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ABSTRACT

Generation of solid waste in Africa has highly been contributed by high population growth and rapid urbanization of 4.5 per annum. The purpose of this study was to investigate effectiveness of newly installed waste collection bins in managing solid waste in Machakos town. Mixed method design was applied to incorporate both qualitative and quantitative methods to collect and analyze data. Open and closed ended questionnaires were used in data collection. 181 households were selected to form the study sample size and systematic random sampling method done in the estates through counting with skips after identifying the first household. Purposive sampling was done on the key informants. Key findings reported confirmed that perception had influence on households' usage of bins, as it was established that low awareness and knowledge influenced perception of bins and that low community participation in SWM triggered negative perception of bins. In addition, overflowing, accumulated and stinking uncollected waste bins created negative perception. It was also observed that households did not take waste to newly installed bins daily besides residents not dropping garbage to the bins twice in a week. Too, households did not dispose waste to the bins on alternate days but households took garbage to bins once a week. The study recommended that adequate and elaborate public sensitization campaigns on health risks of carelessly and illegally disposal of waste aimed at changing attitudes towards bins as well as enhancing community participation in SWM to influence positive perception of the use of bins. To increase the frequency households, dispose waste in the newly installed bins, an elaborate daily, weekly need should be designed and adequate bins proportionate to waste generated in the estates be positioned close to households sloping from homesteads for convenience dropping of waste.

Key Words: *Solid Waste, Waste Generation, Solid Waste Management, Households' Perception, Machakos*

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INTRODUCTION

Globally, industrialization, urbanization and population explosion continue to contribute to the proliferation of solid waste production with severe socio-economic and environmental effects (Lagerkvist & Dahlén, 2019). Presently, over 11.2 billion tons of global waste with 1.3 kg per capita is generated annually and projected to 3.40 billion tonnes in 2050 and rise by 70 per cent by 2050 (World Health Organization, 2020) (Kumar, Samadder, Kumar & Singh, 2018). Unfortunately, such massive solid waste is not properly disposed with at least 33% mismanaged globally today through open dumping, burning or not being accounted for (Ali. 2017).

Global Waste Management Outlook estimated that at least 2 billion people do not have access to regular waste collection (Modak, Wilson & Velis, 2018). Significant decreases in waste production through prevention, reduction, recycling and reuse, as well as safe final disposal, will be necessary to achieve this target (Gillespie, 2017).

However, waste management set-up suffers negative economic legislatives, political, technical and operational limitations. Adding pain to injury, the prevailing coronavirus disease 2019 (COVID-19) pandemic has worsened waste management through disruption and abrupt collapse of waste management chains (World Health Organization, 2020). For instance, more effective and sustainable practices such as recycling have been replaced by less effective and environmentally unfriendly like landfills and incineration (United Nations, 2020). As a result, the quality and efficient institutional as well as organizational structures for solid waste management have been compromised, overwhelmed and constrained.

Poor solid waste management is linked to a wide range of medium- and long-term risks including slowing down of economic growth, higher incidence of diseases, environmental degradation and deterioration in quality of life (Ali, 2017). Particularly, release of SW especially serious heavy metals pollution into soil, plants and water bodies compromises economic activities (Lloyd, 2019). Health impacts from improper waste management include infection transmission from bacterial, viral or other disease-causing organisms, physical bodily injury such as cuts, blunt trauma, chemical injury or burns (WHO, 2020).

Furthermore, solid waste management is the process of controlling the production, storage, collection, transportation, processing, and disposal as well as monitoring and regulation of the process of solid wastes (Bezama & Agamuthu, 2019). In many cases, the waste is disposed of at the designated dumpsites, in open spaces, uncompleted buildings, and so on through means such as anaerobic, digestion, landfill (unspecified, sanitary landfill or controlled landfill), open dump, recycling composting and incineration (Letcher & Vallero, editors. 2019). The main transportation mode for waste is use of trucks which move it to holding center before being taken to final treatment centers.

