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Domestic Practices and Household Adaptation Strategies in the Face of Mistrust Towards Tap Water in Kinshasa

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ABSTRACT

Introduction

In Kinshasa, access to safe drinking water remains a major public health challenge. Aging infrastructure and limited institutional communication contribute to widespread distrust of tap water supplied by the state utility, REGIDESO.

Purpose

To assess household perceptions of tap water quality and the coping strategies adopted in response to public distrust.

Methods

A cross-sectional mixed-methods survey was conducted among REGIDESO subscribers using a structured questionnaire. An initial sample of 378 responses was collected; following data cleaning, 96 complete observations were retained for final analytical processing. Quantitative data were analyzed using descriptive statistics, Fisher's exact test, Spearman's rank correlation, and binary logistic regression, while open-ended qualitative responses underwent thematic analysis.

Results

Overall, 65.3% of respondents reported distrusting tap water quality (N = 378), primarily driven by organoleptic factors—specifically chlorine taste and odor (47.4%)—and inadequate institutional communication. Households adopted several alternative coping strategies, including bottled water consumption (30.4% among adults; 63.0% for infants) and domestic rechlorination (34.7%). These adaptive practices generate additional financial burdens and risk exacerbating socioeconomic inequalities. Bivariate and multivariate analyses revealed no statistically significant association between tap water distrust and age, sex, or educational level ($\rho \approx 0$; $p > .05$).

Conclusion

Distrust in public water infrastructure has shifted the burden of water safety assurance onto individual households, potentially exposing them to secondary health risks from unmonitored domestic treatment methods. Rebuilding public confidence requires transparent water-quality communication and enhanced regulatory oversight of alternative water supplies.

INTRODUCTION

Access to safe drinking water remains a critical public health and environmental governance challenge across rapidly urbanizing Sub-Saharan African metropolises, particularly in Kinshasa. Despite the abundant freshwater resources of the Democratic Republic of the Congo (DRC), providing safe drinking water is severely constrained by rapid demographic expansion, aging distribution networks, intermittent supply, and systemic institutional limitations (Kalanga Kabasele et al., 2025; Kayembe et al., 2018). Numerous empirical studies conducted in Kinshasa have documented significant physicochemical and microbiological contamination in both groundwater and piped water distribution systems, exposing urban populations to severe health risks (Bisimwa et al., 2021; Kaba et al., 2019; Kanjinga et al., 2024; Kapembo et al., 2019).

Drinking water quality, conventionally defined by the absence of microbiological, chemical, and physical hazards above regulatory thresholds, serves as a fundamental determinant of human health. However, beyond objective physical parameters, public trust has emerged as a central pillar of sustainable drinking water management. Trust refers to the confidence consumers place in water utilities and regulatory institutions to consistently deliver safe, reliable, and palatable water (Brouwer et al., 2020). Risk perception denotes the subjective evaluation of potential health hazards associated with water consumption, typically mediated by individual experiences, sensory evaluations, media reporting, and institutional credibility (Doria, 2010). Furthermore, water governance encompasses the institutional, political, and social framework within which water resources and distribution services are regulated and communicated to users (Tangou, 2023; Tortajada, 2010).

Recent literature demonstrates that trust in municipal water systems depends not only on physical compliance with potability standards but also on transparency, institutional communication, and daily sensory evaluations by consumers. Wilson et al. (2023) highlighted that distrust toward municipal water utilities is closely linked to perceived institutional untrustworthiness and communication failures, particularly among marginalized populations. Similarly, Faust et al. (2024) demonstrated that public confidence in water infrastructure systems is driven by perceived reliability, transparency, and service continuity. In low-income urban environments, adverse organoleptic indicators—such as off-tastes, odors, or turbidity—frequently override technical assurances of safety, directly altering consumer behavior (Brouwer et al., 2020; Doria, 2010).

