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Differential Adoption Rate for Households' Solid Waste Management Practices by Socio-Demographic Characteristics in Goma Town, North-Kivu Province of DRC

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Abstract: This study analyses household solid waste management (SWM) practices in Karisimbi Commune and Goma Commune of Goma Town, DRC, comparing intervention (in Ndosho district) and control groups (in Kyeshero district). A cross-sectional design with stratified sampling was employed to examine five primary practices, separation, composting, incineration, storage, and evacuation, across demographic factors, including age, gender, marital status, education level, and religion. Results indicate that storage and evacuation are the most commonly practised methods, while sustainable approaches such as composting and separation remain underutilised. The intervention group demonstrated statistically significant gains in composting and separation, particularly among women and middle-aged participants, highlighting the value of gender- and age-responsive programming. These findings emphasise the need for equity-focused strategies and demographic-specific approaches to promote sustainable waste management and guide inclusive environmental policy decisions.

Keywords: *Solid Waste Management, Karisimbi Commune, Household Behaviour, Intervention Impact, Equity-Responsive Strategies.*

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I. INTRODUCTION

Effective household solid waste management remains a critical challenge in many urban and peri-urban communities across sub-Saharan Africa. The region faces low municipal solid waste (MSW) collection coverage, estimated at just 44% in 2018, with significant backlogs of uncollected waste in public spaces, particularly in low-income neighbourhoods (Adedara *et al*., 2023). In the commune of Karisimbi, located in Goma town, Democratic Republic of Congo, the problems related to waste disposal have been exacerbated by rapid population growth, urban expansion, and inadequate infrastructure. Poor household waste management practices contribute significantly to environmental degradation, increased greenhouse gas emissions, and increased risks for public health (Wahba, 2019).

This study undertakes a comparative analysis of household solid waste management practices between intervention (in Ndosho district) within Karisimbi Commune and control groups (in Kyeshero district) within Goma Commune. The intervention group has been exposed to targeted waste management strategies, such as community sensitisation, provision of waste bins, and organized collection systems. In contrast, the control group relied on conventional waste management practices without receiving any structured support. In comparison, the interventions implemented in this study reflect emerging best practices in sub-Saharan Africa, where a combination of community engagement and infrastructure investments has proven effective in improving waste management outcomes and mitigating environmental impacts .(Okorondu *et al*., 2024).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct836

By examining behavioural patterns, waste handling techniques, and community participation, this research aims to assess the effectiveness of interventions and identify scalable solutions for sustainable waste management (Fakunle *et al*., 2021). Ultimately, the findings informed policy recommendations and community-based strategies that can enhance environmental stewardship and public health outcomes in Goma (Karisimbi, Keshero districts) and similar urban settings (Okorondu *et al*., 2024).

II. LITERATURE SURVEY

Early approaches to solid waste management in sub-Saharan Africa largely concentrated on improving municipal services and expanding collection infrastructure, primarily through centralized systems and landfill use (UNEP, 2018; Bank, 2012). However, over the past decade, research has increasingly shifted toward understanding household-level behaviour and the socio-demographic determinants of waste practices. This evolution reflects a growing recognition that sustainable SWM requires more than technical solutions; it demands inclusive, community-driven approaches that account for household diversity, behavioural intention, and social roles (UN-Habitat *et al*., 2020)

Recent studies underscore the importance of demographic factors in shaping SWM behaviour.). Fadhullah *et al.*, (2022) and *UN-Habitat et al.*, (2020) emphasise that variables such as age, gender, education, and marital status significantly influence the adoption of sustainable practices. Kamweru, (2019) and Mwanza *et al*., (2017) further highlight how gender roles and educational attainment affect household decisions around waste separation, composting, and disposal. These findings are particularly relevant in urban and peri-urban contexts, where informal norms and resource constraints intersect with public health risks. The Theory of Planned Behaviour (Ajzen, 2011), as applied by Elisabeth Brookes, (2023), provides a useful framework for interpreting these dynamics. It posits that behavioural intention and perceived control often outweigh formal education in determining environmental action. This supports the argument that targeted outreach, especially when gender-sensitive and age-responsive, can effectively shift household waste practices even in low-resource settings.

Despite growing awareness, sustainable SWM practices such as composting and separation remain underutilized across much of the region (Manea *et al*., 2024). This gap underscores the need for equity-responsive programming that not only informs but also empowers diverse household groups. As UNEP, (2024) and Singh *et al*., (2024) argue, interventions must be tailored to demographic realities and supported by infrastructure, education, and community engagement. These insights form the foundation for this study's comparative analysis of intervention group (in Ndosho district of Karisimbi Commune) and control groups (in Kyeshero district of Goma Commune).

- *Problem Definition*

Despite targeted interventions in Ndosho district of Karisimbi Commune, including community sensitisation, provision of waste bins, and organised collection systems, sustainable household SWM practices such as composting and separation remain underutilized. While infrastructure and service delivery have improved in some areas, behavioural adoption remain slow, particularly among specific demographic groups. This disconnect highlights a critical gap between program design and community uptake (Weißert *et al*., 2025).

Existing literature has established the influence of demographic factors, such as age, gender, education, and marital status, on waste behaviour (Fadhullah *et al.*, 2022; Kamweru, 2019; Mwanza *et al*., 2017). However, few studies have systematically compared intervention and control groups to assess how structured programming affects adoption across these variables. Moreover, the Theory of Planned Behaviour suggests that behavioural intention and perceived control may be more influential than formal education alone (Ajzen, 2011; Elisabeth Brookes, 2023), reinforcing the need for tailored, equity-responsive strategies.

This study addresses these gaps by evaluating the effectiveness of community-based SWM interventions in Karisimbi Commune. It investigates how demographic characteristics mediate the adoption of five key waste practices, separation, composting, incineration, storage, and evacuation, and identifies which groups respond most positively to structured outreach. The findings aim to inform inclusive policy development and scalable programming that reflects household diversity and promotes environmental stewardship (Weißert *et al*., 2025).

III. MATERIALS AND METHODS

- *Study Design and Setting*

This study employed a cross-sectional comparative design to assess household solid waste management (SWM) practices in Karisimbi Commune**,** located in North-Kivu Province, Democratic Republic of Congo. The commune is marked by rapid urbanization, diverse household structures, and limited formal waste infrastructure, making it a relevant context for evaluating intervention impact (Adedara *et al*., 2023; Wahba, 2019). Such settings reflect broader regional challenges in sub-Saharan Africa, where informal disposal and low adoption of sustainable practices persist despite policy efforts (UN-Habitat *et al*., 2020)

- *Sampling Strategy*

A non-randomised stratified sampling approach was employed to ensure demographic representation across age, gender, marital status, education level, and religion, consistent with equity-responsive research in SWM behaviour (Fadhullah *et al*., 2022; Mwanza et al., 2017). Households were purposively selected within predefined strata based on administrative zones and intervention exposure. This approach allowed for comparative analysis while accommodating logistical constraints and ensuring inclusion of key demographic groups.

A total 521 household respondents were surveyed:

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- 260 households in the intervention group
- 261 households in the control group
- Intervention group: Households exposed to structured SWM programs, including community sensitisation, provision of waste bins, and organized collection systems, as recommended by (UN-Habitat *et al*., 2020) and (Okorondu *et al*., 2024).
- Control group: Households operating under conventional waste practices without formal support or targeted programming.