The UK generated 221.0 million tons of total waste in 2016, with England responsible for 85% of the UK total. These include increased recycling, composting, anaerobic digestion and the use of thermal treatment facilities to recover energy from waste (Eurostat, 2017). In terms of treatment, a total of 214.3 million tons was processed through various means. Notably, recycling and other recovery emerged the most common final waste treatment type in the UK processing 104.04 million tons represented by 48.5% with 2017 statistics reporting 70.0% of UK packaging waste was either recycled or recovered (United Nations Economic Commission for Europe, 2017).

In India, the volume of waste is projected to increase from 64-72 million tonnes at present to 125 million tonnes by 2031. Waste management rules in India are based on the principles of sustainable development, precaution and polluter pays. Of the solid waste produced only 43 million tons (MT) of the waste is collected through public and private entities. Only 45% is actually treated with than 50% remains untreated thrown on the

designated landfills, sewage and water bodies due to the lack of efficient waste management system (Singh, Thind & John, 2018.

In Nigeria, 30,614,830 is generated annually with over 40% disposed through open dumping and 20% is never accounted for (Aderoju, Dias & Gonçalves, 2018). Waste collection systems such as communal container (bin) collection with bins being few, vandalized and dilapidated and emptying is never done for weeks. While no official data available, it is clear that uncontrolled dumping is a common mechanism to get rid of waste.

In DRC Congo, there is very limited data on waste management. Largely, there is a breakdown of government services because of war or economic crisis, waste management services are often the first to suffer. Informal waste collection happens in all cities to a greater or lesser extent. Almost all (98%) waste collection services are provided by the informal workers. City authorities are unable to continue with UN's installed waste collection bins. Open burning is frequently used as a way of dealing with undisposed waste, especially in areas where waste collection is non-existent (Awuah, 2018).

South Africans generate roughly 56.5 million tons of solid waste per year. Of this 56.6 million of tons of waste, a maximum of 38.6% is recycled or recovered for other uses, whilst at least 90% is landfilled or dumped. Every single person of our total population of 57 million generates up to 2,5 kilograms of waste per day, on average (Oelofse, Nahman & Godfrey, 2018). There is inequality in the waste management services that are delivered in different areas. The middle-class areas generally have a formal system of collection with trucks, while many of the poorer areas have a more informal service, or a service that has been contracted out, or a very erratic and inadequate service from the municipality.

In Ethiopia, 1,830,848 metric tones were generated in 2019 with 3,503,253 projected for 2020. Addis Ababa Solid Waste Management Agency manages waste collection in the capital city. The collection rate is as low as 25% (Abebe, 2018). However, over one million tons is dumped in open and unaccounted for due to low capacity attributed to low funding among other factors. As a result of the low financial capacity and communal garbage storage situated far from the residences caused low service coverage that compelled the residences to dump their garbage illegal is the cause for environmental impact disease in the city remains higher.

With a population of 2,132,686 people, Rwanda, the cleanest cities in Africa, is leading in East Africa community in solid waste management and had been used as a bench-mark point in performance of solid waste (Ferronato et al., 2019). About 4,384,969 million tons of waste is produced yearly and 638 tons per day which translated to per capita generation of 0.57kg/day, or 205kg/year. Bins strategically stationed are used to collect waste which is treated through landfill, recycling and composting. There is only one disposal site run by the city of Kigali which also controls treatment, a modern sanitary landfill, a recycling centre and two small private compost facilities. Currently, waste is managed by the Ministry of Local Government, with the participation of private companies which are only in charge of waste collection.

In Tanzania 20, 276,995 million tons of waste is generated annually with 80 to 90% of this not collected (Nyampundu, Mwegoha & Millanzi, 2020). To collect waste, common containers (waste bins) are provided at dedicated points within neighborhoods for households to drop-off their solid waste. Trash collection vehicles then pick up these containers and empty off the trash at designated disposal spots and return the containers to their original locations. Dar es Salaam is an example of a city where the privatization of waste services has led to good coverage in the city area, while poorer neighbourhoods are left out as private providers. Although famed as a model in controlled landfill, only 27% of the mere 10% – 20% collected waste is treated through landfill mainly with little recycling and rest relegated to open dumping (OECD, 2017).