In response to perceived public water system failures across low- and middle-income countries, households frequently implement point-of-use (POU) adaptation strategies, including boiling, filtration, home chlorination, and purchasing bottled water (Atalay et al., 2024; Maraqa & Ghoudi, 2015). Although intended to mitigate microbiological hazards, these coping mechanisms impose substantial economic burdens on household budgets and may inadvertently introduce secondary health risks through improper treatment dosage or contaminated storage vessels. Zuhair El Attaou and Youssef (2023) underscored that structured preventive water safety planning and proactive risk communication are essential to restore public trust in municipal distribution networks.
In Kinshasa, the national water utility (REGIDESO S.A.) faces persistent public skepticism despite routine internal testing reporting compliance with national standards (REGIDESO S.A., 2023). Colonial-era infrastructure, recurrent pipe bursts, pressure loss, intermittent distribution, and poor public risk communication perpetuate this systemic erosion of trust (Bisimwa et al., 2021; Tshimanga, 2019). Consequently, households increasingly resort to private boreholes and bottled water, exemplifying broader structural gaps in municipal service delivery and urban water governance (Munongo et al., 2022). Furthermore, Gaiffe et al. (2023) demonstrated that service instability and weak institutional accountability in low-income settings reinforce household reliance on decentralized, self-managed water treatment.

While previous research in the DRC has predominantly evaluated physicochemical and bacteriological contamination of groundwater, limited scholarly attention has focused on the social constructs of trust, risk perception, and household coping behaviors regarding municipal tap water. Addressing this gap is critical, as public risk perception directly dictates domestic water

practices, health behaviors, and civic engagement with public utilities.

This study conceptualizes the "*privatization of water safety*" as the progressive transfer of drinking water safety management from public institutions to individual households through domestic treatment and alternative sourcing. This paper addresses two primary research questions:

I. How do Kinshasa households perceive the quality of tap water supplied by REGIDESO?

II. What domestic coping strategies are adopted in response to tap water distrust?

We hypothesize that household distrust toward tap water is primarily driven by organoleptic attributes and institutional communication deficits rather than sociodemographic characteristics. The overarching objective of this study is to examine household perceptions of tap water quality and characterize domestic adaptation strategies adopted in response to public supply mistrust in Kinshasa.

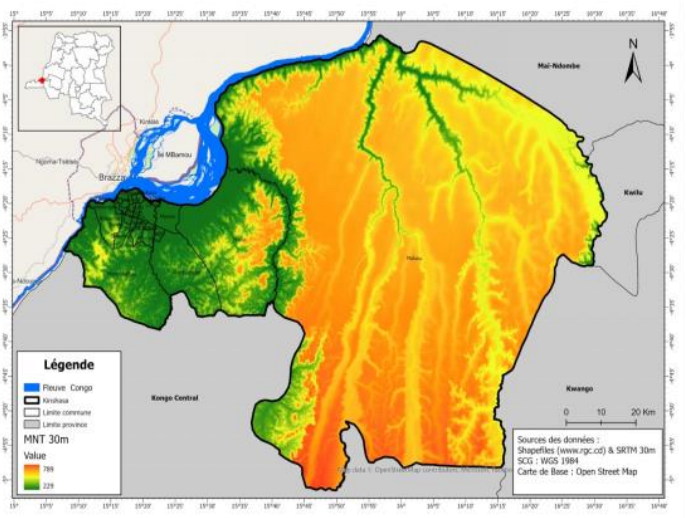
METHODS

Study Area

The study was conducted in Kinshasa, the capital city of the Democratic Republic of the Congo, situated along the southern bank of the Congo River **(Figure 1)**. Spanning an area of 9,965 km² (approximately 2,500 km² urbanized), Kinshasa has an estimated population exceeding 17 million inhabitants, making it one of the largest megacities in Africa (Kayembe et al., 2018). The city features a hot, humid tropical climate with an average annual rainfall of 1,400 mm and a mean temperature of 24 °C. Kinshasa possesses a dense hydrographic network, including major tributaries such as the N'djili, N'sélé, and Lukunga rivers (Lelo, 2008).