➢ *Data Collection*

Primary data were collected through semi-structured household surveys**,** administered by trained enumerators in accordance with ethical and procedural standards for community-based research (Fakunle *et al*., 2021). The survey instrument captured:

- Adoption of five key SWM practices: separation, composting, incineration, storage, and evacuation;
- Demographic characteristics of household heads;
- Perceptions of waste-related health risks**,** service availability, and behavioural motivations.

The questionnaire was pre-tested for clarity and reliability, and translated into French and the local language (Kiswahili) to ensure accessibility and cultural relevance (Kamweru Grace Nyaguthii, 2019). Enumerators received training on gender sensitivity and data confidentiality to enhance respondent trust and data quality.

➢ *Analytical Framework*

Quantitative data were analysed using comparative statistical methods to assess differences in SWM practice adoption between intervention and control groups. Key analytical steps included:

- The data were analysed using SPSS software (version 27);.
- Descriptive statistics to summarize frequencies and proportions;
- Chi-square tests to evaluate statistical significance across demographic variables (Ajzen, 2011)
- P-value threshold set at < 0.05 to determine significance.

Data were disaggregated by age, gender, marital status, education level and religion **to** enable equity-responsive analysis**,** in line with the study's objective to identify demographic determinants of sustainable waste behaviour (UNEP, 2024; Singh *et al*., 2024). This approach aligns with global calls for inclusive and context-sensitive waste management strategies that reflect household diversity and social roles (UN-Habitat & UNEP, 2024).

IV. RESULTS & DISCUSSION

➢ *Waste Management Practices and Age of the Respondents*

Table 1 Distribution of Waste Management Practices by Age of the Respondents

Types of Waste Management Practices	Yes (Freq) Intervention	Yes (%) Intervention	No (Freq) Intervention	No (%) Intervention	p-value (Intervention)	Yes (Freq) Control	Yes (%) Control	No (Freq) Control	No (%) Control	p-value (Control)
Waste separation	69	26.3%	191	73.3%	0.018	61	23.0%	200	76.6%	0.455
Waste composting	58	22.3%	202	77.7%	0.842	45	17.2%	216	82.8%	0.082
Waste incineration	104	40.0%	156	60.0%	0.264	76	29.1%	185	70.9%	0.662
Storage in bags	187	71.9%	73	28.1%	0.719	156	59.8%	105	40.2%	0.451
Evacuation	154	59.2%	106	40.8%	0.224	170	63.1%	91	34.9%	0.037

Sources: Field Survey, 2025

- Note. Frequencies (Freq) and proportions (%) are reported for intervention and control groups. P-values based on chi-square tests.

This table section presents a comparative analysis of five household solid waste management (SWM) practices across intervention and control groups, disaggregated by age. The findings, summarized in Table 1, reveal distinct behavioural patterns and varying degrees of statistical significance, offering insights into the effectiveness of interventions and demographic responsiveness.

Storage in bags emerged as the most widely adopted practice in both groups, with 71.9% of respondents in the intervention group and 59.8% in the control group reporting usage. Despite its prevalence, the difference was not statistically significant (p = 0.719 and p = 0.451). This aligns with findings by (Fadhullah *et al*., 2022), who observed that

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct836

convenience and accessibility are primary drivers of containment behaviour, particularly in urban and peri-urban contexts. The high adoption rate suggests that storage is a foundational practice, influenced more by material availability and immediate household needs than by intervention exposure. Evacuation ranked second in overall adoption.

The control group demonstrated a statistically significant uptake (63.1%, p = 0.037), potentially reflecting reliance on municipal services or informal collection systems. Kamweru, (2019) reported similar trends in Nakuru, Kenya, where non-intervention areas showed higher dependence on external waste removal due to limited household-level initiatives. In contrast, the intervention group showed moderate adoption (59.2%) without statistical significance (p = 0.224), indicating that interventions may not have substantially altered evacuation behaviour.. Incineration was more prevalent in the intervention group (40.0%) than in the control group (29.1%), though neither result reached statistical significance (p = 0.264 and p = 0.662). This suggests that informal disposal methods remain common across both settings. (Smith, 2020) noted that in South African peri-urban areas, older residents often resort to burning due to infrastructure gaps and limited awareness, a pattern that may be mirrored in Karisimbi Commune. Waste separation showed a statistically significant improvement in the intervention group (26.3%, p = 0.018), indicating that targeted programs may have positively influenced behaviour. The control group (23.0%) exhibited no meaningful change (p = 0.455). (Fadhullah *et al.*, 2022), found that age and marital status positively correlate with waste segregation when supported by awareness campaigns, reinforcing the importance of tailored outreach. Composting remained underutilized in both groups, 22.3% in the intervention and 17.2% in the control, with no statistically significant differences (p = 0.842 and p = 0.082). Kamweru, (2019) attributes low composting rates to limited knowledge, space constraints, and perceived lack of utility. The minimal uptake suggests that composting requires more intensive education and infrastructural support to gain traction.

