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Evaluation of household knowledge, attitude and practice concerning malaria in the Djibouti City, Republic of Djibouti

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Abstract

This study presents the first Knowledge Attitudes, and Practices (KAP) survey on malaria in Djibouti City. It was conducted among 1,344 household heads across nine neighbourhoods in Djibouti City. Composite scores were calculated for each KAP dimension. Analysis of variance and multinomial logistic regression identified socio-demographic predictors and Local Indicators of Spatial Association (LISA) characterised the spatial clustering of the KAP scores. No significant association was found between socio-demographic or economic factors and malaria knowledge. Prevention practices varied notably across neighbourhoods, driven by place of residence, mother tongue, and education–underlining the primacy of spatial determinants. Attitudes were found to be linked to gender and income. Despite high disease awareness, 60% of respondents misidentified transmission routes, nearly two-thirds of respondents failed to adopt effective preventive behaviours, while Long-Lasting Insecticidal Net (LLIN) ownership far exceeded correct use. The gap between awareness and practice suggests that information-deficit approaches have reached their limits; future interventions should target motivational norm-based determinants of behaviour, spatially concentrated in the highest-risk neighbourhoods. Language and cultural barriers require tailored communication strategies beyond standard broadcast campaigns. Strengthened vector control and active surveillance remain essential complements to any behavioural intervention.

Key words: malaria; knowledge; attitudes; practices; Djibouti.

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Introduction

In Djibouti City, malaria has reversed from near-elimination in 2012 to become the country's leading infectious disease by 2018. This resurgence is driven by the introduction of *Anopheles stephensi*, a vector well adapted to urban settings; the spread of *Plasmodium falciparum* strains with HRP2/3 gene deletions undetectable by rapid diagnostic tests; and sustained migration from endemic neighbouring countries. Djibouti City now accounts for over 90% of confirmed community cases, yet no population-level behavioural study has previously been conducted there. Against this background, we decided to study carry out a study of Knowledge Attitudes, and Practices (KAP) survey on malaria that has not previously been done there.

The geography of health highlights how local environment variables (physical, social or institutional) influence health outcomes beyond individual socio-demographic characteristics(age, gender or income level) as outlined by Macintyre *et al.* (2002). This approach goes beyond strictly biomedical analysis to incorporate local conditions, such as neighbourhood quality, access to services, and social cohesion, as factors contributing to health inequalities (Gatrell & Elliott, 2015). According to Diez Roux (2001), health behaviours are shaped by neighbourhood characteristics through structural, cognitive, and social mechanisms. The territorial approach to health determinants provides a relevant framework for analysing the unequal distribution of diseases, such as malaria, whose burden remains closely linked to local contexts – including vector breeding conditions, housing quality, water storage practices, and access to prevention tools, particularly on the African continent.

In 2023, the World Health Organization (WHO) recorded 263 million cases of malaria and 597,000 deaths worldwide (WHO, 2024). Africa bears the heaviest burden, accounting for 94% of cases and deaths, making malaria a critical public health challenge across the continent. Malaria was first reported in Djibouti in 1901 (Bouffard, 1901), where it was initially classified as hyperendemic with unstable transmission. In the following decades, indigenous cases and the primary vector disappeared, with no documented transmission until 1973, likely due to population movements. Between 1974 and 1987, malaria re-emerged along major roads from neighbouring countries before spreading to urban areas, particularly the Ambouli District, becoming endemic with annual transmission predominantly caused by *Plasmodium falciparum*.

In the 1980s, malaria control efforts, including the introduction

of larvivorous fish (*Aphanius dispar*) and the use of chemical and bacterial larvicides, yielded promising results (Louis & Albert, 1988). However, significant outbreaks were recorded in 1991, 1993 and 1999 (Rogier *et al*., 2005). Between 2006 and 2011, intensified government interventions led to a sharp decline in cases. In 2012, only 24 cases were reported, and Djibouti entered the pre-elimination phase (Noor *et al.*, 2011; Khaireh *et al*., 2013). Despite these gains, malaria resurged in 2013 and has since become the country's leading infectious disease. In 2018, incidence increased to 25,319 confirmed cases (two-thirds due to *P. falciparum*, one-third to *P. vivax*) and 104,800 suspected cases (de Santi *et al*., 2021). *P. falciparum* parasites are now often undetectable by rapid diagnostic tests (RDTs) due to deletion of the HRP2/3 gene, a phenomenon documented in Eritrea (Berhane *et al.*, 2018), Ethiopia (Kamaliddin *et al.*, 2024), and Djibouti (Iriart *et al.*, 2020; Rogier *et al*., 2022), which may partly explain the observed increase in prevalence (Moussa *et al*., 2023). The situation is particularly severe in Djibouti City, which accounts for over 90% of confirmed cases, making it the primary transmission hotspot. The resurgence is also linked to the introduction and spread of *Anopheles stephensi* (Faulde *et al*., 2014; Seyfarth *et al.*, 2019; de Santi *et al*., 2021). Originally from Asia, this species thrives in urban environments and is a highly efficient vector for both *P. falciparum* and *P. vivax*, and has effectively replaced *An. arabiensis* as the primary malaria vector in Djibouti (Seyfarth *et al*., 2019).

Under the guidance of the WHO, Djibouti's National Strategic Plan for Malaria Control 2020–2024 set out key priorities including distribution of Long-Lasting Insecticidal Nets (LLINs) targeting the general population, pregnant women and children under five, Indoor Residual Spraying (IRS), and mosquito control efforts to reduce larval breeding sites. Control strategies also emphasize Information, Education and Communication (IEC) and Behaviour Change Communication (BCC) to encourage appropriate LLIN use and promote health-seeking behaviours, mainly through television broadcasts, media campaigns and door-to-door outreach (LA NATION, 2020). However, the effectiveness of these interventions depends not only on their availability, but also on how populations perceive malaria risk, understand transmission mechanisms and adopt recommended preventive and treatment behaviours. In urban settings, such as Djibouti City, where transmission dynamics are shaped by human behaviour, rapid urbanization and environmental practices, behavioural determinants become a central component of malaria control. Local cultural beliefs and practices significantly influence community behaviours related to malaria prevention and treatment (Bloland *et al*., 2002). Given the extensive awareness campaigns already underway, it is critical to assess whether these efforts have translated into effective behavioural change.