Municipal drinking water distribution is managed by REGIDESO S.A. However, aging infrastructure inherited from the colonial era suffers from structural breakdown and regular pressure loss, substantially escalating the risk of cross-contamination within the distribution network (Bisimwa et al., 2021). Despite official reports indicating physical compliance with WHO guidelines (REGIDESO S.A., 2023), persistent consumer distrust drives widespread reliance on private boreholes and commercial bottled water (Kanjinga et al., 2024; Munongo et al., 2022).

Figure 1:
Map of the Study Area (Kinshasa, Democratic Republic of the Congo)



Study Design and Sampling Strategy

This exploratory, cross-sectional mixed-methods study combined quantitative survey data with qualitative thematic evaluations. Given the sparse baseline data on institutional trust in drinking water services in the DRC, an exploratory framework was adopted to establish empirical trends for future representative research.

A non-probability convenience sampling strategy was used due to field logistics and municipal accessibility constraint. Data collection was carried out via online administration using KoboToolbox alongside targeted field administration in selected Kinshasa municipalities. While this approach enabled rapid data gathering across heterogeneous service zones, it introduced potential selection bias toward younger, digitally literate, and highly educated individuals.

An initial dataset of 378 responses was collected. Data screening was conducted to eliminate duplicate submissions, unverified entries, and incomplete questionnaires regarding key variables (sex, age, educational level, trust levels, and treatment practices). This yielded a cleaned analytical sample of 96 complete observations. The sociodemographic profile of the cleaned analytical sample (n = 96) remained consistent with the initial raw sample (N = 378), as detailed in **Table 1**.

Table 1:
Sociodemographic Profile Comparison Between Initial Raw Sample and Cleaned Analytical Sample

Variable	Category	Initial Sample (N=378) %	Final Analytical Sample (n=96) %
Sex	Male	81.2	81.3
	Female	18.8	18.7
Age Group	18–29 years	31.5	31.3
	30–39 years	42.1	42.7
	≥ 40 years	26.4	26.0
Education	Higher/University	52.1	53.1
	Secondary	25.1	25.0
	Primary / None	22.8	21.9

Questionnaire Development and Validation

The survey instrument was developed following established literature on drinking water perception and institutional trust (Brouwer et al., 2020; Doria, 2010). The draft questionnaire was reviewed by environmental health and water governance experts to confirm content validity. A pilot study was conducted among a small cohort in Kinshasa to refine phrasing, clarity, and logical flow. Because the instrument gathered descriptive, perceptual, and behavioral metrics rather than standardized psychometric latent scales, formal internal consistency metrics (e.g., Cronbach's α) were not calculated.

The final questionnaire contained closed, semi-closed, and open-ended items covering five primary domains:

a) Household connection status and water source knowledge;

b) Perceived trust in tap water quality;

c) Organoleptic evaluations (taste, odor, color);

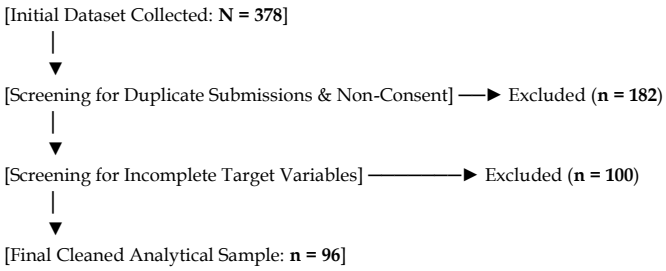
d) Domestic treatment and alternative sourcing practices;

e) Institutional risk communication perceptions.

Inclusion Criteria and Data Cleaning

Participants were required to reside in Kinshasa, be at least 18 years old, and provide informed consent. Data cleaning involved checking for duplicate submission timestamps and consistent demographic entries. Incomplete records missing critical variables were removed. No missing data imputation was performed due to the sample size and exploratory design. The multi-stage data screening process is detailed in **Figure 2**.

Figure 2:
Flowchart of Respondent Screening and Sample Selection



Statistical Analysis

Data were analyzed using Python (SciPy), R, and Microsoft Excel. Descriptive metrics (frequencies, percentages) were computed for the initial dataset (N = 378) to assess broad community trends. Comparative and inferential statistical modeling was conducted on the cleaned analytical dataset (n = 96).