Like most countries in Africa, Kenya lacks proper waste collection, transportation and disposal systems with less than 50% of the population has collection service (NEMA, 2018). In the informal settlements, the situation is compounded by lack of ownership of the garbage and lack of collection points and many inhabitants of such areas opt to through their garbage to nearby rivers, drainages, roadsides or undesignated areas.

Statistical data from National Environment Management Authority (NEMA) in the National Waste Management Strategy indicates that 37 percent of waste generated is not collected in Nakuru, 35 per cent in Mombasa and 45 per cent in Eldoret with Kisumu being unknown. The same report cites a study done in Nairobi that shows that 30-40 per cent of the waste produced is not collected. Poor solid waste management (SWM) has negative health impacts, including the proliferation of infectious and non-communicable diseases. It also contributes to environmental degradation and greenhouse gas emissions.

Finally, to the local context of the current, Machakos Town Constituency is one of the 8 constituencies namely Masinga, Yatta, Kangundo, Matungulu, Kathiani, Mavoko and Mwala which form Machakos County. Machakos town sub-county has a population of 168,255 people (KNBS, 2019). This sub county which hosts the capital centre of Machakos County, is cosmopolitan and is located 63 kilometers southeast of Nairobi. Due to its proximity to Nairobi City and being served by two major highways (Mombasa Road and Namanga Road), Machakos Town Constituency acts as a dormitory for the daily commuters working in Nairobi, Kajiado and Kiambu counties. Such rapid population in addition to industrialization, urbanization and economic growth, have contributed to increased industrial, commercial, clinical/medical and domestic waste generation at 204 tons daily sub-passing the sub-county ecological footprint (KNBS, 2019).

In spite of these issues, there is scarcity of the locally available scholarly works on this topic under study. Little empirical evidence available are on other issues such as Mutua 2017 who examined the effectiveness of sanitation policy instruments in Machakos County. Eboso (2016) studied recycling of solid waste in the context of Machakos County. Ndonye (2018) investigated the role of stakeholders in successful solid waste management while Kiio and Nyang'au (2019) studied the determinants of implementation of asbestos waste disposal projects respectively. To date, there is no evidence whether the newly installed bins would serve the intended purpose in relation to residents' perception and their usage nor their proximity/placement and satisfaction with frequency of the pick-ups for disposal. Evidently, there exist scholarly gap in terms of concept and context that prompted an investigation on how effective the newly installed waste collection bins have been implemented at different places in solid waste management in Machakos Town.

The study therefore assessed household perceptions on usage of bins, extent to which the residents were using newly installed bins, influence of proximity and placement of bins on residential use and their satisfaction with frequency of town pick-ups of bins for waste disposal.