Interpreting KAP data in this context requires engagement with several complementary behavioural frameworks. The Health Belief Model (Rosenstock, 1974; Janz & Becker, 1984) posits that preventive behaviour depends not on awareness alone but on perceived susceptibility, severity, benefits and barriers – providing a lens for understanding why LLIN ownership may not translate into use. Risk perception theory further suggests that endemic populations develop optimistic bias, normalizing chronic threats over time and suppressing preventive motivation even where awareness is high (Slovic, 1987; Weinstein, 1980). Kleinman's explanatory models framework (Kleinman, 1980) draws attention to culturally embedded causal narratives that compete with biomedical explanations and sever the logical pathway to preventive action when transmission is attributed to rain, food or animals rather than mosquitoes. At the neighbourhood level, the Social Cognitive Theory (Bandura, 1986) provides a mechanism for the spatial clustering of health behaviours through observational learning and locally reinforced social norms. The COM-B model (Michie *et al.*, 2011) further proposes that behaviour requires sufficient Capability, Opportunity and Motivation – a structure useful for diagnosing where the critical deficit lies and for translating KAP findings into targeted intervention recommendations. Together, these frameworks guide the interpretation of findings and inform the transition from descriptive results to theoretically grounded policy implications.

The KAP survey is a strategic tool for identifying the educational needs of a target population, analyzing knowledge, attitudes, and practices as interrelated dimensions of health behaviour (Essi & Njoya, 2013). Quantitative KAP surveys have been widely used in research on vector-borne diseases to provide population-level evidence on behavioural determinants, supporting a better understanding of socio-cultural barriers, the strengthening of control strategies, and contributions to public health policy (Tomass *et al.,* 2016; Gupta *et al*., 2016; Desjardins *et al*., 2020;Rajvanshi *et al.*, 2021; Addis & Gebeyehu Wondmeneh, 2023). However, beyond surveys, qualitative and ethnographic approaches have also been used to explore malaria-related knowledge and risk perceptions in endemic settings, offering deeper insight into local illness narratives, care-seeking pathways, and community responses to interventions (Muela *et al*., 2002). Although qualitative approaches offer deeper insight into local meanings and social norms, KAP surveys remain a valuable and efficient method for informing large-scale interventions and monitoring their alignment with community behaviours (Launiala, 2009; Pulford *et al*., 2011). Community perceptions can further support disease surveillance by identifying gaps between programmatic reach and population-level understanding (Desjardins *et al*., 2025).

While malaria control policies in Djibouti have been informed by epidemiological surveillance, entomological investigations and program monitoring reports, population-level knowledge and risk perceptions have so far been assessed only indirectly, without dedicated behavioural studies. This study therefore provides the first quantitative assessment of malaria-related knowledge, attitudes, preventive practices, and health-seeking behaviors in the country, complementing existing epidemiological and entomological data. Its main objective was to evaluate malaria-related knowledge, attitudes and practices among populations in Djibouti City – a setting marked by malaria re-emergence, high population density, and the recent establishment of *An. stephensi* – in areas that had previously benefited from LLIN distribution, IRS, IEC and BCC interventions. More specifically, the study addressed three research questions: What is the level of knowledge, attitudes, and practices regarding malaria prevention and management among household heads in Djibouti City? How are KAP levels associated with socio-demographic characteristics, including sex, age, income, education level, mother tongue, and neighbourhood of residence? To what extent does spatial clustering of KAP scores reveal place-based disparities in malaria prevention behaviours beyond what individual socio-demographic factors can explain?

Materials and Methods

Study area

The Republic of Djibouti is located in the Horn of Africa, with the neighbouring countries Ethiopia, Somalia, Eritrea and Yemen

experiencing malaria endemicity (WHO, 2024) and has an estimated population of 1,066,809 residents (INSTAD, 2025). Djibouti City, the capital and largest urban centre of the Republic of Djibouti, has an estimated population of approximately 776966 residents (INSTAD, 2025).According to the Ministry of Health's health map, Djibouti City is administratively divided into two primary health districts: the Djibouti Health District, which encompasses the Ras Dika and Boulaos communes and the Balbala Health District, which corresponds to the Balbala commune. The city is served by 15 health facilities, including health centres and polyclinics, with eight located in Balbala and seven in the Djibouti Health District. Each facility is responsible for providing healthcare services to a defined group of neighbourhoods, collectively forming its official coverage area.

Djibouti City experiences significant temperature variation, ranging from 17°C to 42°C throughout the year, with consistently high relative humidity levels between 40% and 90%. The climate follows a distinct seasonal pattern, with a cooler period from October to March, during which temperatures range between 22°C and 30°C, accompanied by high humidity. Conversely, the hotter season, from June to September, sees temperatures rising to 30°C–40°C (Moussa Omar *et al*., 2021). These climatic conditions contribute to the region's arid landscape, where vegetation is sparse. Djibouti City is situated in the Ambouli Wadi valley, forming a broad alluvial cone that extends into a coral peninsula. Notably, the north-eastern parts of the capital lie below sea level (Moussa Omar *et al*., 2021). Djibouti is separated from Yemen by the Bab-el-Mandeb Strait, one of the busiest shipping corridors in the world, linking the Red Sea to the Suez Canal. This strategic location is associated with intense population mobility, including cross-border movements, port-related labour migration, and refugee flows, which collectively increase vulnerability to malaria importation and sustained transmission. In addition, rapid urban growth, informal settlements, water storage practices, and unequal access to sanitation services contribute to the persistence of favourable breeding conditions for malaria vectors in urban settings, particularly in Djibouti City.