Inferential evaluations included:

i. **Spearman's Rank Correlation (ρ)**: Assessed monotonic relationships between continuous and ordinal variables;

ii. **Fisher's Exact Test**: Evaluated associations between categorical variables (preferred over Chi-square due to small cell frequencies);

iii. **Two-Sample Z-Tests for Proportions**: Evaluated group differences in alternative water use;

iv. **Binary Logistic Regression**: Modeled key predictors of tap water trust (0 = Distrust/Uncertainty, 1 = Trust).

Multicollinearity was evaluated using Variance Inflation Factors (VIF < 2.0), and model fit was determined via McFadden's pseudo-R^2. Statistical significance was established at $p < .05$. Qualitative responses to open-ended survey items underwent inductive thematic analysis to identify recurring themes surrounding institutional distrust and domestic coping behaviors.

Methodological Limitations

a. Sample size reduction from N = 378 to n = 96 after rigorous screening reduced statistical power, increasing the probability of Type II errors in regression models.

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b. Convenience sampling via digital platforms overrepresented educated, male, and digitally connected respondents, limiting generalizability to all Kinshasa households.

c. Reliance on self-reported data introduces potential recall and social desirability biases.

Ethical Considerations

Ethical approval was granted by the Institutional Review Board of the Faculty of Sciences and Technology, University of Kinshasa, Democratic Republic of the Congo, under authorization clearance No. DFSCT/DEC/MKM/01098/SM/2024. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained electronically or verbally from all participants prior to survey administration. Participation was entirely voluntary, and participants were informed of the objectives of the study, their right to withdraw at any time without consequence, and the confidentiality of the information provided. Data collection remained fully anonymous and non-invasive, and all collected data were securely stored and used exclusively for scientific research purposes.

RESULTS

Descriptive Survey Results (N = 378)

Sociodemographic Profile and Source Knowledge

The majority of respondents were male (81.2%, n = 307), with the largest age cohort falling between 30 and 39 years (42.1%, n = 159). Over half held a university degree (52.1%, n = 197) **(Table 2)**.

Table 2:
Sociodemographic Profile of Survey Respondents (N = 378)

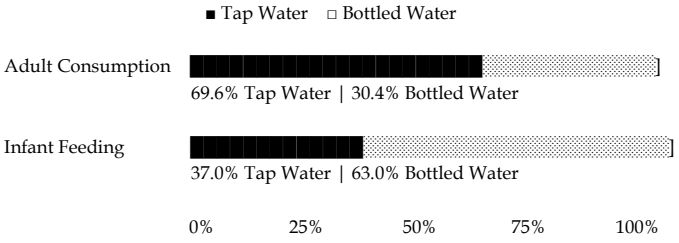
Variable	Category	n	%
Sex	Male	307	81.2
	Female	71	18.8
	Total	**378**	**100.0**
Age Group *(Years)*	18–29	119	31.5
	30–39	159	42.1
	40–49	76	20.1
	50–59	16	4.2
	≥ 60	8	2.1
	Total	**378**	**100.0**
Educational Level	None	3	0.8
	Primary	83	21.9
	Secondary	95	25.1
	Higher / University	197	52.1
	Total	**378**	**100.0**

While 74.0% of respondents reported having an active household tap connection, 56.0% were unaware of the specific environmental origin or treatment facility of their municipal water supply.

Confidence in Tap Water and Alternative Sourcing

A substantial majority of households reported distrusting municipal tap water supplied by REGIDESO (65.3%), while 26.2% expressed confidence and 8.5% remained uncertain. Distrust directly shaped domestic consumption choices: while bottled water was consumed by 30.4% of adults, its usage rose to 63.0% for infant feeding **(Figure 3)**.

Figure 3:
Primary Water Source Used for Adult Consumption vs. Infant Feeding (N = 378)



Sensory Perceptions and Health Concerns

Organoleptic evaluations revealed that 47.4% of respondents strongly perceived an unpleasant taste in tap water. The primary water safety concern was potential microbial contamination (46.3%), followed by excessive chlorine odor and taste (20.1%) **(Table 3)**.

