The effect of housing type on householders' self-reported participation in recycling

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Abstract

Purpose: The purpose of this article is to examine the effect of housing type, relative to demographics, on householders' self-reported recycling across low-, medium- and high-density housing without recycling facilities by using the theory of planned behaviour.

Design/methodology/approach: A survey was conducted amongst 580 households across houses, townhouses and apartments in Pretoria, South Africa. The household member most responsible for recycling completed a self-administered questionnaire. Data were analysed using factor and reliability analyses, decision trees and multivariate analysis of variance.

Findings: Age was the strongest predictor; the older the respondent, the more likely the household recycled. Housing type was the second strongest predictor with a significant increase in recycling in houses compared to townhouses and apartments. Subsequent analyses focussed on young respondents to control for age. Housing type had an overall non-significant effect on the factors behind recycling. Post hoc tests, however, suggest that young respondents in townhouses and apartments felt significantly less able to recycle, particularly because of lack of space and support from managing agencies.

Practical implications: For recycling to be acceptable to young people in medium- and high-density housing, interior architects and site planners should find innovative ways to make individual and communal facilities as convenient and accessible as possible to tenants, owners and recycling companies. The role of managing agencies is also critical.

Originality/value: This study is one of the first to systematically examine recycling across three different housing types with recommendations for planning, design and further research.

Keywords: Theory of planned behaviour, Housing, Interior architecture, Household recycling, Multivariate analysis of variance, Site planning

1. Introduction

Urban South Africans produce two kg of solid waste per person per day, compared to the world-wide average of 1.2 kg (Hoornweg and Bhada-Tata, 2012). In 2011, 90% of this household waste ended up in landfills (Godfrey and Oelofse, 2017). In light of these figures, the South African Department of Environmental Affairs and Tourism proposes recycling as a key strategy in its Integrated Pollution and Waste Management Policy. The South African Municipal Systems Act requires municipalities to create Integrated Development Plans with hierarchical waste management programmes emphasising reduction, reuse and recycling. Each municipality manages waste through its own by-laws and the City of Tshwane (in which Pretoria and the present study is located) uses a straightforward model in which solid waste is collected and transferred to landfills (Snyman and Vorster, 2010).

Recycling in urban South Africa was estimated at only 7.2% in 2015 (Strydom and Godfrey, 2016). The low rate is partly due to lack of incentives (Snyman and Vorster, 2010), inconvenience and lack of space, time and know-how (Strydom, 2018). Considering that household participation is critical for the effectiveness of recycling strategies based on separation at source (Alhassan *et al.*, 2018), and that issues of space and convenience have been raised locally (Strydom, 2018) and internationally (Ando and Gosselin, 2005), a better understanding of how to promote household recycling is needed, including how housing type may affect recycling.

Although a systematic review of the literature suggests that the physical ability to recycle is more important than intrinsic motivation (Johansson, 2016), the literature on the effect of housing type on recycling is surprisingly limited and dated (De Young *et al.*, 1995; Farrell, 1996; McQuaid and Murdoch, 1996). Yet, housing types of varying densities, such as low-density (freestanding houses), medium-density (townhouses, row houses and three-storey walk-ups) and high-density (apartment blocks and multiple-family or multiresidential) housing, pose different obstacles to recycling, such as limited space, restricted access, rigid house rules and unsupportive managing agencies. What is known is that, despite positive attitudes, recycling rates drop if recycling is perceived as inconvenient (Knussen *et al.*, 2004; Tonglet *et al.*, 2004; Chen and Tung, 2010; Nguyen *et al.*, 2017) and that there is a strong correlation between recycling rates and adequate interior space (Ando and Gosselin, 2005). Interior space can, however, vary considerably between different housing types. Households in larger homes (Barr *et al.*, 2003) or on larger stands (Ekere *et al.*, 2009) tend to perceive having more storage space for recycling compared to households in other settings. In Canada and the US, “multiple-family” or “multi-residential” housing is associated with lower recycling rates particularly because of inconvenience and lack of space (Touart, 2000; Martin *et al.*, 2006; Hendrickson and Wittman, 2010; Schwebel, 2012; Miafodzyeva and Brandt, 2013). High-density apartment buildings are particularly challenging because of limited storage inside units and the inconvenience of accessing recycling facilities outside buildings (Lakhan, 2016; Siu and Xiao, 2016).

