323	0.084	0.277	0	1
Reasons for burning plastic as fuel (Likert scale: 1 Strongly disagree to 5 Strongly agree)					
Clean fuel like LPG is more expensive than waste plastic	937	3.819	1.151	1	5
Firewood or charcoal are more difficult to access than waste plastic	931	3.344	1.335	1	5
Lack of awareness of the health impacts of burning plastic	933	4.133	1.077	1	5
People burn plastic to manage excess plastic waste in their local environment	934	3.816	1.165	1	5
Plastic waste is a versatile fuel e.g., burning it is compatible with different stove types	931	3.067	1.141	1	5
Burning waste plastic is a socially acceptable practice	924	2.852	1.372	1	5
Household likelihood of burning waste plastic in your city -10 (not likely) to +10 (very likely)					
Consisting of people living with disabilities	944	-0.68	5.329	-10	10
Consisting of young children	944	0.776	5.566	-10	10

Experiencing poverty	944	4.156	4.987	-10	10
Located in slums	944	4.208	5.145	-10	10
Areas not serviced by waste management services	944	4.732	5.204	-10	10
With member working in waste site like rug picker	944	1.717	5.386	-10	10
Risk of burning plastic in household (Likert scale: 1 Extremely unlikely to 5 Extremely likely)					
Fire hazards starting from inflammable plastic waste	936	4.073	1.024	1	5
The toxic emissions impacting health	936	4.456	0.849	1	5
Toxic chemicals could contaminate food and water	936	4.392	0.899	1	5
Those who are likely to spend more time indoors and are more likely to be impacted	936	4.152	1.005	1	5
Rank possible solution to burning plastic waste? (1 = the most effective and 5 = the least effective).					
Ban the use of plastic	833	3.277	2.179	1	7
Improve and expand solid waste management services to informal settlements	833	2.77	1.359	1	7
Increase clean energy access for low-income household	833	3.012	1.258	1	7
Raise awareness	833	3.03	1.498	1	7
Increase access to alternative fuels like firewood	833	4.192	1.354	1	7
Convert plastic into a safer household fuel	833	4.821	1.525	1	7
Other	833	6.891	0.638	1	7

Supplementary Table 3 Summary statistics of the variables used in the regression analysis.

Variable	Obs	Mean	Std. Dev.	Min	Max
=1 if respondents somewhat agree or strongly agree: it is common practice to burn waste plastic in the traditional stove (Agree)	1018	0.547	0.498	0	1
=1 if respondent is aware of households burning waste plastic as household fuel (Aware)	1018	0.359	0.48	0	1
if respondent has burnt plastic waste for any of cooking, heating, mixed fuel, cattle feed, deter pest or fire starter (Used)	1018	0.16	0.367	0	1
=1 if respondent selects that municipal/government SWM is not affordable (SWM not affordable)	1018	0.13	0.336	0	1
Respondents agree expensive clean energy as reason for burning waste plastic as fuel (0/1) (Expensive clean fuel)	1018	0.706	0.456	0	1
People using at least basic sanitation services, urban (per 10% of urban population) [Urban Basic collection rate]	1018	7.125	2.353	2.18	9.975
Waste generated per capita (in 100 grams per capita) (Waste generation)	1018	8.028	2.179	3.97	13.42
Plastic waste generated per capita (in 10 grams per capita) (Plastic Waste)	1018	9.252	3.578	2.6	19.3
Population without solid waste collection services (in 10 %) [No waste collection]	1018	3.01	2.113	.005	7.509
Respondent is a female (Female)	1018	0.384	0.487	0	1
Age (Year) (Age)	1018	32.939	10.016	19	80
Respondent has university level education (>Undergraduate) (Graduate)	1018	0.754	0.431	0	1
Respondent is active in NGO, CBO or socially engaged professional like teacher (Socially engaged)	1018	0.16	0.367	0	1

Supplementary Table 4 Regression analysis of plastic waste burning

Variables	(1) Agree	(2) Aware	(3) Used
Municipality SWM not affordable	1.67*** (1.15 - 2.44)	1.75** (1.10 - 2.80)	1.56 (0.83 - 2.92)
Expensive clean fuel	1.91*** (1.41 - 2.60)	2.05*** (1.58 - 2.67)	1.57*** (1.15 - 2.14)
Urban basic sanitation rate	0.93 (0.85 - 1.02)	0.96 (0.89 - 1.04)	0.96 (0.86 - 1.07)
Waste generated	0.91 (0.71 - 1.16)	0.71*** (0.55 - 0.92)	0.70** (0.52 - 0.95)
Plastic waste generated	1.00 (0.87 - 1.15)	1.20** (1.03 - 1.41)	1.29*** (1.07 - 1.56)
No waste collection	1.08 (0.96 - 1.22)	1.26*** (1.12 - 1.43)	1.39*** (1.18 - 1.65)
Female	1.42** (1.04 - 1.94)	1.05 (0.79 - 1.41)	0.97 (0.68 - 1.37)
Age	1.00 (0.98 - 1.01)	1.00 (0.98 - 1.01)	1.00 (0.98 - 1.02)
Graduate	0.99 (0.66 - 1.49)	0.70** (0.52 - 0.93)	0.72 (0.47 - 1.10)
Socially engaged	1.63*** (1.18 - 2.25)	0.93 (0.69 - 1.25)	1.24 (0.83 - 1.85)
Constant	1.84 (0.34 - 10.09)	0.70 (0.22 - 2.21)	0.10*** (0.02 - 0.40)
Observations	1,018	1,018	1,018