Figure 1: Sample of installed bins in Machakos County

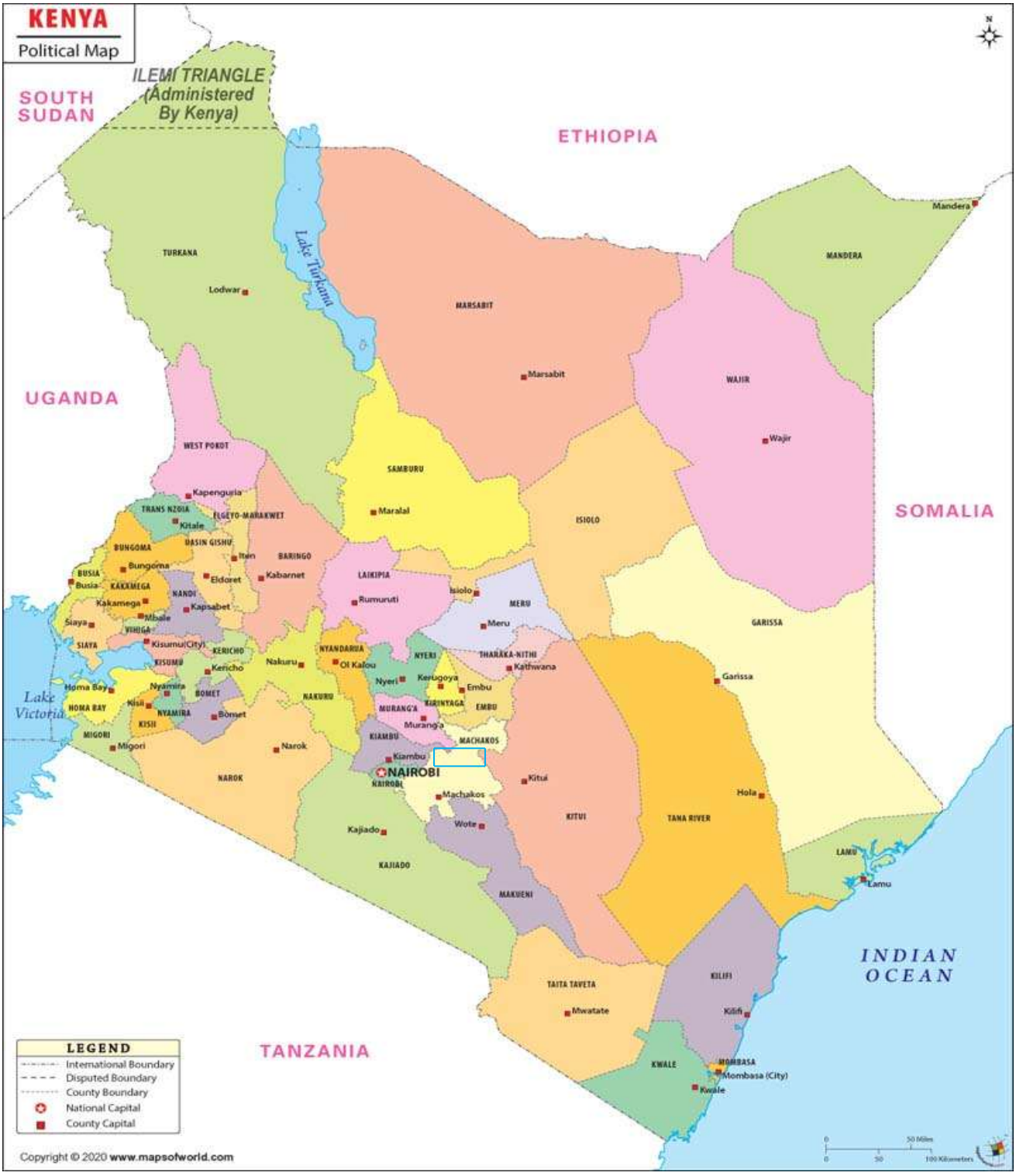

Fig 2: A map of Kenya locality of Machakos County (Google map)

METHODOLOGY

The specific area of study was Machakos town, the county headquarters. The study was conducted in Mjini, Kariobangi and Eastleigh as well as Muthini estates in Machakos Town Sub-county Machakos County. The county had a rapid population which stood at 1,421,932. (Kenya Population and Housing Census, 2019).

Machakos is located 63 kilometers Southeast of Nairobi City. Just like the other counties before

devolvement, it was facing many challenges in solid waste management. The idea of better solid waste services was hatched when the county government entered into a Memorandum of Understanding (MOU) with the World Bank to finance its solid waste activities in 2010. The birth of the bins in the county came with the grant of 1 billion shillings which was advanced to the county through another MOU in 2018/19 fiscal year.

The target population was households in the estates which were categorized as slum, low and middle income residents. Others included SWM staff and a few others from relevant Ministries. Machakos central sub-county had a population of 168,255 (Census 2019). A sample size of 181 households from the four estates namely Mjini, Kariobangi, Eastleigh and Muthini was used. Systematic random sampling was done in the estates through counting with skips after identifying the first household. This was done through the questionnaires with open and close ended questions which were administered by the research assistants. Interview guide was used for the key informants who were from the Department of solid waste. The researcher trained research assistants and pre-tested them to ensure that they were valid. A pilot study was conducted in Athi river town to test reliability. After pre-testing, necessary modifications were made.

Well-structured questionnaires capturing perceptions, attitudes and usage of bins by residents were used. These were given to households in the estates on different days. The research assistants gave out the questionnaires to respondents through drop-and-pick method and gave them an ample time of two days to fill and return them to a designated place.