Given the different obstacles posed to recycling by different housing types, what is the effect of housing type on household recycling relative to socio-demographics that have been shown to be associated with recycling (Martin *et al.*, 2006; Miafodzyeva and Brandt, 2013; Babaei *et al.*, 2015; Alhassan *et al.*, 2018), and how can interior architects and site planners

help facilitate recycling in housing types that are particularly problematic? This article examines the effect of housing type, relative to gender, age and level of education, on householders' self-reported participation in recycling across housing types of varying densities, including houses, townhouses and apartments, all of which had no recycling facilities at the time of the study. The article contributes to the limited literature on the role of housing type in facilitating recycling and is one of the first to systematically examine the effect on recycling across three different housing types.

2. Theoretical framework

The theory of planned behaviour (TPB) is widely used in research on recycling (Tonglet *et al.*, 2004; Botetzagias *et al.*, 2015; Du Toit *et al.*, 2017; Xu *et al.*, 2017; Du Toit and Wagner, 2018). The TPB suggests three factors behind behaviour and pro-environmental behaviour in particular, including "attitude" towards the behaviour, "subjective norm", i.e. social pressure to do the behaviour and "perceived behavioural control" (PBC, referred to as "control"), i.e. ability to perform the behaviour, which, for example, speaks to the facilitating/inhibiting effect of the built environment. These three factors interact to form an intention that in turn leads to the actual behaviour (Davies *et al.*, 2002). Thus, if people are positive about recycling, feel socially pressured to recycle, and they are physically able to recycle, they will form a strong intention to do so.

Additional factors such as morals, past experience and the perceived consequences of recycling have been included in previous studies (Tonglet *et al.*, 2004; Xu *et al.*, 2017). Instead of including additional factors, the original TPB was adapted by operationalising "control" to include situational factors pertinent to housing type, such as storage space, managerial support and access to recycling facilities. The purpose was to better understand the effect of housing type, particularly in terms of households' ability to recycle, relative to attitudes and norms that have been researched extensively (Davies *et al.*, 2002; Khalil *et al.*, 2017).

Using the TPB, a questionnaire was designed to capture the socio-demographic profile, perceptions and self-reported participation in recycling of the household member most responsible for recycling. The full questionnaire is presented as an annexure. Table 1 shows the questions and items used to gauge householders' perceptions in terms of attitude, norm and control using 5-point Likert scales.

Following criticism of the TPB's distinction between intention and actual behaviour (Davies *et al.*, 2002) and considering limited opportunity to observe actual behaviour given the lack of recycling facilities, the focus was on self-reported participation in recycling as the most realistic measure of behaviour. Household recycling was captured with a yes/no question "*Has your household recycled any paper, glass, metal or plastic in the past three months*?" Household recycling in this study was therefore delimited to self-reported participation in the sense of whether households recycled any dry recyclables in the recent past, and it is not indicative of set-out rates or the volume of materials recycled.

Table 1. Items for the theory of planned behaviour constructs

Attitude	**Subjective norm**	**Control**
Please indicate the extent to which you agree or disagree with the following statements	Please indicate the extent to which you agree or disagree with the following statements	On a scale of 1 to 5, with "1" being "not at all", and "5" being "to a large extent", to what extent …
("Agree completely", "Agree to some extent", "Neither agree nor disagree", "Disagree to some extent" and "Disagree completely")	("Agree completely", "Agree to some extent", "Neither agree nor disagree", "Disagree to some extent" and "Disagree completely")	… do you have information on what, where, when and how to recycle? (C1)… is there sufficient space or facilities within your house to do recycling? (C2)… is there sufficient space or facilities in your yard to do recycling? (C3)… is there sufficient space or facilities inside your estate to do recycling? (C4)… does your body corporate or resident association promote or support recycling inside your estate? (C5)… do recycling companies have access to your estate to collect recyclables? (C6)… do you have access to a sidewalk or collection point for recycling just outside your estate? (C7)
Recycling is important for the sake of the environment (A1)Recycling is not worth the cost incurred by recycling companies (A2)Recycling is important to help reduce waste in municipal landfills (A3)Recycling is not worth the effort incurred by households (A4)	My family and friends would like me to recycle my household waste (SN1)My neighbours would approve of me recycling my household waste (SN2)My local authority expects me to recycle my household waste (SN3)	

3. Methodology

A cross-sectional household survey was conducted in three settings in Pretoria, South Africa. The first, Boardwalk Meander (Plate 1), is a low density development with houses on separate stands in a high-income security estate. The second, Equestria (Plate 2), is a medium-density development with various townhouse complexes in a middle-income development. The third, Hillcrest Boulevard (Plate 3), is a high-density multilevel apartment block that includes apartments of various sizes mostly for student accommodation. Table 2 summarises the characteristics and sampling information of the three settings.