Epidemiological data from the 2022 health statistics yearbook show that malaria transmission is unevenly distributed across the city, with some areas experiencing significantly higher infection rates (Ministry of Health of the Republic of Djibouti, 2023). The health facilities in the Boulaos communes have the highest rates of

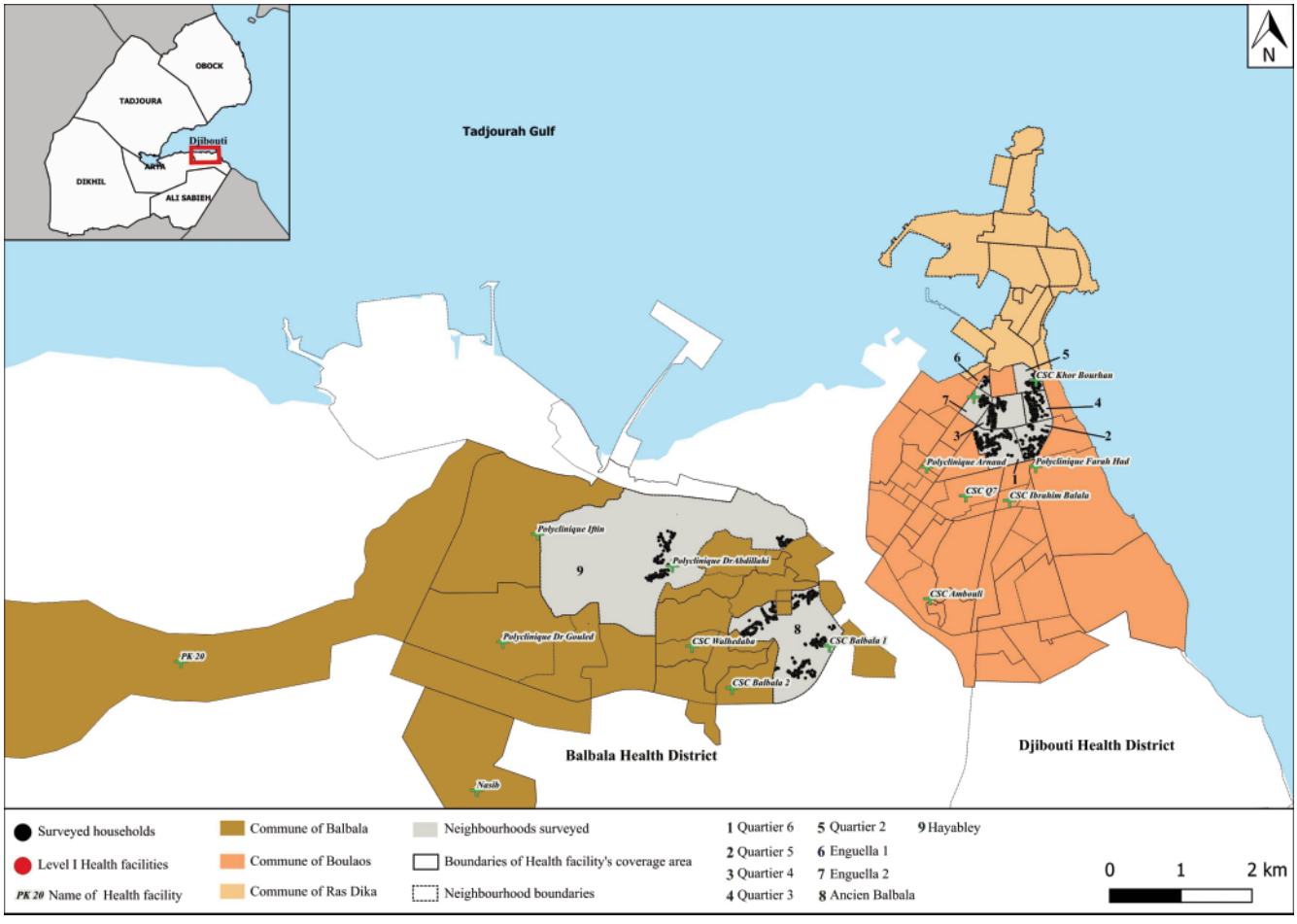

Figure 1. Map of the city of Djibouti showing the areas and households where samples were taken for the study. The city is divided between the Balbala health district, corresponding to the eponymous commune, and the Djibouti health district, which includes the communes of Boulaos and Ras Dika. It comprises 15 level 1 health facilities and is subdivided into as many coverage zones, delimited by a continuous black line. The boundaries of the neighbourhoods are represented by a dotted black line. The nine targeted neighbourhoods are shown in grey. The location of the households surveyed is indicated by black dots.

positivity, with particularly high figures at Ibrahim Balala (15.9%), Quartier 7 (19.4%), Polyclinique Farah Had (27.7%), Polyclinique Arnaud (24.4%), and PolycliniqueHoumed (29.4%). The same applies to the only health facility in the Ras Dika Commune: Khor Bourhan (18.1%). By contrast, the health facilities in the commune of Balbala recorded a relatively lower number of malaria cases: Balbala 1 (5%), Balbala 2 (5.9%), Wahledaba (6.2%), Polyclinique Dr Abdillahi (9.5%), Polyclinique Dr Gouled (16.2%), Polyclinique Iftin (11.7%).

Knowledge, Attitude and Practic (KAP) survey

The survey was conducted from 1 to 30 November 2022, in the BoulaosCommune, and from 1 to 26 December 2022, in the Balbala Commune. Interviews were conducted daily between 8:00 AM and 12:00 PM. The sampling strategy targeted five of the 15level I &II health facility catchment areas in the capital (Figure 1), each encompassing multiple neighbourhoods. To facilitate a comparative analysis, we selected three catchment areas–Farah Had, Houmed Mak and Khor Angar–within the Djibouti Health District, where malaria incidence is the highest. Additionally, we included two areas – Balbala 1 and Dr. Abdillahi – within the Balbala Health District, which report lower numbers of malaria cases.

Within the Farah Had catchment area, surveys were conducted in Quartier 6, Quartier 5 and Quartier 3. The Houmed Maki catchment area included Quartier 4, Enguella 1 and Enguella 2, while Quartier 2 was surveyed in the Khor Angar catchment area. In Balbala, the survey covered Ancien Balbala within the Balbala 1 catchment area and Hayabley within the Dr. Abdillahi catchment area (Figure 1).The selection of these nine neighbourhoods was based on epidemiological data from the corresponding health facilities and demographic characteristics. The study employed a geographic approach aimed at ensuring both demographic and spatial representativeness, while also identifying inter-neighbourhood disparities in KAP-relation to malaria.

