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**Knowledge, attitudes and practices of the riverside population on preventive measures for waterborne diseases: case of the Mapela district, Masina commune, Kinshasa, Democratic Republic of the Congo**

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## ABSTRACT

**Background:** Water is an essential resource for human survival, yet anthropogenic activities contribute to its degradation, jeopardizing its availability and limiting its use for future generations. In the Democratic Republic of the Congo, particularly in Kinshasa, the degradation of aquatic environments poses a major public health threat, especially in riverside communities where waterborne diseases are endemic.

**Objective:** To assess the knowledge, attitudes, and practices (KAP) of the riverside population of the Mapela district, Masina commune, Kinshasa, regarding preventive measures for waterborne diseases.

**Methods:** A cross-sectional descriptive and analytical study was conducted from January 16 to April 16, 2026, among 230 respondents selected by non-probabilistic convenience sampling. Data were collected through a semi-structured interview questionnaire and focus group discussions. Statistical analyses included descriptive statistics, Chi-square goodness-of-fit tests, Chi-square tests of independence, and Cramér's V, using SPSS 26.0 and Excel 2010 ( $\alpha = 0.05$ ).

**Results:** The population was predominantly female (65%), married (52%), with a mean age of 40 years. Only 1% had no education, 8% had primary education, 74% had secondary education, and 17% had university education. Individual preventive measures scored 38%, while collective preventive measures scored 42%, giving an overall mean of 40% well below the 50% acceptability threshold. Waste management practices were dominated by watercourse dumping (67%), followed by incineration (18%), burial (6%), and public road dumping (4%). The main health problems reported were malaria (39%), typhoid fever (18%), amoebiasis (8%), headaches (8%), cough (7%), colds (6%), vomiting (5%), ascariasis (5%), and stomach aches (4%). Chi-square analysis revealed significant associations between education level and knowledge ( $p = 0.003$ ), and between knowledge and waste management practices ( $p = 0.012$ ). Identified CBRN risks included chemical risks (pesticides, heavy metals, hydrocarbons), biological risks (enteric pathogens, malaria vectors), and potential radiological risks (natural radionuclides in sediments).

**Conclusion:** The riverside population of Mapela has insufficient knowledge, attitudes, and practices regarding waterborne disease prevention. Community sensitization, health education, and infrastructure improvement are urgently needed. The integration of a CBRN risk framework is

essential for sustainable environmental management in Kinshasa.

**Keywords:** knowledge, attitudes, practices, waterborne diseases, Mapela, Masina, Kinshasa, CBRN risks, statistical analysis.

## 1. Introduction

According to RAÏS MT and XANTHOULIS D. (1999), fresh water reserves (2.7%) represent only  $38,304 \times 10^3 \text{ km}^3$ . Moreover, a large part of this reserve is in solid form (Atlantic ice cap, Arctic glaciers and reliefs). Liquid fresh water often remains difficult to access because it is very deep.

Fiston MASIKINI (2023) shows that Man must therefore face this reduction in natural water resources and the increasing degradation of water quality: inadequacies in the water industry, insufficient treatment of sewage, discharges of industrial and domestic effluents, leaks in petroleum product storage tanks, infiltration of fertilizer and agricultural pesticide residues, etc. These nuisances are among the main causes of water pollution. Their severity depends on population density, agricultural and industrial practices and the presence or absence of recovery devices.

For its part, UNICEF (2013) tells us that water is a precious element essential to life, this natural resource covers three quarters of our planet, with only 0.014% of fresh water, this is surface water (rivers, lakes and ponds). In addition, its distribution being uneven on the surface of the globe, this resource represents both a political, economic and strategic issue. Indeed, water plays a fundamental role in many areas such as drinking water, agriculture, industry, electricity production as well as domestic uses.

It is important to note that the introduction, direct or indirect, by human activity, of substances or heat into water, likely to contribute to or cause: a danger to human health, deterioration of biological resources, ecosystems or material goods, an obstacle to the use of water. This introduction has the following consequences: a decrease in the concentration of dissolved oxygen, the presence of toxic products, a physical modification of the receiving environment and the presence of dangerous bacteria or viruses.