Plate 1. Boardwalk meander

Plate 2. (Aerial view of Equestria Estate)

Table 2. Characteristics and sampling information of study settings

Characteristics and sampling information	**Study settings**		
	Boardwalk meander	**Equestria**	**Hillcrest boulevard**
Housing type	Freestanding houses in a high-income security estate	Various townhouse complexes in a middle-income development	Studio, two-bedroom and loft apartments in a development mostly for student accommodation
Average stand size	About 1,060 m^2	Small yard for some units at ground level	N/A
Average unit size	About 350 m^2	About 100 m^2	About 60 m^2
Maximum coverage	50%	N/A	N/A
Built density	Low	Medium	High
Ownership status	Mostly owners	Mixed	Mostly tenants
Approximate number of units	260	1,200	200
Sampled units	130	300	150
Approximate sample size	50%	25%	75%

The three settings were purposefully selected given the intended variation in housing type, but also because of certain similarities to allow for comparison. Each was located in the same middle- to high-income eastern parts of Pretoria, was access controlled and lacked recycling facilities apart from weekly municipal waste collection. Households that recycled would have had to drop recyclables at nearby schools, offices or shopping centres with recycling facilities. A total of 580 units were surveyed across the three settings using simple random sampling. The adult household member most responsible for recycling was identified as a respondent in each sampled unit, after which the respondent completed a self-administered questionnaire in the presence of a fieldworker.

Data were analysed in IBM Statistical Package for the Social Sciences (SPSS) Version 25 (α = 0.05). Some scales were reversed in the questionnaire, which enabled the identification of two response sets each in Equestria and Hillcrest Boulevard. These were removed resulting in a sample of 576 valid responses; 130 from Boardwalk Meander, 298 from Equestria and 148 from Hillcrest Boulevard. Factor and reliability analyses were first conducted to determine construct validity and reliability for attitude, norm and control. Classification trees and chi-square tests were used to determine the effect of housing type on self-reported participation in recycling relative to socio-demographics, followed by a multivariate analysis of variance (MANOVA) with post hoc tests to determine the overall effect of housing type on attitude, norm and control.

4. Findings and discussion

4.1 Socio-demographic profile of respondents

Respondents were predominantly female across all three settings, which corresponds with previous studies regarding gender and recycling (Martin *et al.*, 2006; Babaei *et al.*, 2015; Alhassan *et al.*, 2018). Respondents in Boardwalk Meander were mostly aged 36 years or older, whereas respondents in Equestria and Hillcrest Boulevard were mostly younger than 36 years. The average household size at Boardwalk Meander was 3.6 persons per household, 2.7 at Equestria and two at Hillcrest Boulevard.

Table 3. Summary of the PCA results for the TPB constructs. (*n* = 464)

Item	**Rotated factor loadings (pattern matrix)**		
	1	**2**	**3**
C6	0.740		
C5	0.731		
C3	0.650		
C2	0.636		
C4	0.625		
C7	0.618		
C1	0.533		
A4		0.704	
A2		0.686	
A1		0.500	
A3		0.419	
SN1			0.702
SN3			0.673
SN2			0.602
Initial eigenvalues	3.22	1.95	1.38
% of variance	23.0	13.9	9.9
α	0.774	0.501	0.539

4.2 Construct validity and reliability

An exploratory factor analysis was conducted using principal component analysis (PCA) with an Oblimin rotation and Kaiser normalization. Three factors were specified in line with the

TPB constructs of attitude, norm and control. Table 3 shows the factor loadings including initial eigenvalues, per cent variance explained and Cronbach's α.