Qualitative data was entered in excel and analyzed for themes. Quantitative data was analysed using descriptive and inferential statistics in order to determine frequencies and percentages. Descriptive and inferential statistics which comprised frequencies, percentages and graphs were used to test significance and associations. The gathered data was cleaned, verified and coded before entered into SPSS software version 21 where inferential as well as descriptive techniques were utilized for data analysis.

RESULTS AND DISCUSSIONS

Socio-demographic information of the participants sampled

This research sought to determine the age of individual respondents from Mjini, Kariobangi and Eastleigh as well as Muthini estates in Machakos Town Constituency. Respondents were asked to indicate their age. The results were as presented in Table 1.

Table 1: Respondents' Age

Age Bracket	Frequency	Percent
Between 18-25	6	2.9
Between 26-30	7	3.3
Between 31-40	83	39.5
Between 41-50	114	54.3
Total	210	100.0

Source: Author (2020).

According to the findings of the study as indicated in Table 1, majority of the respondents were aged between 41-50 who added up to 114 and represented by 54.3%, followed by those aged between 31-40 at 39.5% years. Further, those aged between 26 - 30 years were 3.3% while those between 18-25 years were 2.9%. This gave an implication that respondents at the county were old enough to provide the required information.

Gender equality is an important consideration in almost all spheres of any institution. As a result, it

was necessary for the study to establish the gender distribution at the county among the respondents as indicated in Table 2.

Table 2: Gender Distribution

Gender	Frequency	Percentage
Male	161	76.7
Female	49	23.3
Total	210	100

Source: Author (2020).

The statistics in Table 2 above indicated that 76.7% represented male respondents while females stood at 23.3% while 0.8% declined to indicate their gender. To that end, there was no gender equity, implying that there was no adherence to the constitutional provision which stipulates that no gender should exceed a third in a group composition.

It was essential to establish the highest level of education qualifications of the respondents. Respondents were asked to indicate their highest education level. The results were as presented in the Table 3.

Table 3: Highest Education Level

	Education Level	Frequency	Percent
	Secondary & below	60	28.6
	TEVs	100	47
Educational	Diploma	38	18
Level	Bachelor's Degree	10	5
	Post-graduate	2	1.0
	Total	**210**	**100.0**

Source: Author (2020).

Statistics in the table above indicated the highest number of respondents represented by 47% had TEVs as highest education level. This was distantly followed by 28.6% with secondary and below educational level. On the other hand, 1% had post-graduate level of qualification. The interpretation was that majority of the respondents were fairly educated to provide required data that needed relative literacy. Also, the 5% and 1% respondents of bachelor's degree and post-graduate level respectively, were adequately qualified to provide the strategic and tactical information required. However, low education levels work against sustainable development predicated on more knowledge and awareness of waste reduction philosophy and practices only possible with increased education levels.

Size of a household was relevant in the current study due to its role in the generation of solid waste. As such, the respondents were asked to provide number of bonafide members of their families whose results were as represented in Table 4.

Table 4: Household Size

Variable	Value & Label	Frequency	Valid Percent
	1. One & below	66	31.4
	2. Between 2-4	107	56.2
Family size	**3**. Between 5-7	30	14
	4. Between 8-10	7	3.3
	5. Over 10	5	2.1
Total		210	100.0

Source: Author (2020).

According to the results shown above, out of the 210 respondents who had returned their questionnaires, 56.2% had a household between 6-10 members while 2.1% had over 10 family members. The interpretation was that most families had few family sizes implying amount of solid waste generated by most families is minimal. This was a positive trend towards reduction of solid waste towards many global, regional and local sustainable development agenda.

It was also imperative to determine the quantity of weekly waste generated in kg per house as presented in Table 5.

Table 5: Weekly Waste Generation (kg/house)

Variable		Frequency	Valid Percent
Family size	**1**. Below 1kg	63	30
	2. Between 1-3kg	110	52
	3. Between 4-6kg	20	10
	4. Between 5-7kg	10	5
	5. Between 7-10	5	2.5
	6. Over 10kg	2	1
Total		210	100.0

Source: Author (2020).