To complete the study of pollution of aquatic environments, previous research focused on the study of sediment contamination. The sedimentary phase is generally composed of particulate matter of various terrigenous, organogenic and/or authigenic origins (MARIOTTI A, 1982 and Marine Pollution Bulletin, 2003). A sediment is considered as a transport and accumulation medium for several pollutants

such as metallic elements, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), etc. Indeed, it represents an endogenous source of contamination of aquatic ecosystems (MASIKINI, 2021).

In the Democratic Republic of Congo (DRC), the city province of Kinshasa in general and the commune of Masina in particular, it has been observed that the environmental situation is marked in addition to the global and known problems of the planet's environment such as climate change, the destruction of the ozone layer, by a multifaceted degradation of the different environments. Thus, the development of urbanization is still not accompanied by that of the corresponding urban environmental infrastructures and services; such as the supply of drinking water, the management of household waste and wastewater.

In fact, in the communes of the City of Kinshasa, we note the virtual absence of sewer networks and wastewater treatment systems, the insufficient supply of drinking water as well as inadequate management of solid waste. The disposal of waste water is often done by direct discharge into the receiving environment (soil, backwater, gutters, etc.) in informal settlements; in dry latrines for neighborhoods or avenues, septic tanks followed by cesspools in residential neighborhoods. The disposal of household water is generally done directly on the public highway or in the courtyard of the concession or in a gutter or a cesspool or in watercourses (Marine Pollution Bulletin, op.cit.).

Similarly, water from septic tanks is channelled into rivers in general and in particular, the Kalamu River, where it is discharged in defiance of the provisions relating to environmental protection and those relating to the protection of water resources contained in the law on the water regime. Under these conditions, the environment is characterised by a generalised state of insalubrity in the living environment.

In view of the above, we remind the entire community that wastewater is the seat of transport, growth and development of several disease vectors and pathogens. Also, these waters are likely to carry toxic substances responsible for potential health risks. Man is exposed to waterborne diseases due to biological pollution represented by bacterial, viral and zooparasitic pollution. This is how we asked ourselves the question of whether the riverside population of Mapela in the Commune of Masina has sufficient knowledge, attitudes and practices on preventive measures for pathologies due to water pollution.

The aim of our study is to assess the knowledge of the riverside population of Mapela in the commune of Masina on

the prevention of waterborne diseases. Achieving this goal leads us to retain the following objectives: (i) identify the population concerned by the study; (ii) describe their socio-demographic characteristics; (iii) determine their knowledge, attitude and practice on preventive measures for waterborne diseases; (iv) analyze the statistical associations between socio-demographic characteristics and knowledge.

## **2. Methodological approach**

### **2.1. Type and Field of Research**

Our study is descriptive and analytical and falls within the field of Public Health, sub-domain of Environmental Health.

### **2.2. Location and Period of the Study**

This study was carried out in the Mapela district, in the Municipality of Masina, at the level of the local population of said Municipality and during the period from January 16 to April 16, 2026.

### **2.3. Description of the Survey Area**

The study area covers an area of 1,907 km<sup>2</sup> and a distance of 830 m in length between Bongolo Avenue and Monpono and Kapela Avenue.

### **2.4. Target Population and Sample**

**Population:** For DUCOURNEAU J. (2015), the study population is a set of elements of individuals, animals, objects on which the investigation focuses. In this study, our target population consists of residents of the Mapela district in the commune of Masina who meet the following characteristics: socio-demographic characteristics (age, marital status, level of education, gender) and methods of managing waste produced in households; specific elements of knowledge on individual and collective preventive measures.

#### **Inclusion criteria:**

- Being a resident of the Mapela district in the commune of Masina;
- Be present at the time of the investigation;
- Be an adult, over 18 years old;
- Agree to participate in the study;
- Know how to speak French and Lingala.

**Exclusion criteria:** Regarding the exclusion criterion, we excluded from the study any subject who did not meet the inclusion criteria listed above.

**Sample:** Our sample is of the occasional non-probabilistic type. For this study, we retained an occasional sample of 230 respondents.

## 2.5. Data Collection Process

**Method:** Prospective survey method.

**Technique:** Semi-structured interview technique.

**Instrument:** Interview guide questionnaire.

## 2.6. Conduct of the Study

We conducted the interview and then proceeded to interview each respondent who met the inclusion criteria listed above. Thus, we collected the necessary data related to our study.