All three factors had initial eigenvalues >1 and in total explained 46.8% of the variance. The clustering of items suggests that component 1 represents control, component 2 attitude and component 3 norm. The factor analysis therefore suggests good construct validity in terms of the three factors of recycling. Cronbach's α suggests that reliability for control is good, but average for attitude and norm. Reliability can be improved if the attitudinal and normative items about the municipality/local authority (A3 and SN3) are omitted. The latter may be due to widespread ambivalence towards local authorities in South Africa.

4.3 Effect on householders' self-reported participation in recycling

The effect of housing type is first examined relative to socio-demographics that were shown in the literature to be associated with pro-environmental behaviour and recycling in particular, including gender, age and level of education (Martin *et al.*, 2006; Miafodzyeva and Brandt, 2013; Alhassan *et al.*, 2018). The purpose was to determine which was statistically the stronger predictor of recycling; the housing type or the socio-demographic profile of the person most responsible for recycling? A classification tree was compiled using the Chi-squared Automatic Interaction Detection (CHAID) growing method. CHAID is a technique in SPSS that identifies which of a set of independent variables is statistically the strongest predictor of a dependent variable, yielding a treelike diagram showing the path of influence on a dependent variable. The question whether the household had recycled in the past three months was specified as the dependent variable, with housing type and the gender, age and level of education of respondents as independent variables.

The tree diagram showed that only 35% of respondents reported their households to have recycled, while the actual rate is likely to be lower due to social desirability bias and the tendency for self-reported recycling to be overstated (Barr *et al.*, 2001; Timlett and Williams, 2009; Thomas and Sharp, 2013; Huffman *et al.*, 2014; Lakhan, 2016). The CHAID identified the age of the respondent as the strongest predictor of household recycling, with only 26.7% were of the age group 19–35 years who reported their households to have recycled, as opposed to 48.6% of them were 36–59 years and 81.2% of them were 60+ years $\chi^2(2) = 40.836$, $p < 0.001$. Clearly, the older the person most responsible for recycling, the more likely the household recycled, which corresponds with several other studies regarding age and recycling, both in developed countries (Barr *et al.*, 2003; Martin *et al.*, 2006; Saphores and Nixon, 2014; Tabernero *et al.*, 2015) as well as developing countries (Pakpour *et al.*, 2014; Khalil *et al.*, 2017; Halder and Singh, 2018). Housing type was therefore nor the strongest predictor neither did it emerge as a significant predictor within any of the three age groups.

Another classification tree was compiled without age as a predictor, in which housing type emerged as the strongest predictor, but only after the CHAID grouped Equestria and Hillcrest Boulevard together as there was no significant difference in recycling rates between these two settings. The tree diagram showed that only 28.8% of respondents in Equestria and Hillcrest Boulevard reported their households to have recycled as opposed to 56.2% in Boardwalk Meander $\chi^2(1) = 33.034$, $p < 0.001$.

With the age of the respondent being the strongest predictor of household recycling, it suggested the need to control for age in subsequent analyses. Subsequent analyses therefore focussed on young respondents (19–35 years), also for the following three reasons: (1) Hillcrest Boulevard included few to no respondents in the upper two age categories, (2) by focussing on a single age group, the assumptions of normality and homogeneity were better met for the MANOVA and (3) focussing on young respondents was critical from a policy perspective considering low rates of recycling amongst young people. In South Africa, young people's lack of knowledge about recycling and concern about inconvenience are issues that require attention (Strydom, 2018).

Considering the effect of housing type on self-reported recycling in the sub-sample of young respondents, a chi-squared test and measure of association (Cramér's *V*) revealed a non-significant and weak association between housing type and household recycling, with only 24% and 26% of young respondents in Hillcrest Boulevard and Equestria reporting their households to have recycled compared to 42.4% in Boardwalk Meander $\chi^2(2) = 4.774$, $p = 0.092$, Cramér's $V = 0.113$. (Coefficients around 0.3 and lower suggest a moderate to weak association between two variables). The odds of "young" households recycling were only 1.12 times higher in Equestria compared to that in Hillcrest Boulevard, but up to 2.09 times higher in Boardwalk Meander compared to that in Equestria. Though the effect is weak across all three housing types, there is a noticeable increase in recycling from the medium- and high-density developments to the low-density development.