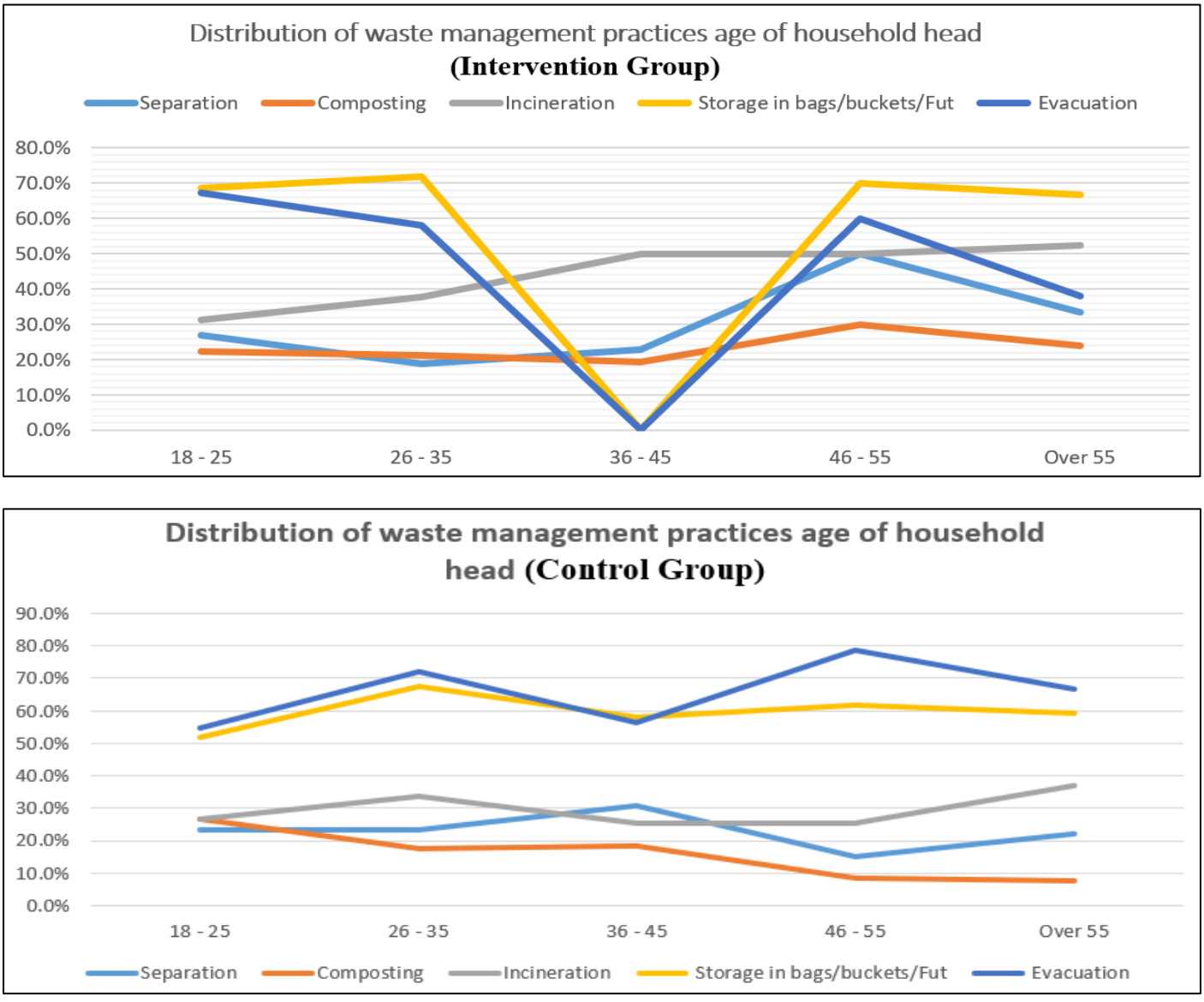

Fig 1 Adoption of Waste Management Practices by Age in the Intervention and Control Groups

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This section presents age-disaggregated trends in the adoption of five household solid waste management (SWM) practices, separation, composting, incineration, storage, and evacuation, across intervention and control groups. The data are visualized in Figure 1 and revealed that: Storage in Bags is the most consistently adopted practice across all age categories in both groups. In the intervention group, adoption peaks among 26–35-year-olds (71.8%) and remains high among 36–45 (70.0%), 46–55 (70.0%), and Over 55 (66.7%). The control group shows similar trends, with highest adoption in 26–35 (67.6%) and 46–55 (61.7%). These findings align with Fadhullah *et al.*, (2022), who observed that containment practices are driven by convenience and accessibility, particularly among younger adults in urban settings. Evacuation ranks second in overall prevalence. In the control group, uptake is highest among 46–55-year-olds (78.7%) and 26–35 (72.1%), with substantial engagement among 18–25 (54.7%) and Over 55 (66.7%). The intervention group shows strong adoption among 18–25 (67.2%), 36–45 (60.0%), and 46–55 (60.0%), but a marked decline among Over 55 (38.1%). Kamweru, (2019) found similar patterns in Nakuru, Kenya, where younger and middle-aged adults relied more on municipal services, while older adults faced access constraints. Incineration increases steadily with age in both groups. In the intervention group, adoption rises from 31.3% (18–25) to 52.4% (Over 55). The control group follows a similar trajectory, from 26.6% (18–25) to 37.0% (Over 55). . Smith, (2020) notes that older residents in peri-urban South Africa often resort to burning waste due to limited infrastructure and awareness, a trend reflected here. Separation shows a statistically significant improvement in the intervention group (26.3%, p = 0.018), peaking at 50.0% among 46–55-year-olds. Moderate adoption is observed in Over 55 (33.3%) and 18–25 (26.9%), with the lowest rate among 26–35 (18.8%). In the control group, separation peaks at 30.9% among 36–45, but drops significantly in 46–55 (14.9%). Fadhullah *et al.*, (2022), found that age and marital status positively correlate with waste segregation when supported by awareness campaigns. Composting remains underutilized across all age groups. In the intervention group, the highest adoption is among 46–55-year-olds (30.0%), with the lowest in 36–45 (19.3%). The control group shows a slight peak in 18–25 (26.6%), followed by a sharp decline in older age brackets (Over 55: 7.4%). Fadhullah *et al.*, (2022), attributes low composting rates to limited knowledge, space constraints, and perceived lack of utility.

As scientific implications, the age-disaggregated data reveal that younger and middle-aged adults are more responsive to containment and evacuation strategies, while older adults tend to adopt informal methods such as incineration. Separation practices benefit from targeted interventions, particularly among middle-aged groups. Composting remains the least adopted practice, underscoring the need for intensive education and infrastructural support. These findings support (Ajzen, 2011) with the theory of Planned Behaviour, which emphasizes intention and perceived control over formal education. They also reinforce the argument by UN-Habitat *et al*., (2020) that age-responsive programming is essential for sustainable waste management.

- *Waste Management Practices and Gender of the Respondents*

Table 2 Distribution of Waste Management Practices According to their Adoption Concerning Gender Characteristic

Types of Waste Management Practices	Yes (Freq) Intervention	Yes (%) Intervention	No (Freq) Intervention	No (%) Intervention	p-value (Intervention)	Yes (Freq) Control	Yes (%) Control	No (Freq) Control	No (%) Control	p-value (Control)
Waste separation	69	26.5%	191	73.5%	0.035	61	23.4%	200	76.6%	0.795
Waste composting	58	23.3%	202	77.7%	0.001	45	17.2%	216	82.8%	0.753
Waste incineration	104	40.0%	156	60.0%	0.000	76	29.1%	185	70.9%	0.961
Storage in bags	187	71.9%	73	28.1%	0.000	156	59.8%	105	40.2%	0.964
Evacuation	154	59.2%	106	40.8%	0.000	170	63.1%	91	34.9%	0.081

- Note. Frequencies (Freq) and proportions (%) are reported for intervention and control groups. P-values based on chi-square tests.

Table 2 presents the distribution of five household solid waste management (SWM) practices across intervention and control groups, disaggregated by gender. The analysis reveals statistically significant differences in adoption rates for several practices, particularly within the intervention group, highlighting the influence of gender-responsive programming. Waste separation shows a statistically significant improvement in the intervention group (26.5%, p = 0.035), while the control group exhibits lower adoption (23.4%) with no statistical significance (p = 0.795). This suggests that gender-targeted interventions may have positively influenced sorting behaviour. Gender-sensitive outreach, including community education and visual cues, has been shown to enhance women's participation in household waste segregation (Singh *et al.*, 2024; UNEP,

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2022). Composting demonstrates a marked improvement in the intervention group (23.3%, p = 0.001), compared to the control group (17.2%, p = 0.753). The statistically significant uptake in the intervention group suggests that composting behaviour is responsive to targeted training and demonstration. %). Kamweru, (2019) found that composting is often hindered by lack of knowledge and perceived utility, particularly among male-headed households. These data indicate that inclusive messaging and practical demonstrations may overcome these barriers. Incineration is more prevalent in the intervention group (40.0%, p = 0.000) than in the control group (29.1%, p = 0.961). This significant difference may reflect informal disposal practices normalized through intervention exposure. . Smith, (2020) cautioned that incineration, while convenient, often reflects infrastructural gaps and poses environmental risks. The gender dimension may be linked to decision-making roles in waste disposal, with male-headed households more likely to resort to burning. Storage in bags is the most widely adopted practice across both groups, 71.9% in the intervention and 59.8% in the control. The difference is statistically significant in the intervention group (p = 0.000), but not in the control (p = 0.964). This aligns with findings by Atiq Uz Zaman, (2014), who noted that containment practices are often the first to be adopted due to their low barrier to entry. Gender dynamics may influence storage behaviour, with women more likely to prioritize containment for hygiene and household order. Evacuation shows moderate adoption in both groups, 59.2% in the intervention and 63.1% in the control. While the control group approaches statistical significance (p = 0.081), the intervention group shows a significant uptake (p = 0.000). UN-Habitat et al., (2020) emphasized that evacuation practices are shaped by service availability and household leadership roles, with women often coordinating waste removal. The results suggest that gender-inclusive programming may enhance evacuation behaviour, particularly when supported by infrastructure.