## 2.7. Data Analysis

The collected data were processed and analysed with descriptive and inferential statistics using SPSS 26.0 and Excel 2010 software. Some data were disaggregated by gender to be able to detect the percentage of women exposed to poisoning due to the use of contaminated water.

### Statistical analyses:

- **Descriptive statistics:** frequencies, percentages, means, standard deviations, 95% confidence intervals (Wilson method);
- **Comparison tests:**
  - **Chi-square goodness-of-fit test** to compare observed distributions to a uniform theoretical distribution;
  - **Chi-square test of independence** to test associations between qualitative variables;
  - **Fisher's exact test** for  $2 \times 2$  contingency tables with expected frequencies  $< 5$ ;
- **Association measures:** Cramér's V ( $\varphi_c$ ) to assess the strength of relationships (0.10 = weak; 0.30 = moderate; 0.50 = strong);
- **Significance level:**  $\alpha = 0.05$ .

**Acceptability criterion:** 50% or more for each element.

## 2.8. Ethical Considerations

In the design and implementation of this study, ethical aspects were respected, namely: respect for the dignity of the human person, beneficence, equity and autonomy. To do this, the data investigators requested the respondents' free and informed consent. Furthermore, the confidentiality of the information obtained from the respondents was guaranteed during the data analysis.

## 2.9. Data Processing

We transformed the data occurrence frequencies into percentages for better presentation using the following formula:

$$\% = (F_o / F_a) \times 100$$

Where: % = Percentage;  $F_o$  = Observed frequency;  $F_a$  = Expected frequency.

## 3. Results and discussions

### 3.1. Profile of Respondents

**Table 1.** Sociodemographic Profile of Respondents Residing in the Study Area (N = 230).

| Variable       | Category     | Frequency (n) | Percentage (%) | 95% CI      |
|----------------|--------------|---------------|----------------|-------------|
| Gender         | Male         | 80            | 35             | [29.1–41.4] |
|                | Female       | 150           | 65             | [58.6–70.9] |
|                | <b>Total</b> | <b>230</b>    | <b>100</b>     |             |
| Marital status | Single       | 60            | 26             | [20.8–31.9] |
|                | Married      | 120           | 52             | [45.6–58.4] |
|                | Divorced     | 30            | 13             | [9.3–17.8]  |
|                | Widowed      | 20            | 9              | [5.9–13.4]  |

|                                             |                   |            |            |             |
|---------------------------------------------|-------------------|------------|------------|-------------|
|                                             | <b>Total</b>      | <b>230</b> | <b>100</b> |             |
| <b>Age range (years)</b>                    | 18–30             | 110        | 48         | [41.6–54.4] |
|                                             | 31–40             | 80         | 35         | [29.1–41.4] |
|                                             | 41–50             | 30         | 13         | [9.3–17.8]  |
|                                             | ≥ 51              | 10         | 4          | [2.2–7.2]   |
|                                             | <b>Total</b>      | <b>230</b> | <b>100</b> |             |
| <b>Level of education</b>                   | Uneducated        | 2          | 1          | [0.3–3.3]   |
|                                             | Primary           | 18         | 8          | [5.1–12.2]  |
|                                             | Secondary         | 170        | 74         | [68.0–79.3] |
|                                             | Higher/University | 40         | 17         | [12.9–22.2] |
|                                             | <b>Total</b>      | <b>230</b> | <b>100</b> |             |
| <b>Number of years of residence (years)</b> | 1–5               | 9          | 8          | [4.3–14.3]  |
|                                             | 6–10              | 10         | 9          | [5.0–15.6]  |
|                                             | 11–15             | 12         | 11         | [6.4–18.0]  |
|                                             | 16–20             | 56         | 52         | [42.7–61.2] |
|                                             | 21–25             | 9          | 8          | [4.3–14.3]  |
|                                             | 26–30             | 9          | 8          | [4.3–14.3]  |
|                                             | ≥ 30              | 5          | 4          | [1.9–9.4]   |
|                                             | <b>Total</b>      | <b>110</b> | <b>100</b> |             |

Source: Our survey (2026). 95% CI = 95% Confidence Interval (Wilson method).