With age of the respondent identified as the strongest predictor of household recycling, it suggests that recycling policies and interventions should foremost be cognisant of young peoples' needs and perceptions (Ojala, 2008; Khalil *et al.*, 2017; Halder and Singh, 2018; Strydom, 2018). Young peoples' attitude towards recycling is significantly influenced by the perceived value and actual gains of recycling (Ramayah and Rahbar, 2013). Moreover, age correlates with other factors that may also influence recycling, such as income and home ownership (Saphores and Nixon, 2014).

Yet, the role of the built environment is still important considering that housing type was the second strongest predictor of household recycling, especially when low-density housing is compared to medium- and high-density housing. The key difference is that houses typically have more interior and yard space, whereas townhouses and apartments have less or may even lack yard space and convenient access to communal recycling facilities. This highlights the issues of space and convenience cited in the literature under Section 1. The question arises to what extent the higher rate of recycling in houses is attributable to differences between young respondents in attitude, norm or control.

4.4 Effect on attitude, norm and control

A MANOVA was conducted to determine the overall effect of housing type on attitude, norm and control amongst young respondents. MANOVA is an extension of analysis of variance used in situations where there is more than one outcome variable, in this case whether housing type had a significant effect on attitude, norm and control combined. A single composite mean was computed for each factor and compared across each of the three settings, thus yielding nine comparisons or distributions. The assumption of

multivariate normality was tested using the Kolmogorov–Smirnov (K–S) test to see whether each of the nine distributions differed significantly from a normal distribution, and the assumption of homogeneity of co-variance matrices was tested using Levene's test and Box's test. Table 4 shows the descriptive statistics of the MANOVA.

Young respondents across all three settings felt positive about recycling, given a total composite mean of 1.72 on a 5-point scale with “1” denoting a positive attitude and “5” a negative attitude. They also felt peer pressure to recycle, given a total composite mean of 2.36 on a 5-point scale with “1” denoting strong norms and “5” weak norms. The higher standard deviation for norm (0.89) compared to attitude (0.58) suggests that, although some may have felt as positive about recycling as their counterparts, they did not necessarily feel it was expected of them. Despite positive attitudes and a sense of responsibility, they felt somewhat unable to recycle, given a total composite mean of 2.41 on a 5-point scale with “1” denoting no control at all and “5” denoting control to a large extent.

Table 4 also shows little difference in attitude and norm across the three settings, except for control, where young respondents from Boardwalk Meander felt noticeably less unable to recycle compared to their counterparts in the other two settings. Yet, a significant difference in a single dependent variable can yield an overall significant effect in a MANOVA (Field, 2018). Was the difference in control large enough to yield an overall significant effect?

Table 4. Descriptive statistics of the MANOVA

Factor	Statistic	Setting			Total/Aggregate
		Boardwalk Meander	Equestria	Hillcrest Boulevard	
	n	33	199	146	378
Attitude	Composite mean	1.76	1.73	1.71	1.72
	SD	0.597	0.560	0.615	0.584
	n	33	199	146	378
Subjective norm	Composite mean	2.34	2.32	2.40	2.36
	SD	0.922	0.920	0.848	0.891
	n	33	199	146	378
Control	Composite mean	2.82	2.37	2.38	2.41
	SD	0.719	0.781	0.766	0.779

The MANOVA suggests that housing type had an overall non-significant effect on attitude, norm and control amongst young respondents $V = 0.03$, $F(6, 748) = 1.895$, $p = 0.079$, apart from young respondents in low-density housing appearing less unable to recycle. Post hoc tests compared each housing type in terms of attitude, norm and control. Table 5 shows the probability values of the post hoc tests. Probability values are based on Hochberg's GT2 given the differences in sample size and that variances between housing types were not significantly different.

Table 5. Probability (*p*) values of the post hoc tests of the MANOVA

		Equestria	Hillcrest Boulevard
Attitude	Boardwalk Meander	0.982	0.943
	Equestria		0.986
Subjective norm	Boardwalk Meander	0.999	0.980
	Equestria		0.787
Control	Boardwalk Meander	0.006[1]	0.011[1]
	Equestria		0.997

Note(s): [1]Significant at the 0.05 level

Table 5 shows no significant differences in attitude and norm between the three settings. However, Boardwalk Meander differed significantly from both Equestria ($p = 0.006$) and Hillcrest Boulevard ($p = 0.011$) with regard to control. Considering these differences, and the argument that different housing types pose different obstacles to the ability of households to recycle, chi-squared tests with measures of association (Cramér's *V*) were also conducted between housing type and each of the seven control items using the sub-sample of young respondents. Responses on the original 5-point scales were recoded into three categories to reduce the number of cells with expected frequencies below five. Table 6 shows the test statistics of the chi-squared tests and measures of association.