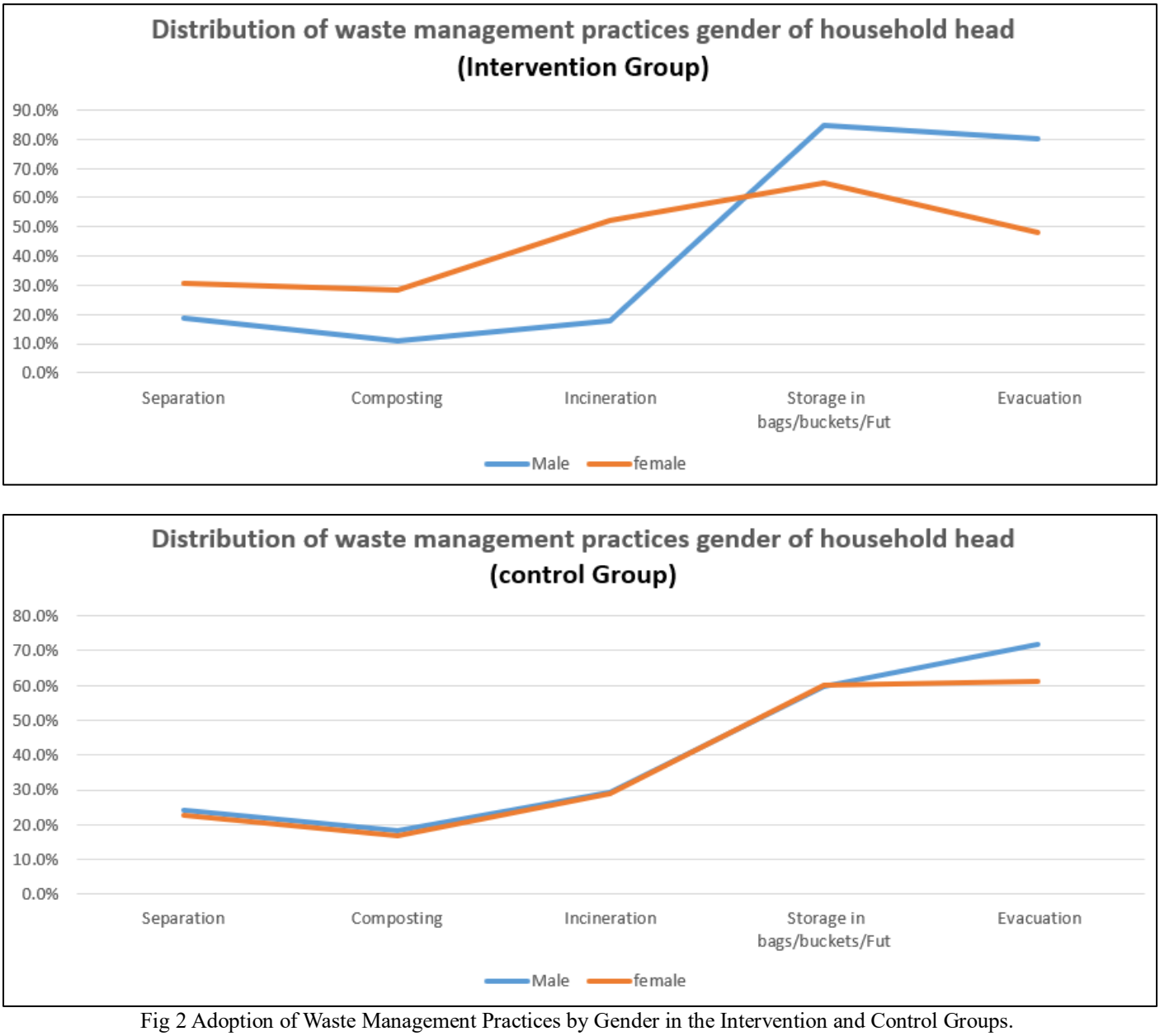

Fig 2 Adoption of Waste Management Practices by Gender in the Intervention and Control Groups.

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This section presents a comparative analysis of five household solid waste management (SWM) practices, separation, composting, incineration, storage, and evacuation, disaggregated by gender across intervention and control groups. The trends visualized in Figure 2 reveal statistically significant gender-based differences in the intervention group, while the control group shows more uniform behaviour across genders.

In the intervention group, gender differences are statistically significant across all five SWM practices. Women demonstrate higher engagement in separation (30.8%), composting (28.4%), and incineration (52.1%), while men dominate in storage (84.6%) and evacuation (80.2%). These findings suggest that women are more involved in practices requiring sorting and processing, whereas men tend to manage external disposal tasks. UN-Habitat & UNEP, (2022) observed that women's proximity to household waste generation, particularly kitchen waste, enhances their involvement in separation and composting. The statistically significant differences (separation: $p = 0.035$; composting, incineration, storage, and evacuation: $p = 0.000$) indicate that the intervention successfully mobilized gender-specific behaviours. In contrast, the control group shows no statistically significant gender differences across any of the five practices. Men exhibit slightly higher adoption of storage (59.6%) and evacuation (71.7%), while women show greater engagement in separation (30.8%), composting (28.4%), and incineration (52.1%). However, the lack of statistical significance (case of separation: $p = 0.795$; composting: $p = 0.753$; incineration: $p = 0.961$) suggests that without structured interventions, gendered behaviours in waste management remain diffuse and uncoordinated. Mwanza *et al.*, (2017) emphasized that gender-sensitive programming is essential to shift entrenched norms and promote equitable participation in sustainable waste practices

As a scientific implication, the statistically significant gender differences in the intervention group underscore the effectiveness of targeted outreach. Women's increased participation in separation and composting reflects the success of interventions that align with their domestic roles and responsibilities. Conversely, men's dominance in storage and evacuation suggests that external disposal remains a male-led activity. UN-Habitat *et al.*, (2020) advocate for gender-responsive waste management strategies, such as training women in composting and involving men in sorting, to enhance sustainability and equity. The absence of significant gender differences in the control group reinforces the importance of structured engagement. Without targeted programming, gendered waste behaviours may remain unaltered, limiting the potential for sustainable household-level change.

- *Waste Management Practices and Marital Status of the Respondents*

Table 3 Distribution of Waste Management Practices According to their Adoption about Marital Status Characteristic

Types of Waste Management Practices	Yes (Freq) Intervention	Yes (%) Intervention	No (Freq) Intervention	No (%) Intervention	p-value (Intervention)	Yes (Freq) Control	Yes (%) Control	No (Freq) Control	No (%) Control	p-value (Control)
Waste separation	69	27%	191	73.5%	0.38	61	23.4%	200	77%	0.036
Waste composting	58	22%	202	77.7%	0.262	45	17.2%	216	83%	0.09
Waste incineration	104	40%	156	60%	0.1	76	29.1%	185	71%	0.068
Storage in bags	187	72%	73	28.1%	0.567	156	59.8%	105	40%	0.999
Evacuation	154	59%	106	40.8%	0.04	170	65.1%	91	35%	0.218

Source: Field Survey, 2025

- Note. Frequencies (Freq) and percentages (%) are reported for intervention and control groups. P-values are based on chi-square tests.

This section presents the adoption of five household solid waste management (SWM) practices across intervention and control groups, disaggregated by marital status. The analysis reveals nuanced behavioural patterns, with statistically significant differences emerging in specific practices, particularly within the control group.