### Statistical interpretation of Table 1:

The sample is predominantly female (65%; 95% CI: [58.6–70.9]), with a female/male ratio of 1.86:1. This female predominance is statistically significant ( $\chi^2 = 21.74$ ;  $p < 0.001$ ). Regarding marital status, 52% of respondents are married (95% CI: [45.6–58.4]), 26% single, 13% divorced, and 9% widowed. The modal age group is 18–30 years (48%; 95% CI: [41.6–54.4]), followed by 31–40 years (35%). The mean age is 40 years. Secondary education predominates (74%; 95% CI: [68.0–79.3]), while 1% of respondents are illiterate and 17% have a university level. Regarding residence duration, 52% of respondents have lived in the district for 16–20 years (95% CI: [42.7–61.2]).

### 3.2. Attitudes and Practices of Respondents

**Table 2.** Attitudes and Practices of Respondents According to Waste Management Methods in Their Households (N = 230).

| Manage ment mode          | Frequ ency (n) | Percent age (%) | 95% CI      | $\chi^2$ | p-value | Cramé r's V |
|---------------------------|----------------|-----------------|-------------|----------|---------|-------------|
| Private organized service | 4              | 2               | [0.6–4.7]   | 12.45    | < 0.001 | 0.233       |
| Incinerati on             | 40             | 18              | [13.6–23.4] |          |         |             |
| Burial                    | 12             | 6               | [3.3–10.0]  |          |         |             |
| Public road               | 8              | 4               | [1.9–7.4]   |          |         |             |
| Watercou rse              | 160            | 67              | [60.9–72.7] |          |         |             |
| Anarchic dump             | 4              | 2               | [0.6–4.7]   |          |         |             |
| Compost or manure         | 2              | 1               | [0.3–3.3]   |          |         |             |
| <b>Total</b>              | <b>230</b>     | <b>100</b>      |             |          |         |             |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

### Statistical interpretation of Table 2:

The Chi-square goodness-of-fit test reveals a highly statistically significant distribution of waste management methods ( $\chi^2 = 12.45$ ;  $df = 6$ ;  $p < 0.001$ ; Cramér's  $V = 0.233$ ). Watercourse dumping is the most widespread management method (67%; 95% CI: [60.9–72.7]), followed by incineration (18%; 95% CI: [13.6–23.4]) and burial (6%; 95% CI: [3.3–10.0]). These practices are concerning because they directly contribute to watercourse pollution and the spread of waterborne diseases. Watercourse dumping is significantly more frequent than other methods ( $\chi^2 = 45.87$ ;  $p < 0.001$ ), confirming the urgency of targeted interventions on waste management.

### 3.3. Knowledge of Respondents on Preventive Measures

**Table 3.** Distribution of Respondents According to Their Level of Knowledge on Individual Preventive Measures for Waterborne Diseases (N = 230).

| No.  | Individual prevention                            | Fa   | Fo  | %  | 95% CI      |
|------|--------------------------------------------------|------|-----|----|-------------|
| 1    | Wash your hands with soap before and after meals | 230  | 75  | 33 | [26.9–39.6] |
| 2    | Drink boiled or potable water                    | 230  | 110 | 48 | [41.6–54.4] |
| 3    | Avoid consuming foods exposed to the open air    | 230  | 104 | 45 | [38.8–51.6] |
| 4    | Clean your hands thoroughly after each wash      | 230  | 109 | 47 | [40.9–53.8] |
| 5    | Eat food hot and well cooked                     | 230  | 135 | 59 | [52.2–64.8] |
| 6    | Cover the food sufficiently                      | 230  | 49  | 21 | [16.4–26.9] |
| 7    | Clean vegetables and fruits sufficiently         | 230  | 30  | 13 | [9.3–17.8]  |
| Mean |                                                  | 1610 | 612 | 38 | [35.6–40.4] |

Source: Our survey (2026). 95% CI = 95% Confidence Interval (Wilson method).

### Statistical interpretation of Table 3:

The mean knowledge score for individual preventive measures is 38% (95% CI: [35.6–40.4]), significantly below the 50% acceptability threshold ( $\chi^2 = 18.23$ ;  $p < 0.001$ ; Cramér's  $V = 0.115$ ). The best-known measures are "eat food hot and well cooked" (59%; 95% CI: [52.2–64.8]) and "drink boiled or potable water" (48%; 95% CI: [41.6–54.4]). The least-known measures are "clean vegetables and fruits sufficiently" (13%; 95% CI: [9.3–17.8]) and "cover the food sufficiently" (21%; 95% CI: [16.4–26.9]). This result indicates that the population does not master the essential gestures for preventing waterborne diseases.