A cross-sectional design was selected as the most appropriate approach for generating population-level baseline evidence on behavioural determinants in a setting where no prior dedicated behavioural study had been conducted. While a longitudinal or multi-season design would better capture seasonal variation in practices, this was beyond the scope and resources of this first KAP assessment in Djibouti. A quantitative approach was chosen to enable robust statistical analysis and spatial comparisons across nine neighbourhoods, objectives best served by standardized quantitative instruments.

The data collection relied primarily on quantitative questionnaires, structured around closed and semi-open questions with predefined response options to facilitate standardized data collection. Responses were recorded in a numerical format for future statistical analysis. *Supplementary Data 1* illustrates the questionnaire comprising 60 questions, organised around the following four themes: i) socio-demographic characteristics; ii) housing conditions; iii) water-related factors, including supply systems, storage and sanitation; iv) malaria-related knowledge, general beliefs, attitudes and preventive behaviours.

The KoBoToolbox software, an open-source platform based on the Open Data Kit (ODK) framework, was selected for questionnaire design, digital data management, and online database integration (Pundhi *et al.*, 2024; Odis *et al*., 2024). Prior to full implementation, the questionnaire underwent pre-testing in households near the University of Djibouti one month before the survey. This identified a high refusal rate among heads of households regarding the participation of children in the survey. As a result, the methodology was refined by adopting a KAP survey approach that focused on the household head as the primary respondent (Jumbam *et a*l., 2020). We added questions for heads of household on the number of children under 5 and pregnant women. Given that Djibouti has no tribal or ethnic statistics and that it might be sensitive to ask questions about ethnic origins, we avoided direct reference to ethnicity by instead asking what their native language was. We chose to use practical sampling because of these constraints.

Once improved, the field survey questionnaire was conducted by third-year undergraduate students specializing in Geography and Regional Planning at the University of Djibouti. As part of an academic project, students received comprehensive training, including simulated surveys in tutorial sessions, to ensure proficiency with the survey instruments. To optimize data accuracy and efficiency, the survey was digitally administered via smartphones, eliminating the need for manual data entry, which is time-intensive and prone to errors. This approach facilitated real-time data entry, streamlined data processing, enabled direct Global Positioning System (GPS) location recording and allowed for photo documentation when relevant. The number of surveys each interviewer conducted per day was determined by their academic schedule and availability. The survey gave priority to the head of household, but in his or her absence, another adult member of the household was invited to respond.

Choice of questions and calculation of KAP scores

Our study measures the knowledge, attitudes and practices of participants in the malaria survey in a balanced way. We assigned a weight of two to each question. All questions were weighted in the same way, reflecting the choice to give them the same weight in each category (knowledge, attitude, practice). This approach ensures that the results did not favour one specific aspect of the survey. We retained the questions that the respondents considered to be of similar importance by selecting those with a weighted average between 2 and 4 (*Supplementary Table 1*). This threshold was chosen to identify questions that respondents consistently engaged with and considered relevant. Questions below this range were too rarely endorsed to be informative at the population level, while questions above this range showed ceiling effects that reduced their discriminatory power.

Among the knowledge questions, which relate to the information or understanding of malaria by the participants, we selected three: familiarity with the disease; knowledge of the modes of transmission; and the ability to recognise the symptoms. For the questions about attitudes, which relate to beliefs, opinions or general dispositions, we selected three items: the perceived severity of malaria; the perceived efficacy of anti-malarial drugs; and the perceived usefulness of insecticide-treated nets. For the questions on practices, which concern the specific actions or behaviours adopted by participants to prevent malaria or respond to symptoms, we selected four elements: possession of a mosquito net; its appropriate use; its use by children and pregnant women; and the adoption of preventive treatment when travelling.

For each dimension of the survey's knowledge, attitude and practice, we calculated a composite index based on the relevant questions as shown in *Supplementary Table 2*. This structured approach allows for a detailed and systematic evaluation of each dimension, enabling a comprehensive analysis of how participants' knowledge, attitude, and practice relate to malaria. Regarding practice indices, the categories 'good and high' advanced' were defined as the ability to provide at least 3 correct answers out of 4, and to provide all 4correct answers, respectively. It might be appropriate to simplify this scale to 2or 3levels (*e.g.*,

poor, moderate, good) to facilitate analysis. However, we chose to retain all categories, including those with low representation, so as not to lose descriptive precision.

Statistical analysis

These were performed using R software (version 4.4.1). Initially, a descriptive analysis of the variables derived from the KAP survey was conducted. This was followed by an analysis of variance (ANOVA) to evaluate the impact of socio-demographic and economic variables such as gender, age, income, primary occupation, mother tongue, education level, and marital status on the KAP index scores and individual survey responses. This step helped to identify significant predictors within the data.

Building on the insights gained from the ANOVA, a multinomial regression analysis was carried out using the *VGAM* package (1.1.11). This analysis utilized the *vglm()* function with the 'multinomial' family argument to appropriately model the categorical nature of the dependent variables. For the regression, each KAP index was treated as a dependent variable. The independent variables included socio-demographic characteristics, which were encoded as follows: neighbourhood of residence (9 categories); gender (2 categories); age (6 categories); mother tongue (5 categories); household income (8 categories); primary occupation (7 categories); marital status (4 categories); and education level (6 categories). Only those socio-demographic variables that showed statistical significance in the ANOVA ($p< 0.05$) were incorporated into the regression model. This approach allows for a thorough examination of the relationships between socio-demographic factors and malaria-related knowledge, attitude and practice among the survey participants, providing valuable insights into the factors influencing malaria prevention and treatment behaviours.

Spatial analysis

The LISA approach has been applied in various epidemiological contexts, notably to characterise the distribution and risk factors of malaria (Kawaguchi *et al*., 2022), the spatial distribution of malaria (Azongnibo *et al*., 2023) and analyze its spatio-temporal distribution (Cumbrera *et al.,* 2024). In our study, the CAP scores were integrated into a shapefile of neighbourhoods and then analysed in R using the *spdep* package (1.3.13). After calculating the LISA index for each spatial unit (each household surveyed) based on the attitude and practice scores, the values obtained were associated with polygons representing the neighbourhoods. An overall average score was then calculated.