Waste separation (23.4%) shows a statistically significant difference in the control group ($p = 0.036$), suggesting that marital status may influence sorting behaviour in non-intervention settings. Married and widowed individuals may be more likely to engage in separation due to household responsibilities and exposure to informal norms. Fadhullah *et al.*, (2022) found that marital status correlates with increased environmental responsibility, particularly in households with children or caregiving roles. Composting remains underutilized across both groups, with no statistically significant differences. The intervention group shows slightly higher adoption (22.0%) than the control (17.2%), but the difference is not significant ($p = 0.262$ and $p = 0.090$,

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respectively). Kamweru, (2019) noted that composting is often hindered by lack of space and perceived utility, especially among single or transient households. Incineration is more prevalent in the intervention group (40.0%) than in the control (29.1%), though neither result reaches statistical significance. Smith (2020) cautioned that incineration is often a default practice among households with limited access to formal disposal services, and may be more common among divorced or widowed individuals managing waste independently. Storage in bags is the most widely adopted practice in both groups, with 72.0% in the intervention and 59.8% in the control. However, the differences are not statistically significant ($p = 0.567$ and $p = 0.999$). Atiq Uz Zaman (2014) emphasised that containment practices are universally adopted due to their simplicity and immediate utility, regardless of marital status. Evacuation shows a statistically significant uptake in the intervention group ($p = 0.040$), suggesting that marital status may influence access to or coordination of waste removal services. UN-Habitat *et al.*, (2020) reported that married households are more likely to engage in organized evacuation due to shared responsibilities and stronger ties to community systems. As a scientific implication, the data suggest that marital status influences certain waste management behaviours, particularly in non-intervention settings. Separation and evacuation practices appear more sensitive to household structure, while composting and incineration remain underutilized across marital categories. These findings support the need for equity-responsive programming that considers household composition and social roles in designing SWM interventions.

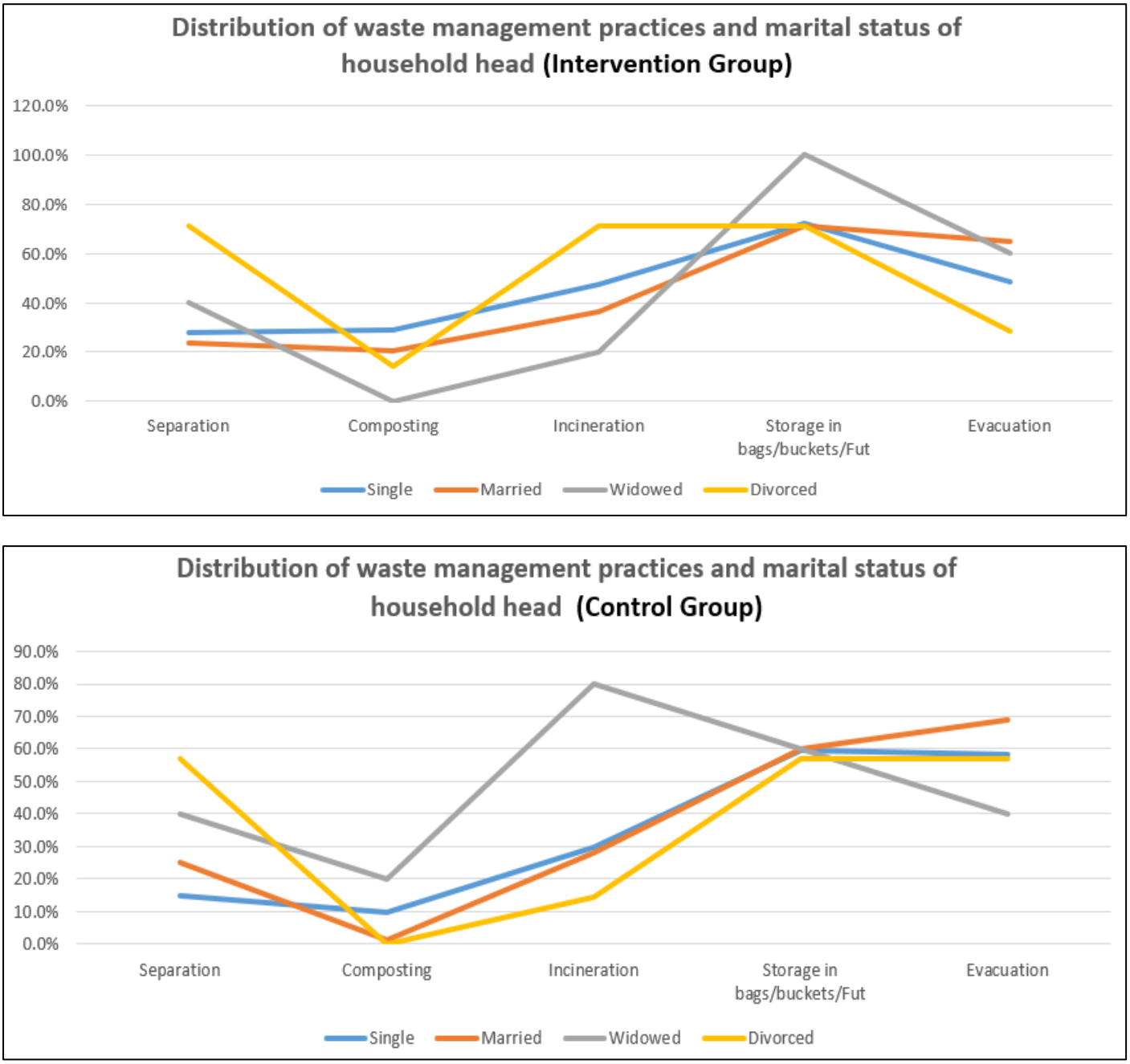

Fig 3 Adoption of Waste Management Practices by Marital Status in the Intervention and Control Groups.

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This section presents a comparative analysis of five household solid waste management (SWM) practices, separation, composting, incineration, storage indoors, and evacuation, disaggregated by marital status across intervention and control groups. The trends visualized in Figure 3 reveal distinct behavioural patterns, with widowed and married individuals demonstrating differentiated engagement across practices.

Across both groups, separation practices remain low among all marital categories, with no significant peaks. This suggests that marital status alone may not be a strong determinant of sorting behaviour. However, Fadhullah *et al*., (2022) observed that separation is more likely when reinforced by household structure and environmental awareness, particularly in married households with children. The lack of variation here may reflect limited outreach or infrastructural constraints. Composting shows a notable peak among widowed individuals in both intervention and control groups. In the intervention group, widowed respondents exhibit the highest adoption rate, suggesting that targeted messaging or community support may have reached this demographic effectively. Kamweru, (2019) reported that widowed individuals, especially older women, often engage in composting due to their involvement in subsistence gardening and food preparation.

The control group mirrors this trend, though at lower levels, indicating latent potential for composting uptake if supported by tailored interventions. Incineration is most prevalent among married individuals in both groups, particularly in the intervention setting. This may reflect informal disposal practices normalised within larger households. Smith, (2020) cautioned that incineration is often a default method in peri-urban areas where infrastructure is lacking, and married households may resort to burning due to higher waste volumes and limited alternatives. The trend suggests a need for targeted education on the environmental and health risks associated with incineration. Storage in bags shows the highest adoption among widowed individuals in both groups, with the intervention group exhibiting particularly elevated rates. This may reflect heightened concern for hygiene and containment among older or single-person households.

Atiq Uz Zaman, (2014) emphasized that containment practices are often adopted first due to their simplicity and immediate utility, especially among individuals managing waste independently. Evacuation trends show a general decline across all marital statuses in both groups, with no category demonstrating dominant uptake. In the intervention group, the decline may reflect gaps in service access or coordination, particularly among divorced and widowed individuals. UN-Habitat et al., (2020) noted that evacuation practices are shaped by household leadership and community ties, with married households more likely to engage in organized waste removal. The absence of strong uptake here suggests a need for infrastructure reinforcement and the design of inclusive services.