Table 3:
Reported Concerns Regarding Municipal Tap Water Quality (N = 378; Multiple Responses Allowed)

Primary Reported Concern	n	%
Perceived microbial contamination	175	46.3
Chlorine taste / odor	76	20.1
Visible turbidity / discoloration	58	15.3
Suspected chemical pollution	42	11.1
Intermittent flow / pipe rust	27	7.1
Total	**378**	**100.0**

Domestic Water Treatment and End Use

To compensate for perceived tap water safety risks, households employed physical filtering devices, including tap filters (36.4%), refrigerator filters (20.5%), ceramic beads (16.0%), and pitcher filters (9.0%).

Chemical treatment was reported by 34.7% (n = 131) of households **(Table 4)**. Among these households, Aquatabs (54.9%) and liquid sodium hypochlorite/chlorine (41.9%) were the primary products used.

Table 4:
Domestic Disinfectant Usage and Product Selection (N = 378)

Variable	Category	n	%
Use of Chemical Disinfectant	No	231	61.1
	Yes	131	34.7
	Unsure	16	4.2
	Total	**378**	**100.0**
Disinfectant Product *Used* *(n = 131)*	Aquatabs (NaDCC)	72	54.9
	Liquid chlorine	55	41.9
	Alpha Spin / Alternative	4	3.1
	Total	**131**	**100.0**

Regarding general utilization, tap water was primarily restricted to non-ingestion domestic tasks, such as house cleaning (40.2%), gardening (29.6%), and irrigation (12.7%).

Inferential Statistical Results (n = 96)

Correlation Analyses

Spearman rank correlation analyses evaluated relationships between household trust in tap water and sociodemographic or behavioral metrics (n = 96). No statistically significant correlation was found between trust and age, educational level, source knowledge, or treatment practices ($p > .05$). However, a moderate positive correlation was observed between age and educational level ($\rho = .417$, $p < .001$) **(Table 5)**.

Table 5:
Spearman Rank Correlation Matrix for Tap Water Trust and Household Metrics (n = 96)

Variable Pair	n	ρ	p	Significance	Interpretation
Trust vs. Age	96	-.013	.903	ns	No correlation
Trust vs. Education Level	96	.046	.669	ns	No correlation
Trust vs. Source Knowledge	96	-.059	.589	ns	No correlation
Trust vs. Domestic Treatment	96	-.058	.597	ns	No correlation
Age vs. Education Level	96	.417	< .001	***	Moderate positive

Note: ns = not significant ($p \geq .05$); *** $p < .001$, ρ = Spearman's ρ, p = p-value.

Categorical Association Tests

Fisher's exact tests showed no statistically significant differences in tap water trust across gender or educational tiers ($p > .05$). A non-significant trend was noted between tap water distrust and bottled water reliance (OR = 0.33, p = .091) **(Table 6)**.

Table 6
Fisher's Exact Test Assessments of Household Tap Water Trust (n = 96)

Comparison Test	CM [a,b,c,d]	OR	p-value	Significance
Trust vs. Education Level *(Low vs. High)*	[14, 51, 7, 24]	1.17	1.000	ns
Trust vs. Bottled Water Use	[6, 46, 6, 15]	0.33	.091	ns
Trust vs. Sex	[14, 52, 6, 24]	1.26	1.000	ns
Domestic Treatment vs. Sex	[12, 47, 8, 29]	1.13	1.000	ns

Note: ns = not significant ($p \geq .05$), OR = Odds Ratio, CM = Contingency Matrix.

Binary Logistic Regression Modeling

A binary logistic regression model was constructed to evaluate predictors of household trust in tap water (n = 96). Sociodemographic variables and domestic practices did not emerge as statistically significant predictors ($p > .05$) **(Table 7)**. McFadden's pseudo-R^2 was 0.041, confirming that demographic factors alone do not explain household trust dynamics.