Each neighbourhood was classified into a cluster type according to its own value and that of its neighbours. Neighbourhood relationships were modelled using Queen's contiguity. The clusters detected were classified into four categories: High-High (HH), Low-Low (LL), High-Low (HL) and Low-High (LH) according to the local value of the score and that of its neighbours. Only statistically significant clusters ($p<0.05$) were selected for interpretation. We produced the map using the *tmap* package (4.1) of the R software.

Data mapping

Based on a previous KAP study on vector-borne diseases (Casas *et al*., 2023),we reclassified the knowledge index into two categories. We grouped participants, whose knowledge was classified as "no knowledge" and "low knowledge" into a new "low" category, while the others, namely "medium knowledge" and "high knowledge", were grouped into the "high" category. We also reclassified the attitude index into two categories, using "negative attitude" for participants with "no attitude" and "low attitude", and "positive attitude" for participants with "medium attitude" and "high attitude". Finally, for the practice-related index, we named the first category "negative practice", which includes participants with "no practice" and those with "poor practice", with the second category, "positive practice", including participants with "moderate practice", "good practice" and "high practice". The data were encoded using QGIS (version 3.36), an open-source commercial software, to create maps representing each participant's KAP level.

Sub-group analysis by household characteristics

To better understand variations in KAP according to certain household characteristics, we stratified the results into sub-groups considered potentially vulnerable. The sub-groups included: the age of the household head (<65 years *vs* ≥65 years), the gender of the household head (male vs. female), the presence of children under 5 years in the household, and the presence of pregnant women in the household. For each sub-group, we calculated the percentages of household heads exhibiting low or high levels of knowledge; negative or positive attitudes; and negative or positive practices.

Results

Descriptive statistics

The main socio-demographic characteristics of the 1,344 study participants living in nine neighbourhoods in the two health districts of Balbala and Djibouti are presented in Table 1. The high number of women (748 or 58.3%)may be attributed to the fact that the men (560 or 41.7%) were away from home, for professional or cultural reasons, during the survey. Although many Djiboutians speak other languages, such as French, Arabic and Somali, the majority of respondents stated that their mother tongue was Somali (1,068 individuals, 79.5%), followed by Afar (118 individuals, 8.8%), Arabic (101 individuals, 7.5%), Oromo (38 individuals, 2.8%) and other languages (19 individuals, 1.4%) (Table 1).

Knowledge

The results showed that participants were very familiar with malaria and its symptoms, with 98% of respondents stating that they had prior knowledge of the disease, and 87% showing a general understanding of its symptoms (Table 2). Around 40% of participants correctly identified mosquito bites as the mode of transmission of malaria, with television being the main source of information on this subject. Nevertheless, it is notable that a majority (60%) did not know how malaria is contracted. Furthermore, a majority wrongly attributed the cause of malaria to factors such as contact with animals, rain, vegetation or the consumption of spoiled food.

The knowledge index showed that 36% of participants had a high level of knowledge, 54% a medium level, 10% a low level and 1% had no knowledge at all. Participants with a high level of knowledge were heavily concentrated in the districts of Ancien Balbala and Hayabley (Figures 2 and 3). The results of the ANOVA tests did not reveal any significant relationship between the socio-demographic variables and the knowledge index.

Attitude

The attitude index indicated that 69% of respondents showed a medium attitude, 28% a low attitude, 3% no attitude and no participant showed a high attitude (Table 3). Survey participants display-

ing a "positive attitude" were mainly concentrated in Ancien Balbala compared to other neighbourhoods (Table 3; Figures 2 and 3). Analysis of variance (ANOVA) tests revealed statistically significant relationships between the attitude index and socio-demographic variables, in particular gender (p=0.01) and monthly income (p=0.04). Multinomial regression analysis confirmed the results of the ANOVA tests, showing that gender and monthly income were statistically significantly associated with the attitude index (Table 4). Gender was a factor significantly associated with an average or high attitude towards malaria. In addition, among participants who declared their monthly income (excluding those who did not respond or said they did not know), a clear trend

Table1. Socio-demographic characteristics of study participants.

Variable	Category	n (%)
Neighbourhood	Quartier 6	174 (12.9)
	Quartier 5	103 (7.7)
	Quartier 4	186 (13.8)
	Quartier 3	144 (10.7)
	Quartier 2	116 (8.6)
	Enguella 1	60 (4.5)
	Enguella 2	14 (1.1)
	Ancien Balbala	354 (26.3)
	Hayabley	193 (14.4)
Health facility's coverage area	Farah Had	421 (31.3)
	Houmed Maki	260 (19.3)
	Khor Bourhan	116 (8.7)
	Balbala 1	354 (26.3)
	Dr. Abdillahi	193 (14.4)
Age category	Less than 25 years	37 (2.8)
	25-35 years	242 (18.0)
	35-45 years	428 (31.8)
	45-55 years	355 (26.4)
	55-65 years	245 (18.2)
	More than 65 years	37 (2.8)
Gender	Male	560 (41.7)
	Female	784 (58.3)
Marital status	Single	91 (6.8)
	Married	1042 (77.5)
	Divorced	101 (7.5)
	Widowed	110 (8.2)
Native language	Afar	118 (8.8)
	Arabic	101 (7.5)
	Somali	1068 (79.5)
	Oromo	38 (2.8)
	Other	19 (1.4)
Education level	Illiterate	261 (19.4)
	Madrassa	184 (13.7)
	Primary	187 (13.9
	College (lower secondary education)	241 (17.9)
	Secondary (upper secondary education)	233 (17.4)
	Superior	238 (17.7)
Primary activity	Civil servant	543 (40.4)
	Shopkeeper	281 (20.9)
	Worker	154 (11.4)
	Farmer	9 (0.7)
	Stockbreeder	9 (0.7)
	Unemployed	123 (9.2)
	Other	225 (16.7)
Monthly income	Less than 30,000 Djibouti francs (<170 USD)	96 (7.1)
	30,000 to 50,000 Djibouti francs (170 to 282 USD)	134 (10.0)
	50,000 to 100,000 Djibouti francs (282 to 563 USD)	273 (20.3)
	100,000 to 200,000 Djibouti francs (563 to 1127 USD)	274 (20.4)
	More than 200,000 Djibouti francs (>1127 USD)	32 (2.4)
	Don't know	189(14.1)
	No answer	269 (20.0)
	No fixed income	77 (5.7)

Table 2. Knowledge questions and index.