As a scientific implication, the data suggest that marital status influences specific waste management behaviours, particularly composting, incineration, and storage. Widowed individuals appear more responsive to containment and organic waste practices, while married households dominate in incineration. These findings underscore the importance of equity-responsive programming that considers household composition, caregiving roles, and access constraints. Tailored interventions that engage widowed and divorced individuals, often overlooked in mainstream outreach, could enhance sustainability and inclusivity in SWM systems.

- *Waste Management Practices and Respondents' Level of Education*

Table 4 Distribution of Waste Management Practices According to their Adoption about the Education Level Characteristic

Types of Waste Management Practices	**Yes (Freq) Intervention**	**Yes (%) Intervention**	**No (Freq) Intervention**	**No (%) Intervention**	**p-value (Intervention)**	**Yes (Freq) Control**	**Yes (%) Control**	**No (Freq) Control**	**No (%) Control**	p-value (Control)
Waste separation	69	26.5%	191	73.5%	0.215	61	23%	200	77%	0.717
Waste composting	58	22.3%	202	77.7%	0.852	45	17%	216	83%	0.762
Waste incineration	104	40.0%	156	60.0%	0.861	76	29%	185	71%	0.434
Storage in bags	187	71.9%	73	28.1%	0.599	156	60%	105	40%	0.188
Evacuation	154	59.2%	106	40.8%	0.949	170	63%	91	35%	0.57

Source: Field Survey, 2025

- Note. Frequencies (Freq) and percentages (%) are reported for intervention and control groups. P-values are based on chi-square tests.

In table 4, Waste separation shows moderate adoption across both groups, with slightly higher uptake in the intervention group (26.5%) compared to the control (23.0%). However, the differences are not statistically significant (p =

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0.215 and p = 0.717). Fadhullah *et al.*, (2022) found that while education can enhance environmental awareness, its impact on sorting behaviour is often mediated by access to infrastructure and community norms. Composting remains underutilised, with 22.3% adoption in the intervention group and 17.0% in the control. The lack of statistical significance (p = 0.852 and p = 0.762) suggests that education level does not strongly influence composting behaviour. Kamweru, (2019) noted that practical barriers, such as space constraints and lack of perceived utility, often outweigh educational background in determining composting uptake. Incineration is more prevalent in the intervention group (40.0%) than in the control (29.0%), yet neither result reaches statistical significance (p = 0.861 and p = 0.434). Smith, (2020) cautioned that incineration is frequently adopted in low-resource settings regardless of education, driven by convenience and the absence of formal disposal options. Storage in bags is the most widely adopted practice across both groups, with 71.9% in the intervention and 60.0% in the control.

Despite its prevalence, the differences are not statistically significant (p = 0.599 and p = 0.188). Atiq Uz Zaman, (2014) emphasized that containment practices are often universally adopted due to their simplicity and immediate utility, making them less sensitive to educational attainment. Evacuation shows moderate adoption—59.2% in the intervention and 63.0% in the control, with no statistically significant differences (p = 0.949 and p = 0.570). UN-Habitat et al., (2020) reported that evacuation behaviour is more closely linked to service availability and household leadership roles than to formal education.

As scientific implications, the data suggest that education level does not significantly influence the adoption of SWM practices in the studied population. While education may enhance awareness, its impact appears limited without corresponding infrastructure, community engagement, and behavioural reinforcement. These findings support the need for inclusive, context-sensitive interventions that prioritize accessibility and practical utility over educational targeting alone.

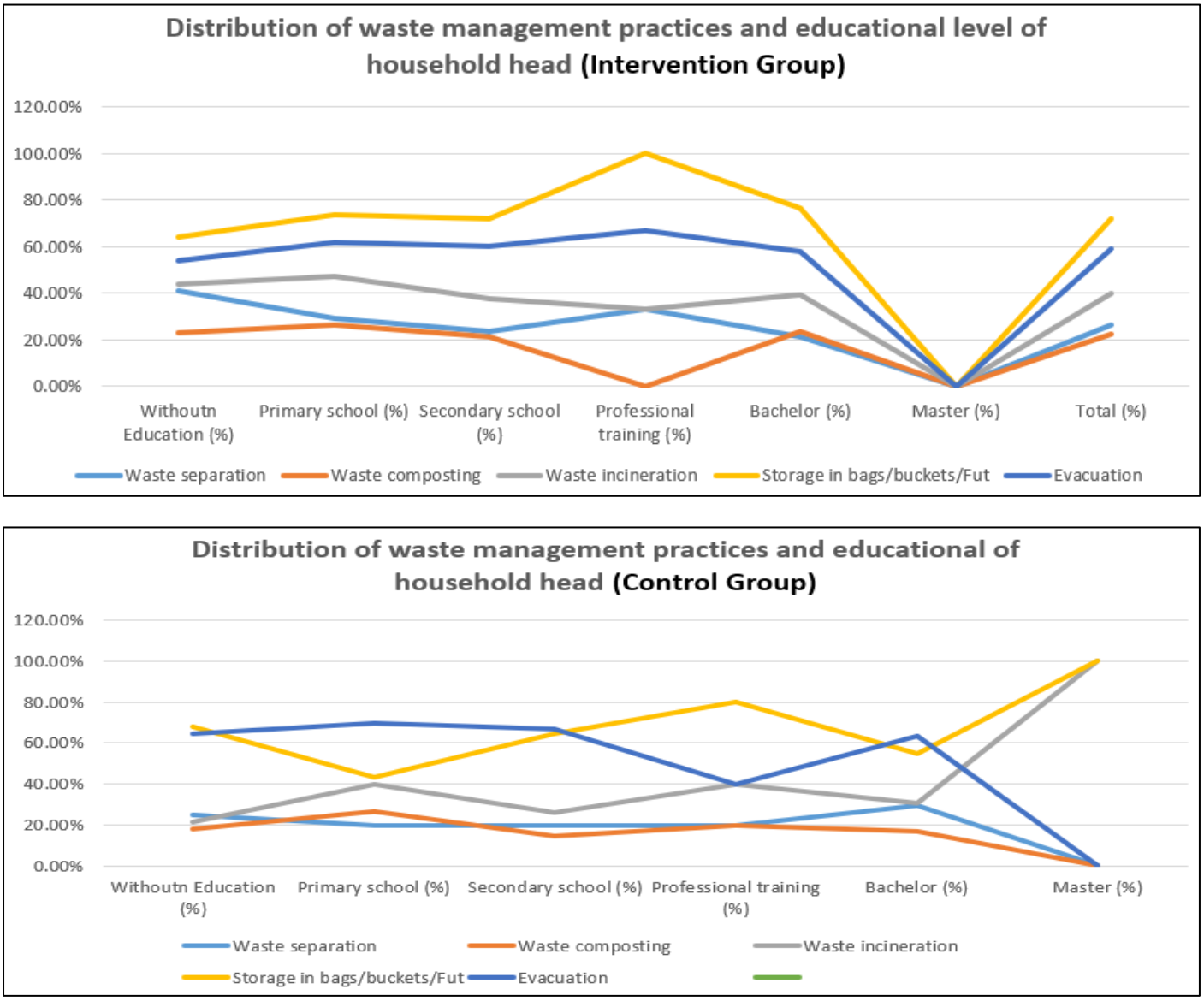

Fig 4 Adoption of Waste Management Practices by Education Level

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This section presents a comparative analysis of five household solid waste management (SWM) practices: waste separation, composting, incineration, storage indoors, and evacuation, disaggregated by the education level of household heads across intervention and control groups. The trends visualized in Figure 4 reveal distinct behavioural patterns, with education level influencing the adoption of specific practices in both settings. *Waste separation* shows modest adoption across all education levels in both groups, with no consistent upward trend. In the intervention group, separation peaks among those with secondary education, while in the control group, the highest uptake is observed among those with professional training. These findings suggest that while education may enhance awareness, it does not uniformly translate into sorting behaviour. (Fadhullah *et al.*, 2022) noted that waste separation is often driven by contextual factors such as infrastructure and community norms, rather than formal education alone.