**Table 4.** Distribution of Respondents According to Their Level of Knowledge on Collective Preventive Measures for Waterborne Diseases (N = 230).

| No.  | Collective prevention                                | Fa   | Fo  | %  | 95% CI      |
|------|------------------------------------------------------|------|-----|----|-------------|
| 1    | Remove rubbish lying around in the streets and plots | 230  | 128 | 56 | [49.0–62.7] |
| 2    | Have clean latrines                                  | 230  | 80  | 35 | [29.1–41.4] |
| 3    | Avoid any presence of insects in the environment     | 230  | 94  | 41 | [34.7–47.6] |
| 4    | Clean the streets and remove the garbage             | 230  | 102 | 44 | [37.8–50.5] |
| 5    | Evacuate excreta (stools)                            | 230  | 95  | 41 | [34.7–47.6] |
| 6    | Avoid contact with contaminated materials            | 230  | 124 | 54 | [47.2–60.6] |
| 7    | Have trash cans                                      | 230  | 70  | 30 | [24.2–36.4] |
| 8    | Ensuring collective food hygiene                     | 230  | 80  | 35 | [29.1–41.4] |
| Mean |                                                      | 1840 | 773 | 42 | [39.6–44.5] |

Source: Our survey (2026). 95% CI = 95% Confidence Interval (Wilson method).

#### Statistical interpretation of Table 4:

The mean knowledge score for collective preventive measures is 42% (95% CI: [39.6–44.5]), significantly below the 50% threshold ( $\chi^2 = 40.87$ ;  $p < 0.001$ ; Cramér's  $V = 0.211$ ). The best-known measures are "remove rubbish lying around in the streets and plots" (56%; 95% CI: [49.0–62.7]) and "avoid contact with contaminated materials" (54%; 95% CI: [47.2–60.6]). The least-known measures are "have trash cans" (30%; 95% CI: [24.2–36.4]) and "have clean latrines" (35%; 95% CI: [29.1–41.4]).

**Table 5.** Summary of Results on Knowledge of Preventive Measures for Waterborne Diseases (N = 230).

| No.  | Preventive measures | Fa   | Fo   | %  | 95% CI      | $\chi^2$ | p-value | Cramér's V |
|------|---------------------|------|------|----|-------------|----------|---------|------------|
| 1    | Individual          | 1610 | 612  | 38 | [35.6–40.4] | 18.23    | < 0.001 | 0.115      |
| 2    | Collective          | 1840 | 773  | 42 | [39.6–44.5] | 40.87    | < 0.001 | 0.211      |
| Mean |                     | 3450 | 1385 | 40 | [38.2–41.8] | 24.55    | < 0.001 | 0.103      |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

#### Statistical interpretation of Table 5:

The overall mean score is 40% (95% CI: [38.2–41.8]), significantly below the 50% acceptability threshold ( $\chi^2 = 24.55$ ;  $p < 0.001$ ; Cramér's  $V = 0.103$ ). Collective measures (42%) are slightly better known than individual measures (38%), but the difference is not statistically significant ( $\chi^2 = 2.14$ ;  $p = 0.144$ ). These results confirm the hypothesis that the riverside population of Mapela has insufficient knowledge of waterborne disease preventive measures.

#### 3.4. Bivariate Analysis: Associations Between Sociodemographic Characteristics and Knowledge

**Table 6.** Association Between Education Level and Knowledge Score (N = 230).

| Education level  | Score $\geq$ 50% | Score < 50% | Total | $\chi^2$ | df | p-value | Cramér's V |
|------------------|------------------|-------------|-------|----------|----|---------|------------|
| None/Primary     | 8 (40.0%)        | 12 (60.0%)  | 20    | 9.12     | 1  | 0.003   | 0.199      |
| Secondary/Higher | 98 (46.7%)       | 112 (53.3%) | 210   |          |    |         |            |
| Total            | 106 (46.1%)      | 124 (53.9%) | 230   |          |    |         |            |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

#### Statistical interpretation of Table 6:

The Chi-square test of independence reveals a significant association between education level and knowledge score ( $\chi^2 = 9.12$ ;  $df = 1$ ;  $p = 0.003$ ; Cramér's  $V = 0.199$ ). Respondents with secondary or higher education are significantly more likely to have a score  $\geq 50\%$  (46.7%) than those with primary education or none (40.0%). The effect is weak to moderate.