Question	Total N (%)	Quartier 6 N (%)	Quartier 5 N (%)	Quartier 4 N (%)	Quartier 3 N (%)	Quartier 2 N (%)	Enguella 1 N (%)	Enguella 2 N (%)	Ancien Balbala N (%)	Hayabley N (%)
Familiarity with malaria										
Yes	1320 (98)	173 (99)	101(98)	184 (99)	143 (99)	115(99)	59(99)	14(100)	346(98)	187(97)
No	24 (2)	1 (1)	2 (2)	2 (1)	1 (1)	1 (1)	1 (1)	0(0)	6 (2)	6 (3)
Knowledge about how malaria is contracted										
Yes	533(40)	43 (25)	36 (35)	63 (82)	69 (48)	95 (82)	35 (58)	6(43)	132 (37)	54 (28)
No	811(60)	131 (75)	67 (65)	123 (18)	75 (52)	21 (18)	25 (42)	8(57)	222 (63)	139 (72)
Familiarity with the symptoms of malaria										
Yes	1173 (87)	154 (89)	97(94)	139 (95)	134 (93)	110 (95)	55 (95)	14(100)	315 (89)	155 (80)
No	171 (13)	20 (11)	6 (6)	48 (5)	10(7)	6 (5)	5 (5)	0(0)	39 (11)	38 (20)
Knowledgeindex										
No knowledge	8 (1)	0 (0)	1 (1)	1 (1)	0 (0)	1 (1)	1 (2)	0 (0)	3 (1)	1 (1)
Low knowledge	128 (9)	18(10)	4 (4)	35 (19)	7 (5)	3 (3)	0 (0)	0 (0)	31 (9)	29 (15)
Medium knowledge	726 (54)	115 (66)	64 (62)	100 (53)	72 (50)	19 (16)	28 (47)	8 (57)	199 (56)	122 (63)
High knowledge	482 (36)	41 (24)	34 (33)	50 (27)	65 (45)	93 (80)	31 (51)	6 (43)	121 (34)	41 (21)
Total	1344	174	103	186	144	116	60	14	354	193

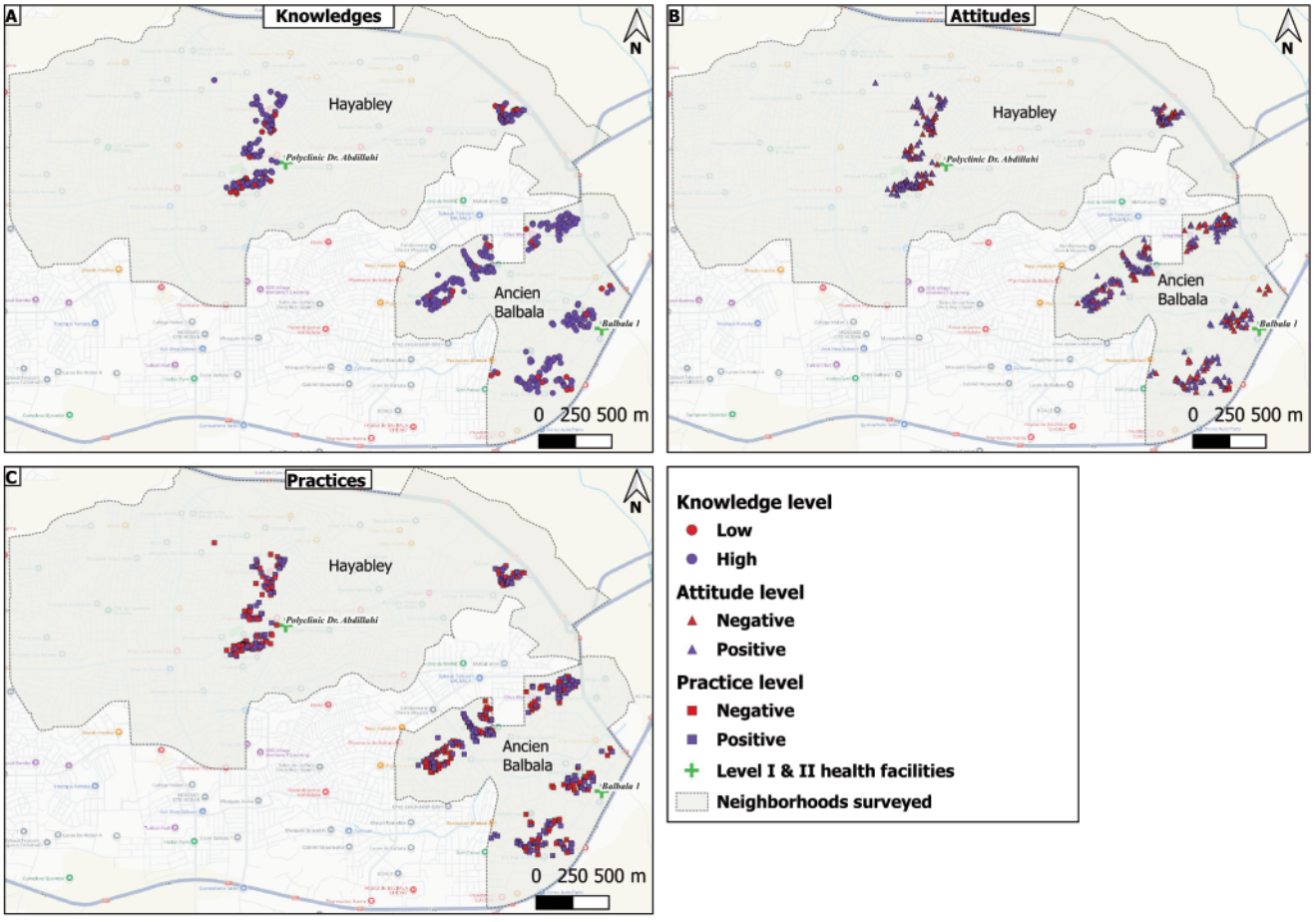

Figure 2. Maps of the city of Djibouti illustrating the three different components of the KAP approach. The neighbourhoods surveyed in the commune of Balbalaarerepresented in grey and delimited by a dotted black line;the KAP components are distinguished by symbols and colours: a circle for knowledge, a triangle for attitudes and a square for practices, with each category represented in red or blue; Level 1 health facilities are indicated by a green cross.