Composting exhibits a pronounced peak among widowed individuals with primary or secondary education in both groups. In the intervention group, composting is highest among those with secondary education, while in the control group, it peaks among those with primary education. . Kamweru, (2019) observed that composting is more common among households engaged in subsistence farming or food preparation, often associated with lower formal education but higher practical engagement.

The data here affirm that composting behaviour is shaped more by livelihood and domestic roles than by academic attainment. Incineration is most prevalent among household heads with secondary and professional education in both groups. In the intervention group, married individuals with secondary education show the highest adoption, while in the control group, incineration peaks among those with professional training. Smith (2020) cautioned that incineration is frequently adopted in peri-urban areas due to infrastructural gaps, and may be normalized among educated households seeking quick disposal solutions.

The trend suggests a need for targeted education on the environmental and health risks associated with burning waste. Storage in bags is the most consistently adopted practice across all education levels, with the highest uptake among household heads with secondary and bachelor-level education. This pattern is evident in both intervention and control groups. Atiq Uz Zaman, 2014) emphasised that containment practices are often the first to be adopted due to their simplicity and immediate utility, making them less sensitive to educational attainment.

The high prevalence across education levels suggests that storage is a foundational behaviour, likely influenced by household size and hygiene priorities. Evacuation trends show moderate adoption across all education levels, with peaks among household heads with bachelor and professional training in both groups. In the intervention group, evacuation is highest among those with bachelor-level education, while in the control group, it peaks among those with professional training. UN-Habitat et al., (2020) reported that evacuation practices are shaped by service availability and household leadership roles, with educated individuals more likely to coordinate waste removal through formal or informal systems.

As scientific implications, the data suggest that education level influences certain waste management behaviours, particularly incineration, storage, and evacuation. However, the relationship is not linear, and formal education alone does not guarantee sustainable practices. Composting and separation remain underutilized across all education levels, underscoring the need for practical, context-sensitive interventions. These findings support the argument that SWM programming should prioritize accessibility, behavioural reinforcement, and community engagement over educational targeting alone.

- *Waste Management Practices and Religion of Respondents*

Table 5 Distribution of Waste Management Practices According to their Adoption Based on the Religious Characteristics

Types of Waste Management Practices	Yes (Freq.)	Yes (%)	No (Freq.)	No (%)	p-value	Yes (Freq.)	Yes (%)	No (Freq.)	No (%)	p-value
Waste separation	69	26.5	191	73.5	0.731	61	23.4	200	76.6	0.156
Waste composting	58	22.3	202	77.7	0.150	45	17.2	216	82.8	0.129
Waste incineration	104	40.0	156	60.0	0.964	76	29.1	185	70.9	0.772
Storage in bags/buckets/Fut	187	71.9	73	28.1	0.089	156	59.8	105	40.2	0.839
Evacuation	154	59.2	106	40.8	0.992	170	65.1	91	34.9	0.464

Source: Field Survey, 2025

- Note. Values are reported as frequencies and proportions (%). p-values are based on chi-square tests.

This section presents the adoption of five household solid waste management (SWM) practices across intervention and control groups, disaggregated by the education level of household heads. The analysis reveals that education level does not significantly influence the adoption of most SWM practices, with all p-values exceeding the conventional threshold for statistical significance ($p > 0.05$).

Waste separation shows low adoption across both groups, with slightly higher uptake in the intervention group (26.5%) compared to the control (23.4%). However, the differences are not statistically significant ($p = 0.731$ and $p =$

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0.156). Fadhullah *et al.*, (2022) emphasized that education alone may not drive sorting behaviour unless reinforced by infrastructure and community norms. Composting remains underutilized, with 22.3% adoption in the intervention group and 17.2% in the control. The lack of statistical significance ($p = 0.150$ and $p = 0.129$) suggests that composting behaviour is shaped more by domestic roles and livelihood practices than by formal education. Kamweru, (2019) found that composting is often adopted by households engaged in subsistence gardening, regardless of academic background. Incineration is more prevalent in the intervention group (40.0%) than in the control (29.1%), yet neither result reaches statistical significance. Smith, (2020) cautioned that incineration is frequently adopted in low-resource settings due to convenience and lack of alternatives, often irrespective of education level. Storage in bags is the most widely adopted practice in both groups, with 71.9% in the intervention and 59.8% in the control. Although the intervention group shows higher uptake, the difference is not statistically significant ($p = 0.089$ and $p = 0.839$). Atiq Uz Zaman, (2014) noted that containment practices are universally adopted due to their simplicity and immediate utility, making them less sensitive to educational attainment. Evacuation shows moderate adoption, 59.2% in the intervention and 65.1% in the control, with no statistically significant differences ($p = 0.992$ and $p = 0.464$). UN-Habitat et al., (2020) reported that evacuation behaviour is more closely linked to service availability and household leadership roles than to formal education.

As scientific implications, the data suggest that education level does not significantly influence the adoption of SWM practices in the studied population. While education may enhance environmental awareness, its impact appears limited without corresponding infrastructure, behavioural reinforcement, and community engagement. These findings support the need for inclusive, context-sensitive interventions that prioritize accessibility and practical utility over educational targeting alone.