Table 7:
Binary Logistic Regression Analysis of Predictors of Household Tap Water Trust (n = 96)

Variable	β	SE	Wald Z	p	OR	95% CI for OR	Significance
Constant	-0.600	0.947	-0.634	.526	0.55	[0.09, 3.51]	ns
Sex	0.127	0.659	0.193	.847	1.14	[0.31, 4.13]	ns
Age	0.154	0.282	0.548	.584	1.17	[0.67, 2.03]	ns
Education Level	-0.119	0.210	-0.568	.570	0.89	[0.59, 1.34]	ns
Domestic Treatment	-0.716	0.532	-1.347	.178	0.49	[0.17, 1.39]	ns

Note: Dependent variable: Tap Water Trust (0 = Distrust/Uncertainty, 1 = Trust). ns = not significant ($p \geq .05$), OR = Odds Ratio, β = Coefficient, SE = Standard Error, p = p-value.

Proportion Difference Tests

Two-sample Z-tests for proportions showed no significant differences in bottled water consumption by sex ($Z = 0.55$, $p = .582$) or age ($Z = 0.06$, $p = .955$). However, respondents who distrusted tap water showed a non-significant tendency toward higher bottled water reliance (88.5%) compared to those who trusted tap water (71.4%) ($Z = 1.78$, $p = .076$) **(Table 8)**.

Table 8
Two-Sample Z-Test Comparison of Bottled Water Usage Proportions (n = 96)

CG	SG 1 (n1)	% G1	SG 2 (n2)	% G2	Z	p	Significance
Sex	Male (n = 63)	85.7	Female (n = 15)	80.0	0.55	.582	ns
Age	18–39 (n = 59)	84.7	≥ 40 (n = 19)	84.2	0.06	.955	ns
TS	Distrust (n = 52)	88.5	Trust (n = 21)	71.4	1.78	.076	ns

Note: CG = Comparison Group, SG = Subgroup, ns = not significant ($p \geq .05$), p = p-value, Z = Z-statistic, TS = Trust Status.

Qualitative Findings

Perceived Drivers of Distrust

Thematic coding of qualitative survey responses revealed three main drivers of consumer distrust:

A. **Organoleptic Off-Sensations**: Frequent complaints focused on high residual chlorine odors, chemical tastes, and temporary turbidity.

B. **Infrastructure Vulnerability**: Participants associated pipe bursts, brown water surges following repairs, and low water pressure with active contamination.

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C. **Institutional Communication Deficits**: Respondents noted an absence of transparent risk communication, public water testing reports, or advance notices of pipe flushing from REGIDESO S.A.

Household Adaptation and Financial Burden

To mitigate perceived health risks, households implemented secondary treatment routines or changed sourcing behaviors.

i. **Risk Stratification**: Piped tap water was commonly demoted to cleaning and laundry, whereas commercial bottled water was prioritized for drinking and preparing infant formula.

ii. **Economic Strain**: Lower- and middle-income respondents emphasized the significant financial burden of purchasing bottled water or sodium hypochlorite solutions.

iii. **Uncertainty in Point-of-Use Safety**: Many respondents expressed uncertainty regarding correct dosing for domestic rechlorination, raising concerns about potential over-chlorination or chemical byproduct formation.

DISCUSSION

This study evaluated household perceptions of municipal tap water in Kinshasa and the domestic adaptation strategies adopted in response to service distrust. The findings show that tap water distrust is widespread (65.3%) and largely independent of sociodemographic characteristics such as age, sex, or educational attainment.

Rather than indicating a lack of meaningful relationships, these non-significant statistical findings align with modern water governance frameworks. These frameworks suggest that institutional trust is primarily built through utility performance, system reliability, and transparent communication rather than demographic profiles (Faust et al., 2024; Wilson et al., 2023). When municipal service is characterized by intermittent supply and frequent pressure loss, public distrust becomes a systemic response across all demographic groups.

The widespread adoption of household coping mechanisms—such as physical filtration, domestic chlorination, and bottled water reliance—reflects an adaptive strategy driven by perceived municipal service failure. This dynamic illustrates the "*privatization of water safety*," where the responsibility for health protection shifts from the public utility to individual households. Similar patterns have been documented in other Sub-Saharan urban contexts, where decentralized domestic treatment acts as a compensatory mechanism for unreliable utility infrastructure (Atalay et al., 2024; Gaiffe et al., 2023). However, this shift can exacerbate socioeconomic inequalities, as lower-income households spend a disproportionate share of their income on bottled water or home treatment chemicals.