emerged: the lower or more fixed the income, the less favourable attitudes towards malaria. In other words, participants on low incomes have significantly lower average to high attitudes to prevention and understanding of the disease (Table 4).

Practice

Of the participants, 79% reported owning a mosquito net (Table 5). However, only 34% reported correct use, defined as regular or occasional, and 34% reported that the net was used by the

Table 3. Questions on attitude and index.

Question	Total N (%)	Quartier 6 N (%)	Quartier 5 N (%)	Quartier 4 N (%)	Quartier 3 N (%)	Quartier 2 N (%)	Enguella 1 N (%)	Enguella 2 N (%)	Ancien Balbala N (%)	Hayabley N (%)
Awareness of the severity of malaria										
Yes	762 (57)	98 (56)	67(65)	143 (56)	95 (66)	39 (34)	41(68)	11(79)	192(54)	114(59)
No	582 (43)	76 (44)	36 (35)	81 (44)	49 (34)	77 (66)	19 (32)	3(21)	162 (46)	79 (41)
Belief about antimalarial medications in case of malaria										
Yes	1259 (94)	168 (97)	98 (95)	167 (90)	143 (99)	108 (93)	58 (97)	13(93)	328 (93)	50 (26)
No	85 (6)	6 (3)	5 (5)	19 (10)	1 (1)	8(7)	2 (3)	1(7)	26 (7)	143 (74)
Belief about the effectiveness of impregnated mosquito										
Yes	530 (39)	53 (30)	33(32)	67 (36)	58(40)	91 (78)	51(85)	14(100)	21962)	46 (26)
No	814 (61)	121 (70)	70 (68)	119 (64)	86(60)	25 (22)	9 (15)	0(0)	135(38)	147 (26)
Attitudes index										
No attitude	40 (3)	3 (2)	4 (4)	9 (5)	0 (0)	2 (2)	1 (2)	0 (0)	13 (4)	8 (4)
Low attitudes	383 (28)	63 (36)	25 (24)	56 (30)	40 (28)	19 (16)	2 (3)	1(7)	117 (33)	60 (31)
Medium attitudes	921 (69)	108 (62)	74 (72)	121 (65)	104 (72)	95 (82)	57 (95)	13 (93)	224 (63)	125 (65)
High attitudes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	1344	174	103	186	144	116	60	14	354	193

Table 4. Multinomial regression analysis of the attitudes index.

Attitudeindex	Gender estimate	p	Monthly income Estimate	p
No attitude	Reference		Reference	
Medium attitude	0.656	0.020	-0.182	0.007
High attitude	0.794	0.004	-0.083	0.217

Table 5. Questions on practice and index.

Question	Total N (%)	Quartier 6 N (%)	Quartier 5 N (%)	Quartier 4 N (%)	Quartier 3 N (%)	Quartier 2 N (%)	Enguella 1 N (%)	Enguella 2 N (%)	Ancien Balbala N (%)	Hayabley N (%)
Possession of an impregnated mosquito net										
Yes	1057 (79)	160 (92)	94(91)	142 (76)	126 (88)	89 (77)	48 (80)	4 (29)	39 (34)	132 (68)
No	287 (21)	14 (8)	9 (9)	24 (44)	18(13)	27 (23)	12(20)	10 (71)	77 (66)	61 (32)
Proper use of the impregnated mosquito net										
Yes	451 (34)	29 (17)	3 (3)	25(13)	32 (22)	33 (28)	13 (22)	0 (0)	108 (93)	97 (50)
No	893 (66)	143 (83)	100 (97)	161 (87)	112 (78)	83(72)	47(78)	14 (100)	8(7)	96 (50)
Use of the impregnated mosquito net for the whole family										
Yes	451 (34)	29 (17)	3 (3)	25(13)	32 (22)	33 (28)	13 (22)	0 (0)	91 (78)	97 (50)
No	893 (66)	143 (83)	100 (97)	161 (87)	112 (78)	83(72)	47(78)	14 (100)	25 (22)	96 (50)
Adoption of malaria prevention measures during travel										
Yes	19 (1)	173 (99)	0 (0)	1 (1)	0 (0)	1 (1)	0 (0)	0 (0)	11 (3)	5 (3)
No	1325 (99)	1 (1)	103(100)	185 (99)	144(100)	116 (99)	60 (100)	14(100)	343 (97)	188 (97)
Practices index										
No practice	280 (21)	14 (8)	9(9)	43 (23)	13 (9)	27(23)	12 (20)	10 (71)	89(25)	58 (30)
Poor practices	611 (45)	131 (75)	91 (88)	118 (63)	127 (88)	55 (47)	35(58)	4 (29)	45 (13)	38 (20)
Moderate practices	2 (0)	0 (0)	0 (0)	1 (1)	0 (0)	1(1)	0 (0)	0 (0)	0 (0)	0 (0)
Good practices	441 (33)	28 (16)	3 (3)	25 (13)	4(3)	33(29)	13(22)	0 (0)	212 (60)	95 (49)
High practices	10 (1)	1 (1)	0 (0)	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	7(2)	2 (1)
Total	1344	174	103	186	144	116	60	14	354	193