Statistics in Table 5 presented varied weekly generated per household quantified in kilograms. Notably, a total of 110 respondents represented by 52%, produced between 1 to 3 kilograms of solid waste per house. Also evident was 2 respondents accounting for 1% that generated over 10 kilograms per household. The implication was that majority of the families account for diminished waste production which augurs well with waste management goals for improved health, environment and sustainable development.

To determine the effectiveness of newly installed bins, it was necessary to obtain required from households hailing from the site of the study in addition to a long span stay. As such, respondents were asked to state their estate of residence as presented in the in Table 6.

Table 6: Respondents' Estate of Residence

Age Bracket		Frequency	Percent
Estate of Residence	**1.** Mjini	102	48
	2. Kariobangi	58	28
	3. Eastleigh	33	16
	4. Muthini	17	8
	Total	210	100.0

Source: Author (2020).

From Table 6, majority of the respondents represented by 48%, resided to Mjini Estate. This large population was attributed to its lowest cost of housing by the virtue of exhibiting informal settlement characteristics. Kariobangi with 28% of households comes next which was occupied by relatively low-income households although it is not classified as a slum like Mjini. Eastleigh was third in terms of population of 16% of the total respondents. Muthini accounting for the smallest number of residents, was categorized as an expensive estate to stay in due to high cost of housing among others.

On households' distance to the newly installed bins (meters), being the first stage in the process of management of waste implied the success of the subsequent stages largely depended on waste collection. In that regard, premium should be placed on waste collection if the entire waste management process had to accomplish the set

goals. One of the key determinants of effective waste collection was the optimum proximity and placement of the waste collection containers to the target beneficiaries or primary consumers. This was the motivation of this part to determine how far the newly installed were from the target users as summarized in Table 7.

Table 7: Respondents' Distance to the Newly Installed Bins

Variable	Values	Frequency	Percent
Distance to the Bin	1. Below 100 meters	10	5
	2. Between 100-300 meters	8	4
	3. Between 300-500 meters	14	6
	4. Over 500 meters	178	85
	Total	210	100.0

Source: Author (2020).

For effective waste management, bins should be positioned in shortest distance for convenience walking to the waste collection point (bin) to drop household garbage. This predicated on the finding that reported most of the households (85%) generated less than 3kg of household waste which was light enough to walk and drop it in the bin. Ironically, majority of households represented by 85% as indicated in the table were located 500 meter and above from the bin as opposed to 10% whose houses were below 100 meters from the newly installed bins. Optimal proximity and placement of bins instrumental in solid waste management.

Descriptive findings of key study variables

Households' perception on use of bins

This part sought to establish how household perceived the use of newly installed bins in Mjini, Kariobangi and Eastleigh as well as Muthini estates in Machakos Town Constituency. The results were summarized and presented in the Table 8.

Table 8: Households' Perception on use of bins

Variable		5	4	3	2	1	SD	M
Low awareness and knowledge influence perception of bins	F	1	5	11	115	78	0.706	1.74
	%	0.5	2.4	5.2	54.8	37.1		
Perception of risk (health risks) is a factor in changing attitudes towards bins	F	6	5	18	116	65	0.862	1.91
	%	2.9	2.4	8.6	55.2	31.0		
Low community participation in SWM trigger negative perception of bins	F	2	3	19	95	91	0.767	1.71
	%	1.0	1.4	9.0	45.2	43.3		
Overflowing, accumulated and stinking uncollected waste bins create negative perception	F	3	13	17	97	80	0.908	1.87
	%	1.4	6.2	8.1	46.2	38.1		
Cost of waste collection services influence perception of bins	F	3	13	17	97	80	0.793	1.73
	%	1.4	6.2	8.1	46.2	38.1		

** 5= Strongly Disagree, 4=Disagree, 3= Not Sure, 2=Agree and 1=Strongly Agree. F=Frequency; SD=Standard Deviation; M=Mean*

Source: Author (2020).

Manifestly, the statistics in Table 8, demonstratively, variables in this thematic area demonstrated that the prevailing circumstances influenced the perception of the usage of newly

installed bins. For instance, 115 respondents represented by 54.8% with SD and M of 0.706 and 1.74, respectively indicated that low awareness and knowledge influenced perception on usage of bins. A further 116 respondents represented by 55.2% with SD and M of 0.862 and 1.91 respectively agreed that perception of risk (health risks) is a factor in changing attitudes towards usage of bins.