Organoleptic evaluations play a primary role in shaping public risk perception. Nearly half of respondents reported unpalatable chlorine tastes or odors. In the absence of accessible, regular water quality reports from municipal authorities, consumers rely on sensory cues (taste, odor, clarity) as primary proxies for water safety (Brouwer et al., 2020; Doria, 2010). Although residual chlorine is necessary to prevent microbial recontamination in aging networks, strong chemical tastes can be misinterpreted by consumers as harmful contamination, driving them toward unmonitored alternative sources (Hatchuel & Ortalda, 2000; Tiama et al., 2018).

From a public health perspective, self-managed domestic adaptation strategies can introduce secondary risks. Uncontrolled POU chlorination without proper dosing guidance can lead to harmful disinfection byproducts (Kanjinga et al., 2025; Tangou, 2023). Furthermore, heavy reliance on bottled water stored in polyethylene terephthalate (PET) containers under high ambient temperatures in Kinshasa poses potential chemical exposure risks, including antimony leaching and microplastic ingestion (Kanjinga et al., 2024; Shotyk & Krachler, 2007).

Policy and Governance Implications

Achieving Sustainable Development Goal 6 (SDG 6) in Kinshasa requires addressing both physical infrastructure needs and institutional communication gaps. To rebuild public confidence, municipal water authorities and public health institutions should:

1. **Enhance Risk Communication**: Publish transparent, accessible water-quality reports and issue timely public notices during service interruptions or network maintenance;
2. **Promote Safe Point-of-Use Treatment**: Provide clear guidance on proper home treatment methods and chemical dosing to minimize secondary health risks;
3. **Regulate Alternative Supplies**: Strengthen regulatory oversight of commercial bottled water manufacturers and private urban boreholes to ensure safety standards.

CONCLUSION

This study demonstrates that public distrust of municipal tap water in Kinshasa is widespread and primarily driven by sensory perceptions and institutional communication gaps rather than sociodemographic factors. In response, households frequently adopt point-of-use adaptation practices, including chemical disinfection, physical filtration, and commercial bottled water purchasing.

While these coping strategies aim to mitigate perceived health risks, they transfer the burden of water safety management to individual consumers. This shift creates financial strain for households and can introduce secondary health risks from unmonitored domestic treatment methods or poorly regulated alternative supplies. Rebuilding public trust in Kinshasa's municipal water distribution system requires combining physical infrastructure improvements with transparent water-quality reporting, public education on safe POU practices, and stronger regulatory oversight of alternative water sources.

Use of Artificial Intelligence (AI) Declaration: The authors declare that no generative artificial intelligence was used in the conception and design of the study, data collection, data analysis, interpretation of results, or the generation or modification of the primary research data. Artificial intelligence-assisted language tools were used solely to improve the English translation, grammar, spelling, and overall linguistic clarity of the manuscript. All scientific content, interpretations, conclusions, and the final version of the manuscript were critically reviewed, verified, and approved by the authors, who take full responsibility for the content of this article.

Authors' Contributions:

- A.K.N.: Conceptualization, Methodology, Investigation, Formal Analysis, Writing – original draft
- B.M.L.: Investigation, Validation, Writing – review & editing
- T.T.T.: Conceptualization, Methodology, Supervision, Writing – review & editing
- All authors: Conceptualization, Writing – review & editing, and final approval of the manuscript.

Data Availability Statement: The datasets generated and analyzed during the current study are not publicly available because they contain information that could compromise participant confidentiality. However, anonymized data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to approval by the University of Kinshasa and applicable institutional ethical policies.

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Ethical Approval: Ethical Approval: The study was approved by the Institutional Review Board of the Faculty of Sciences and Technology, University of Kinshasa, Democratic Republic of the Congo (Approval No. DFSCT/DEC/MKM/01098/SM/2024).

Informed Consent: All participants provided informed consent prior to inclusion.

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