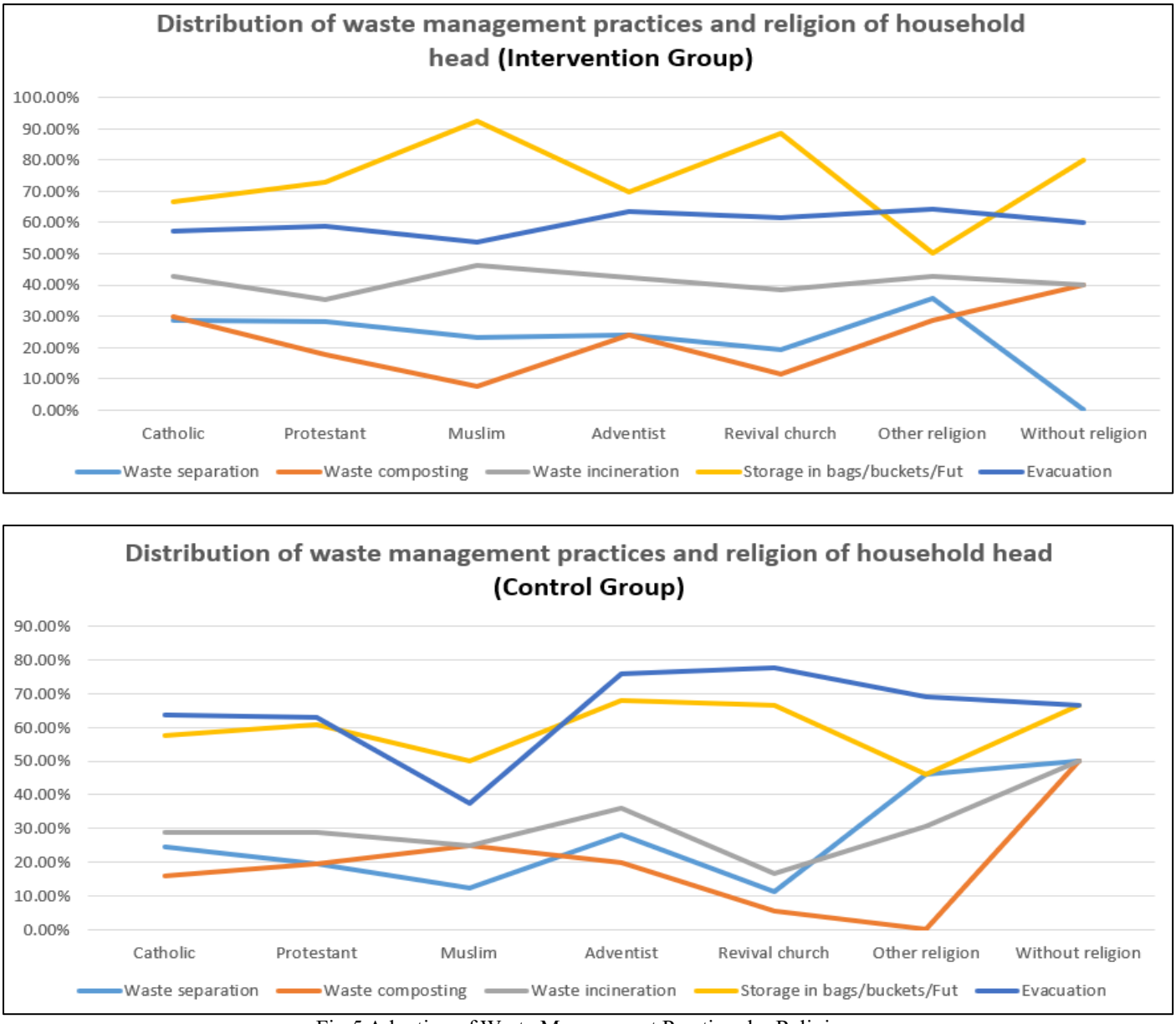

Fig 5 Adoption of Waste Management Practices by Religion

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This section presents a comparative analysis of five household solid waste management (SWM) practices, waste separation, composting, incineration, storage in bags, and evacuation, disaggregated by the religious affiliation of household heads across intervention and control groups. The trends visualized in Figure 5 reveal that religious identity may influence behavioural patterns in SWM, particularly in practices requiring routine engagement and community reinforcement.

Storage is the most consistently adopted practice across all religious categories in both groups. In the intervention group, adoption exceeds 80% among Catholics, Protestants, and Revival Church members, with similarly high rates among Muslims and Adventists. The control group mirrors this trend, with storage rates above 70% across most affiliations. Atiq Uz Zaman, (2014) emphasized that containment practices are universally adopted due to their low barrier to entry and immediate utility, often independent of religious or cultural norms. Evacuation shows moderate adoption across religious groups, with slightly higher uptake in the control group. Catholics and Protestants exhibit the highest rates in both settings, while Muslims and those without religious affiliation show lower engagement. UN-Habitat *et al*., (2020) reported that evacuation practices are shaped by service availability and household leadership roles, which may be reinforced by religious community structures. The data suggest that organized religious networks may facilitate access to waste removal services or promote collective norms around cleanliness. Incineration is more prevalent among Protestant and Catholic households in both groups, with lower adoption among Muslims and Revival Church members.

In the intervention group, incineration peaks among Protestants, while in the control group, Catholics lead. .Smith, (2020) cautioned that incineration is often a default practice in peri-urban areas with limited infrastructure, and its prevalence may reflect informal norms rather than religious doctrine. However, religious teachings on environmental stewardship may influence attitudes toward burning waste, particularly in faiths emphasizing ecological responsibility. Composting remains underutilized across all religious categories, with slightly higher adoption among Revival Church and Adventist households in the intervention group. The control group shows minimal engagement across all affiliations. Kamweru, (2019) found that composting behaviour is often driven by practical necessity and domestic roles, particularly among women in faith-based households engaged in subsistence gardening. The data suggest that religious outreach could be leveraged to promote composting as a sustainable and faith-aligned practice. Separation shows low adoption across all religious categories, with marginally higher rates among Catholics and Adventists in the intervention group. The control group exhibits uniformly low engagement. Fadhullah *et al.*, (2022) noted that sorting behaviour is more likely when reinforced by community norms and visual cues, which may be absent in religious settings lacking environmental programming. The data suggest that religious institutions could play a role in promoting separation through faith-based education and symbolic reinforcement.

As scientific implications, the data indicate that religious affiliation may influence household waste management behaviours, particularly in practices requiring routine engagement or community coordination. Storage and evacuation benefit from strong uptake across religious groups, while composting and separation remain underutilised. These findings support the integration of faith-based organizations into SWM programming, leveraging religious networks to promote sustainable practices and reinforce behavioural norms. Faith-sensitive interventions, such as sermons on environmental stewardship, mosque-based composting demonstrations, or church-led clean-up campaigns, could enhance adoption and sustainability. As UN-Habitat *et al.*, (2020) and Mwanza *et al*., (2017) argue, religious institutions are critical partners in advancing community health and environmental resilience.

V. CONCLUSION

This study provides a nuanced understanding of household-level solid waste management practices in Goma Town revealing critical behavioural differences between intervention group (Ndosho district of Karisimbi Commune) and control groups (Kyeshero district of Goma Commune). While storage and evacuation remain the most widely adopted practices, sustainable methods such as composting and separation continue to be underutilised, particularly in non-intervention settings. Statistically significant improvements in separation and composting within the intervention group suggest that targeted outreach, especially gender-sensitive and age-responsive programming, can positively influence household behaviour.

Socio-demographic factors such as gender, age and marital status emerged as key determinants of SWM adoption, reinforcing the need for equity-responsive strategies. Education and religion show limited direct impact. Women demonstrated higher engagement in sorting and composting, while men were more involved in external disposal tasks, highlighting the importance of aligning interventions with household roles and responsibilities. The findings affirm the Theory of Planned Behaviour, emphasizing that intention and perceived control, rather than formal education alone, drive sustainable waste practices.

Overall, the results underscore the importance of context-sensitive, inclusive interventions that combine infrastructure support with community education. Scaling such approaches across urban and peri-urban settings in Karisimbi and Goma Communes of Goma Town, and similar urban settings could significantly enhance environmental stewardship, public health outcomes, and the sustainability of municipal waste systems.

FUTURE SCOPE

Future efforts in Goma Town (Karisimbi and Goma Communes) should prioritise the expansion of structured

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solid waste management (SWM) programs to underserved zones, with particular emphasis on increasing the adoption of composting and separation practices. Interventions must integrate gender-sensitive training, vocational education, and faith-based outreach to ensure inclusive engagement. Gender-responsive strategies, such as tailored messaging and visual cues, are essential to mobilize both women and men effectively. Age-specific programming should focus on middle-aged adults, who demonstrated higher responsiveness, while also addressing informal disposal behaviours among older populations. Additionally, household structure, including marital status and caregiving roles, should inform targeting frameworks to enhance relevance and uptake. To accelerate composting adoption, future initiatives must strengthen both infrastructure and community education. Lastly, longitudinal studies are recommended to assess the sustainability of behavioural change and the evolving impact of interventions across demographic segments.

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