Table 6. Chi-squared tests and measures of association for control items across Boardwalk Meander, Equestria and Hillcrest Boulevard

Item	*n*	χ^2	Cramer's *V*	*p*-value
C1	378	3.705	0.070	0.447
C2	377	12.917	0.131	0.012[1]
C3	371	8.532	0.107	0.074
C4	371	10.361	0.118	0.035[1]
C5	348	21.509	0.176	0.000[1]
C6	335	19.324	0.170	0.001[1]
C7	348	3.112	0.067	0.539

Note(s): [1]Significant at the 0.05 level

There was a significant, though weak, association between housing type and four of the seven control items, including C2 ($p = 0.012$), C4 ($p = 0.035$), C5 ($p < 0.001$) and C6 ($p = 0.001$). Table 7 shows the descriptive statistics of the chi-squared tests for three of these items. *C*6 is not shown considering that none of the settings provided routine access to recycling companies at the time of the study. Statistics are shown for the two outlier categories and not for the middle category. Per cent for each item therefore do not add up to 100.

Table 7. Descriptive statistics of the chi-squared tests for significant control items

Item	Descriptor	Statistic	Setting		
			Boardwalk Meander	Equestria	Hillcrest Boulevard
C2	Not at all	*n*	16	144	85
		%	48.5	72.7	58.2
	To a large extent	*n*	9	24	26
		%	27.3	12.1	17.8
C4	Not at all	*n*	10	76	78
		%	31.3	39.0	53.8
	To a large extent	*n*	15	76	40
		%	46.9	39.0	27.6
C5	Not at all	*n*	11	112	95
		%	33.3	64.4	67.4
	To a large extent	*n*	12	22	12
		%	36.4	12.6	8.5

The bulk of young respondents in Equestria and Hillcrest Boulevard felt there was insufficient space within their units to do recycling. In fact, a significantly larger proportion of respondents in Equestria (72.7%), a medium-density development, perceived insufficient space compared to Hillcrest Boulevard (58.2%), a high-density development. Although townhouses are typically larger than apartments, average household sizes in Equestria are larger than those in Hillcrest Boulevard. A significantly larger proportion of respondents in Boardwalk Meander (27.3%) felt they had sufficient space compared to those in Equestria (12.1%) and Hillcrest Boulevard (17.8%).

As expected, a significantly larger proportion of young respondents in Hillcrest Boulevard (53.8%) felt there was insufficient space within their development to do recycling, whereas a significantly larger proportion of respondents in Boardwalk Meander (46.9%) felt there was sufficient space. Here, a linear effect between housing type and the perceived availability of space for recycling within the development is evident, with the availability of space increasing as the density of the housing type decreases.

The strongest association with housing type was whether young respondents perceived the managing agency to promote or support recycling within the development (Cramer's $V = 0.176$). Again, a linear effect is evident where the perceived support for recycling increases as the density of the housing type decreases. Many young respondents in Hillcrest Boulevard, and to some extent in Equestria, would have been tenants as opposed to owners, and they would therefore have had less contact with the managing agency that in turn may have contributed to perceptions about the agency as being unsupportive of recycling.

Although young respondents across all three settings felt equally positive about recycling, rendering the overall effect of housing type to be non-significant in this regard, the findings do show a significantly negative effect on household ability to recycle in medium- and high-density housing, particularly because of lack of space (see, e.g. Ando and Gosselin, 2005; Martin *et al.*, 2006; Schwebel, 2012; Miafodzyeva and Brandt, 2013) and lack of support

from managing agencies or “building governance” (see, e.g. Hendrickson and Wittman, 2010).

5. Recommendations

Table 8 summarises optional and critical recommendations to increase recycling in medium- and high-density housing, especially for young households. The recommendations should be seen in a South African or developing country context where gated developments and lack of separation at source are the norm and where comingled recycling may be more realistic.