Column 1 in Table 1 presents the odds ratios from logistic regression for respondents' agreement on the use of plastic as fuel. The dependent variables in Column 1 are binary variables, converted to indicate if respondents somewhat or strongly agreed with the statement "It is common practice to burn plastic waste (like polythene bags) in the fire of traditional stoves," as 1, and otherwise 0. Column 2 presents the odds ratios for the dependent variable for awareness of plastic waste burning based on the third question in Figure 1, which takes the value 1 if respondents answered 'yes' to the question: "Are you aware of households burning plastic waste as fuel to meet their household energy needs (e.g. fire starters and for cooking and heating)?", otherwise 0. Column 3 shows the odds ratios of respondents' own burning plastic waste for various purposes, where the dependent variable takes a value of 1 if respondents reported burning plastic themselves for cooking, heating, mixed energy use, preparing cattle feed, deterring pests, or starting fires. To improve the readability of coefficient estimates and odds ratios in the coefficient plot, variables measured in percentages (no waste collection and basic sanitation services) and grams (total waste and plastic waste generation) were rescaled. Robust 95% confidence interval in parentheses. Errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1.

Supplementary Table 5 City-level regression of cities with at least 5 respondents.

VARIABLES	(1) Aware	(2) Used
Urban basic sanitation rate	-0.009 (-0.033 - 0.015)	-0.011 (-0.036 - 0.015)
Waste generated	-0.047 (-0.114 - 0.021)	-0.043 (-0.099 - 0.014)
Plastic waste generated	0.019 (-0.023 - 0.061)	0.025 (-0.011 - 0.060)
No waste collection	0.048*** (0.018 - 0.078)	0.038*** (0.012 - 0.064)
Constant	0.502*** (0.139 - 0.865)	0.250 (-0.052 - 0.551)
Observations	42	42
R-squared	0.420	0.284

Same Robust CI in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Supplementary Table 6 Detailed summary statistics of respondents.

Variable	N	Mean	Std. Dev.	Min	Max	P25	P50	P75
Gender								
Male	908	0.543	0.498	0	1	0	0	1
Female	908	0.431	0.495	0	1	0	0	1
Non-binary/ third gender	908	0.007	0.081	0	1	0	0	0
Prefer not to say	908	0.020	0.139	0	1	0	0	0
Age (Year)	908	33.1	10.4	19	80	24	32	40
What type of organization do you work?								
University or Polytechnical	904	0.388	0.488	0	1	0	0	1
Commercial entity	904	0.095	0.294	0	1	0	0	0
Government agency	904	0.233	0.423	0	1	0	0	0
Not-for-profit (NGO)	904	0.112	0.315	0	1	0	0	0
Other	904	0.171	0.377	0	1	0	0	0
Education								
Up to Grade 12	904	0.091	0.287	0	1	0	0	0
Post secondary qualifications	904	0.052	0.222	0	1	0	0	0
Bachelor's degree	904	0.390	0.488	0	1	0	0	1
Master's degree	904	0.327	0.470	0	1	0	0	1
PhD	904	0.132	0.338	0	1	0	0	0
Other	904	0.008	0.088	0	1	0	0	0
How long (in years) have you been engaged in your current field of work/research								
Less than 2 years	897	0.312	0.464	0	1	0	0	1
Less than 5 years	897	0.261	0.439	0	1	0	0	1
Less than 10 years	897	0.145	0.352	0	1	0	0	1
More than 10 years	897	0.282	0.450	0	1	0	0	1
What is the geographical coverage of your work?								
Multinational	904	0.179	0.384	0	1	0	0	0
National	904	0.446	0.497	0	1	0	0	1
City level	904	0.205	0.404	0	1	0	0	1
Community	904	0.170	0.376	0	1	0	0	11
What area does your work fall under?								
Natural sciences	904	0.159	0.366	0	1	0	0	0
Engineering and technical	904	0.250	0.433	0	1	0	0	.5
Medical and health services	904	0.082	0.274	0	1	0	0	0
Agricultural science	904	0.102	0.303	0	1	0	0	0
Social sciences	904	0.189	0.392	0	1	0	0	0
Arts and humanities	904	0.043	0.203	0	1	0	0	0
Other	904	0.175	0.380	0	1	0	0	0
Type of institution								
University or Polytech	904	0.388	0.488	0	1	0	0	1
Commercial entity	904	0.095	0.294	0	1	0	0	0
Government agency	904	0.233	0.423	0	1	0	0	0
Not-for-profit (NGO)	904	0.112	0.315	0	1	0	0	0
Other	904	0.171	0.377	0	1	0	0	0
To which of the following categories do you belong?								
Researcher	904	0.355	0.479	0	1	0	0	1
Local government and civil servant	904	0.208	0.406	0	1	0	0	0
Socially engaged professional	904	0.067	0.251	0	1	0	0	0
Community leader	904	0.019	0.136	0	1	0	0	0
NGO or CBO	904	0.094	0.292	0	1	0	0	0

Private operators	904	0.116	0.321	0	1	0	0	0
Others	904	0.140	0.348	0	1	0	0	0

Note: Socio-demographic questions were asked in the concluding section of the survey.