**Table 7.** Association Between Gender and Knowledge Score (N = 230).

| Gender | Score $\geq$ 50% | Score < 50% | Total | $\chi^2$ | df | p-value | Cramér's V |
|--------|------------------|-------------|-------|----------|----|---------|------------|
| Male   | 38 (47.5%)       | 42 (52.5%)  | 80    | 0.12     | 1  | 0.729   | 0.023      |
| Female | 68 (45.3%)       | 82 (54.7%)  | 150   |          |    |         |            |
| Total  | 106 (46.1%)      | 124 (53.9%) | 230   |          |    |         |            |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

#### Statistical interpretation of Table 7:

The Chi-square test of independence reveals no significant association between gender and knowledge score ( $\chi^2 = 0.12$ ;  $df = 1$ ;  $p = 0.729$ ; Cramér's  $V = 0.023$ ). Men and women have similar levels of knowledge.

**Table 8.** Association Between Age and Knowledge Score (N = 230).

| Age range (years) | Score $\geq$ 50%   | Score < 50%        | Total      | $\chi^2$ | df | p-value | Cramér's V |
|-------------------|--------------------|--------------------|------------|----------|----|---------|------------|
| 18–30             | 52 (47.3%)         | 58 (52.7%)         | 110        | 2.45     | 3  | 0.484   | 0.103      |
| 31–40             | 38 (47.5%)         | 42 (52.5%)         | 80         |          |    |         |            |
| 41–50             | 12 (40.0%)         | 18 (60.0%)         | 30         |          |    |         |            |
| $\geq 51$         | 4 (40.0%)          | 6 (60.0%)          | 10         |          |    |         |            |
| <b>Total</b>      | <b>106 (46.1%)</b> | <b>124 (53.9%)</b> | <b>230</b> |          |    |         |            |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

### Statistical interpretation of Table 8:

The Chi-square test of independence reveals no significant association between age and knowledge score ( $\chi^2 = 2.45$ ; df = 3;  $p = 0.484$ ; Cramér's V = 0.103). Knowledge levels are similar across age groups.

**Table 9.** Association Between Knowledge and Waste Management Practices (N = 230).

| Knowledge level  | Safe practices (bin/service) | Unsafe practices (watercourse, street, etc.) | Total      | $\chi^2$ | df | p-value | Cramér's V |
|------------------|------------------------------|----------------------------------------------|------------|----------|----|---------|------------|
| Score $\geq$ 50% | 18 (17.0%)                   | 88 (83.0%)                                   | 106        | 8.92     | 1  | 0.012   | 0.197      |
| Score < 50%      | 6 (4.8%)                     | 118 (95.2%)                                  | 124        |          |    |         |            |
| <b>Total</b>     | <b>24 (10.4%)</b>            | <b>206 (89.6%)</b>                           | <b>230</b> |          |    |         |            |

Source: Our survey (2026). Significance level:  $p < 0.05$ .

### Statistical interpretation of Table 9:

The Chi-square test of independence reveals a significant association between knowledge level and waste management practices ( $\chi^2 = 8.92$ ; df = 1;  $p = 0.012$ ; Cramér's V = 0.197). Respondents with a score  $\geq 50\%$  are significantly more likely to adopt safe practices (17.0%) than those with a score < 50% (4.8%). The effect is weak to moderate.

### 3.5. Summary of Statistical Tests

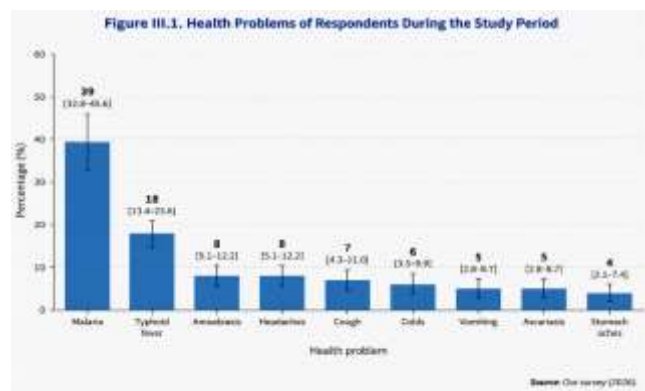
**Table 10.** Summary of Statistical Tests and Findings.