Table 8. Recommendations to increase recycling in medium and high-density housing

Role players	**Housing type**	
	Medium density	**High density**
Interior architects and developers	Create space for comingled recycling facilities inside units, e.g. space for recycling bin as part of kitchen layout (optional)	Create space for comingled recycling facilities inside units, e.g. space for recycling bin as part of kitchen layout (optional)Provide co-mingled recycling chutes near elevators or staircases (optional)
Site planners and developers	*For smaller housing developments inaccessible to collection vehicles*: create additional courtyard space for communal comingled recycling facilities next to residual waste facilities conveniently located near entrance to development (critical)*For larger housing developments accessible to collection vehicles*: Provide opposite entrances and a more permeable driveway configuration to optimise route. Create additional courtyard space for communal comingled recycling facilities next to residual waste facilities at conveniently located points along driveways *en route* to entrances. Ensure that bags are out of sight and windblown litter is minimised (critical)	Create additional courtyard space for communal comingled recycling facilities next to residual waste facilities conveniently located near entrance to development (critical)
Managing agencies	Actively engage recycling companies and both owners and tenants. Provide concise and friendly information on what, when and where to recycle using both printed and electronic communication. Properly maintain facilities (critical)	Actively engage recycling companies and both owners and tenants. Provide concise and friendly information on what, when and where to recycle using both printed and electronic communication. Properly maintain facilities (critical)

Although young households in townhouses and apartments indicated a lack of space inside units, the survey also revealed that they are not keen to sacrifice space inside already small units, and they prefer to take recyclables to communal facilities inside the development. Individual facilities are therefore optional, while communal facilities are critical. Similarly, recycling chutes are optional in high-density apartments. The provision of chutes in multiresidential buildings in Ontario, Canada, had a weak effect on recycling, while the visibility of bins in lobbies had a stronger effect (Lakhan, 2016).

While co-mingled kerbside collection can be viable inside larger gated developments, hierarchical or looped driveway configurations hinder accessibility and route optimisation

(Du Toit *et al.*, 2017; Du Toit and Wagner, 2018). Opposite entrances and more permeable configurations are therefore recommended. Finally, the role of managing agencies is critical in several respects (see, e.g. Hendrickson and Wittman, 2010). The recommendations above are generic and should be adapted to the unique circumstances that each housing development poses.

6. Conclusion

This article examined the effect of housing type, relative to socio-demographics, on householders' self-reported participation in recycling across low-, medium- and high-density housing in the absence of formal recycling facilities. This is one of the first studies within the framework of the TPB to systematically examine the effect on household recycling across three different housing types. Although the age of the household member most responsible for recycling was the strongest predictor, highlighting the importance for recycling policies and initiatives to be foremost cognisant of generational differences, housing type was the second strongest predictor. The role of the built environment, i.e. the planning and design of housing in particular, is therefore still critical to enable households to recycle. While there was little difference in attitude and norm between young respondents across housing type, the inability of young respondents to recycle in medium- and high-density housing compared to low-density housing is statistically significant. The study pointed out lack of space and support from managing agencies as critical areas requiring innovative solutions from interior architects and site planners.

Further research is necessary to better understand the effect of housing type on recycling across different contexts and demographic groups, especially young people. While the constructs of attitude, norm and control have been validated given most of the items formulated for this study, the construct of control can be further operationalised to include additional items on convenience, specifically with regard to storing recyclables, accessing recycling facilities and engagement with managing agencies. In addition to self-reported recycling, further research may observe set-out rates and volume of materials recycled. Equal sample sizes across different housing types stratified by age are recommended.

Acknowledments

The authors would like to thank the managing agencies of Boardwalk Meander, Equestria, and Hillcrest Boulevard for granting permission for the survey, and the residents who participated in the survey. The authors would also like to thank the following Planning students at the University of Pretoria who participated as fieldworkers for their final year research report in the Bachelor of Town and Regional Planning: Jean-Pierre Adendorff, Kailash Chetty, Claudia Coetzer, Ryno Coetzer, Willie Erasmus, Nicholas Grainger, Carl Harding, Johan Herbst, Dineo Lesejane, Zamanhlenga Mpanza Gamuchirai Mutezo, Melissa Peens, Mvuyo Nzima, Lourens Toerien, Megan van der Berg, Magnus Wessels.

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