Equally, 45.2% with SD and M of 0.767 and 1.71 respectively, opined that low community participation in SWM triggered negative perception of bins. Similarly, 46.2% with SD and M of 0.908 and 1.87 respectively, indicated that overflowing, accumulated and stinking uncollected waste bins created negative perception. Alike, 46.2% with SD and M of 0.793 and 1.73 respectively, were of the view that the cost of waste collection services influenced perception of bins in Mjini, Kariobangi and Eastleigh as well as Muthini estates in Machakos Town Constituency.

Extent of the use of Bins by Households

The part sought to determine the extent of the use of newly installed bins in Mjini, Kariobangi and Eastleigh as well as Muthini estates in Machakos Town Constituency. As such, respondents were asked to rate how often newly installed bins were utilized by households in the four estates of Mjini, Kariobangi and Eastleigh as well as Muthini. The findings were as summarized and presented in Table 9.

Table 9: Extent of Households use of newly installed bins (n = 210)

Variable		5	4	3	2	1	SD	M
Households do not take waste to newly installed bins daily	F		1	10	94	105	0.610	1.56
	%		0.5	4.8	44.8	50.0		
Households do not dispose waste to the bins on alternate days	F	1	5	11	115	78	0.706	1.74
	%	0.5	2.4	5.2	54.8	37.1		
Residents do not drop garbage to the bins twice in a week	F	6	5	18	116	65	0.862	1.91
	%	2.9	2.4	8.6	55.2	31.0		
Households take garbage to bins once a week	F	2	3	19	95	91	0.767	1.71
	%	1.0	1.4	9.0	45.2	43.3		
Households only drop waste on the day they are able to pay due to high	F	3	13	17	97	80	0.908	1.87
	%	1.4	6.2	8.1	46.2	38.1		
Households have no fixed schedule and drop waste only sporadically	F	1	4	15	101	89	0.726	1.70
	%	0.5	1.9	7.1	48.1	42.4		

** 5= Strongly Disagree, 4=Disagree, 3= Not Sure, 2=Agree and 1=Strongly Agree. F=Frequency; SD=Standard Deviation; M=Mean*

Source: Author (2020).

Manifestly, the statistics in Table 9 report that 50% of the respondents with a standard deviation of 0.610 and a mean of 1.56 strongly agreed that households did not take waste to newly installed bins daily. Additionally, 115 respondents represented by 54.8% with standard deviation and mean of 0.706 and 1.74, respectively indicated that residents did not drop garbage to the bins twice in a week. A further 116 respondents represented by 55.2% with standard deviation and mean of 0.862 and 1.91 respectively agreed that households did not dispose waste to the bins on alternate days.

As well, 45.2% with standard deviation and mean of 0.767 and 1.71 respectively, indicated that households took garbage to bins once a week. Besides, 46.2% respondents with standard deviation and mean of 0.908 and 1.87 respectively, specified that households only dropped waste on the day they were able to pay due to high. Finally, 48.1% with SD and M of 0.726 and 1.70

respectively, revealed that households had no fixed schedule and dropped waste only sporadically.

CONCLUSION AND RECOMMENDATIONS

The study concluded that low awareness and knowledge influenced perception of bins, that perception of risk (health risks) was a factor in changing attitudes towards bins and that low community participation in SWM triggered negative perception of bins. It also concluded that household's not taking waste to newly installed bins daily besides residents not dropping garbage to the bins twice in a week. Too, households did not dispose waste to the bins on alternate days but households took garbage to bins once a week.

To change perception of household on bins usage, the study recommends that adequate and elaborate public sensitization campaigns on health risks of carelessly and illegally disposal of waste aimed at changing attitudes towards bins. To increase the frequency households, dispose waste in the newly installed bins, an elaborate daily, weekly need should be designed and adequate bins proportionate to waste generated in the estates should be positioned close to households.

Recommendations for future study

The study proposes further studies on other processes of data management namely, waste separation for better treatment such as recycling and disposal mechanisms among others in the same context.

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