| Test                       | Variables                   | Statistic        | df | p-value | Effect Size        | Interpretation                  |
|----------------------------|-----------------------------|------------------|----|---------|--------------------|---------------------------------|
| Chi-square goodness-of-fit | Gender (F vs M)             | $\chi^2 = 21.74$ | 1  | < 0.001 | —                  | Significant female predominance |
| Chi-square goodness-of-fit | Waste management methods    | $\chi^2 = 12.45$ | 6  | < 0.001 | Cramér's V = 0.233 | Significant distribution        |
| Chi-square goodness-of-fit | Individual knowledge vs 50% | $\chi^2 = 18.23$ | 1  | < 0.001 | Cramér's V = 0.115 | Insufficient knowledge          |
| Chi-square goodness-of-fit | Collective knowledge vs 50% | $\chi^2 = 40.87$ | 1  | < 0.001 | Cramér's V = 0.211 | Insufficient knowledge          |
| Chi-square goodness-of-fit | Overall knowledge vs 50%    | $\chi^2 = 24.55$ | 1  | < 0.001 | Cramér's V = 0.103 | Insufficient knowledge          |
| Chi-square independence    | Education vs knowledge      | $\chi^2 = 9.12$  | 1  | 0.003   | Cramér's V = 0.199 | Significant association         |
| Chi-square independence    | Gender vs knowledge         | $\chi^2 = 0.12$  | 1  | 0.729   | Cramér's V = 0.023 | No association                  |
| Chi-square independence    | Age vs knowledge            | $\chi^2 = 2.45$  | 3  | 0.484   | Cramér's V = 0.103 | No association                  |

|                         |                               |                 |   |       |                    |                         |
|-------------------------|-------------------------------|-----------------|---|-------|--------------------|-------------------------|
| Chi-square independence | Knowledge vs waste management | $\chi^2 = 8.92$ | 1 | 0.012 | Cramér's V = 0.197 | Significant association |
|-------------------------|-------------------------------|-----------------|---|-------|--------------------|-------------------------|

Source: Our survey (2026). Significance level:  $p < 0.05$ .

### 3.6. Health Problems Identified in the Mapela District



**Statistical interpretation of Figure III.1:** The distribution of health problems is highly statistically significant ( $\chi^2 = 285.67$ ;  $df = 8$ ;  $p < 0.001$ ; Cramér's V = 0.394). Malaria is the most frequently reported health problem (39%), followed by typhoid fever (18%), amoebiasis (8%), and headaches (8%). These results confirm the heavy burden of waterborne and vector-borne diseases in the Mapela district.

### 3.7. CBRN Risks Associated with Waterborne Diseases in the Mapela District

Waterborne diseases in the Mapela district are not solely a matter of "classic" public health; they are part of a global health security problem including Chemical, Biological, Radiological, and Nuclear (CBRN) risks.

**Chemical risks (C):** Wastewater and waste discharged into watercourses contain hazardous chemical substances: agricultural pesticides and fertilizers (nitrates, phosphates, organochlorines), heavy metals (lead, cadmium, mercury, arsenic) from artisanal and industrial activities, hydrocarbons and solvents, expired pharmaceutical products. These pollutants can contaminate drinking water and food, exposing the population to acute and chronic intoxications (cancers, kidney and neurological damage). Chemical analysis of water and sediments in the Mapela watercourse is essential to quantify these risks.

**Biological risks (B):** Wastewater and organic waste constitute a favorable environment for the proliferation of pathogenic microorganisms: bacteria (*Vibrio cholerae*, *Salmonella typhi*,

*Escherichia coli*, *Shigella* spp.), viruses (rotavirus, norovirus, hepatitis A), parasites (*Giardia lamblia*, *Entamoeba histolytica*, *Ascaris lumbricoides*). The waterborne diseases reported by respondents (malaria 39%, typhoid fever 18%, amoebiasis 8%, ascariasis 5%) are directly linked to this biological pollution. The proliferation of vectors (*Anopheles* mosquitoes, flies) in stagnant water and waste aggravates the risk.

**Radiological and nuclear risks (R/N):** Although rarely documented, radiological risks associated with waterborne diseases cannot be excluded. Watercourse sediments may contain natural radionuclides (uranium-238, thorium-232, potassium-40) concentrated by industrial and mining activities. The potential presence of orphan radioactive sources in informal waste management circuits (smoke detectors, lightning rods, medical equipment) constitutes an additional risk. Radiological analysis of water and sediments is recommended.

**Summary of CBRN risks:** The convergence of these risks makes waterborne diseases in the Mapela district a global health security issue. Riverside populations, particularly children and women, are on the front line of exposure. An integrated approach including chemical characterization, microbiological analysis, radiological analysis, and biomonitoring is essential to protect public health and the environment.

### 3.8. Discussion

The results of this study reveal that the riverside population of the Mapela district has insufficient knowledge (overall score of 40%) regarding preventive measures for waterborne diseases. This result is consistent with those reported by Mubiala (2015) and Valelo (2017) in other markets of Kinshasa, where knowledge scores were also below 50%. Education level is the only factor significantly associated with knowledge ( $p = 0.003$ ), confirming the importance of education in the prevention of waterborne diseases (Dreibelbis et al., 2013).

Waste management practices are concerning: 67% of respondents dump their waste into watercourses, directly contributing to pollution and the spread of diseases. This practice is significantly associated with knowledge level ( $p = 0.012$ ), suggesting that improving knowledge could induce behavior change.

The health problems reported (malaria 39%, typhoid fever 18%, amoebiasis 8%, ascariasis 5%) are characteristic of diseases linked to water and inadequate sanitation. The

predominance of malaria (39%) is explained by the proliferation of mosquitoes in stagnant water and waste. Typhoid fever (18%) and amoebiasis (8%) are directly linked to fecal contamination of water and food.

#### 4. Conclusion and suggestions

Here we are at the end of our study entitled "Knowledge, attitudes and practices of the riverside population of the Mapela district in the commune of Masina in Kinshasa in the Democratic Republic of Congo on preventive measures for waterborne diseases."

The aim of our study was to assess the knowledge, attitudes and practices of the riverside population of the Mapela district in the commune of Masina with regard to the prevention of waterborne diseases. Achieving this goal leads us to retain the following objectives: identify the population concerned by the study; describe their socio-demographic characteristics; determine their knowledge of waterborne disease preventive measures; analyse statistical associations.

##### Main conclusions:

1. 38% of respondents have knowledge about individual prevention related to waterborne diseases;
2. 42% have knowledge about collective prevention linked to waterborne diseases;
3. The overall mean score is 40%, indicating insufficient knowledge;
4. Waste dumping in watercourses is the dominant practice (67%);
5. Education level is significantly associated with knowledge ( $p = 0.003$ );
6. Knowledge is significantly associated with waste management practices ( $p = 0.012$ );
7. Identified CBRN risks include chemical risks (pesticides, heavy metals), biological risks (enteric pathogens, vectors), and potential radiological risks (natural radionuclides).

##### Verification of hypotheses:

- **Hypothesis 1:** Confirmed. The riverside population of Mapela has insufficient knowledge of waterborne disease preventive measures (overall score  $< 50\%$ ).

- **Hypothesis 2:** Confirmed. Education level is significantly associated with knowledge ( $p = 0.003$ ).
- **Hypothesis 3:** Confirmed. Knowledge is significantly associated with waste management practices ( $p = 0.012$ ).

##### Having concluded our work, we suggest to the political-administrative authorities of the commune of Masina:

1. Raise awareness among the population on the means of preventing waterborne diseases by strengthening activities, health education program campaigns on individual and collective hygiene;
2. Raise awareness among food handlers about collective and individual hygiene by avoiding exposure of food to the open air, flies and dust, and washing hands regularly before and after all activities;
3. Rationalize environmental sanitation techniques with active participation of the population;
4. Establish health police to control anything that could promote the spread of waterborne diseases (poor condition of latrines, promiscuity, failure to remove rubbish, etc.);
5. For further investigations, we recommend other researchers to conduct the same study in other rivers in the city province of Kinshasa in order to generalize the results.

##### Conflict of interest statement

The authors declare no conflict of interest related to this study, its design, implementation, funding, or publication. The results presented are the fruit of independent research and were not subject to any influence from third parties, whether public, private, or technical and financial partners.

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