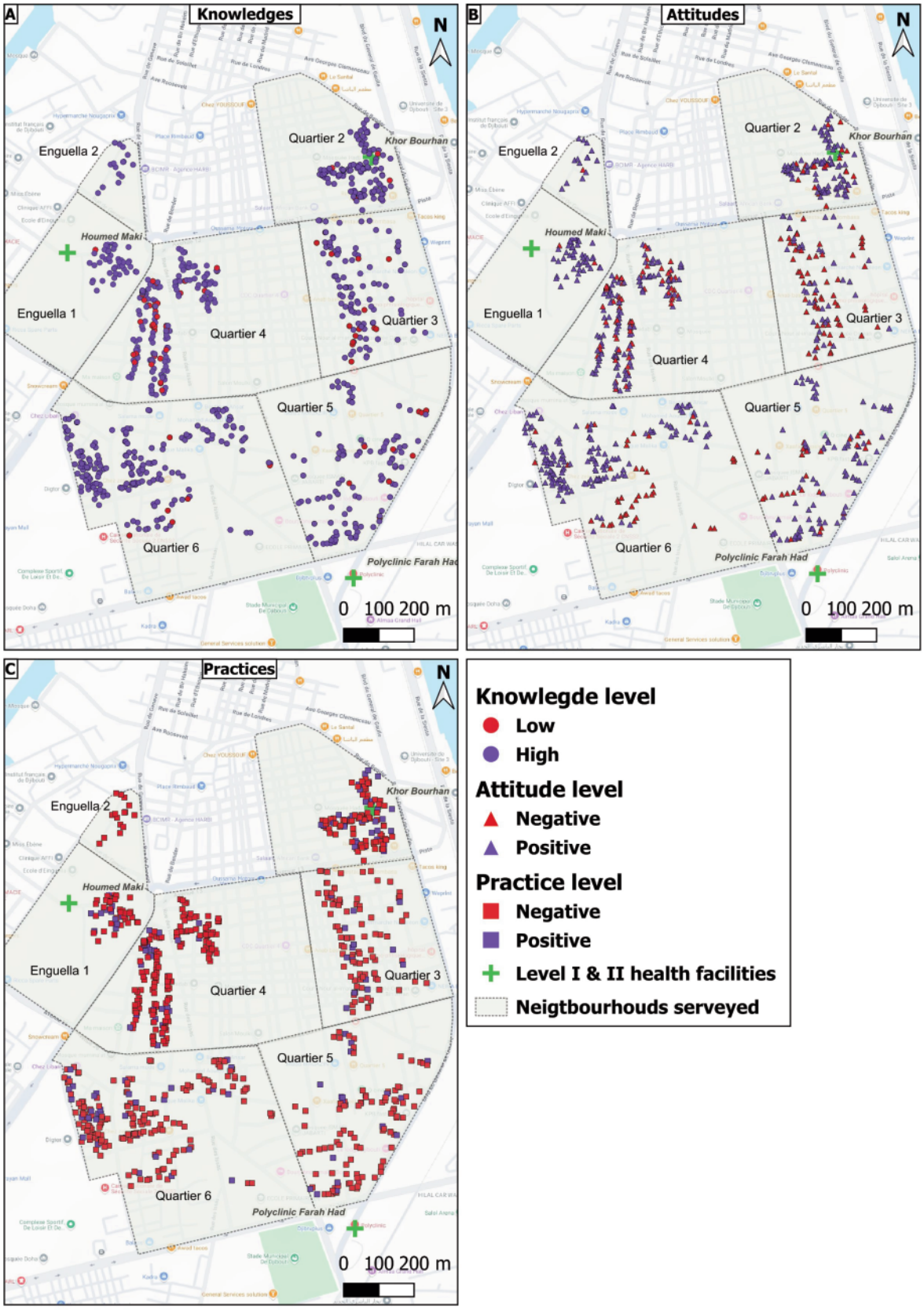

Figure 3. Maps of the city of Djibouti illustrate the three different components of the KAP approach. The neighbourhoods surveyed in the commune of Boulaos are represented in grey and delimited by a dotted black line: the KAP components are distinguished by symbols and colours: a circle for knowledge, a triangle for attitudes and a square for practices, with each category represented in red or blue: level 1 health facilities are indicated by a green cross.

whole family. In addition, 99% of respondents stated that they did not take any preventive measures when travelling to malaria-risk areas (Table 5).Survey participants with "good and high practices" were more concentrated in Ancien Balbala and Hayabley, while participants with no, poor and moderate practices were found in the other seven neighbourhoods (Figures 2, Figure 3 and Table 6). ANOVA tests revealed significant relationships between the practice index and socio-demographic variables, in particular native language (p=10^{-4}) and level of education (p=10^{-3}).

Multinomial regression analysis, with the practice index as the dependent variable, corroborated the ANOVA results. It identified neighbourhood of residence, native language, and education level as significant predictors (Table 6). Residents of Ancien Balbala and Hayabley were more likely to achieve a high level of practice than those in other neighbourhoods. Somali speakers were more likely to have low levels of use than other language groups. It is notable that as the level of education increases, the likelihood of achieving a high or advanced level of use decreases.

Spatial analysis

Cluster analysis using LISA applied to knowledge scores shows that the other neighbourhoods do not present any significant clusters, meaning that no groupings are detected. Cluster analysis using LISA applied to attitude scores shows that only neighbourhood 3 was a HH hotspot, a cluster indicating that this neighbourhood has insufficient attitudes and is surrounded by similar neighbourhoods, suggesting local vulnerability. Conversely, the other neighbourhoods show an insignificant cluster, meaning that no clustering is detected (Figure 4). Regarding practice scores, only district 2 showed an insignificant cluster. Neighbourhoods 3, 4, 5, 6, as well as Enguella 1 and 2, showed a LL cluster, indicating favourable contexts for good practices. The Haybley and Ancien Balbala neighbourhoods showed a LH cluster, indicating outlier situations with a high local value surrounded by low values, reflecting an anomaly (Figure 5).

KAP Stratification by sub-groups

The analysis of KAP according to household head characteristics and household composition (Table 7) showed that the majority of household heads, regardless of age or gender, had high knowledge about malaria (between 87% and 90%). Positive attitudes are slightly more common among household heads aged ≥65 years (75.7%) compared to those <65 years (68.3%), and among women (69.0%) compared to men (67.9%). The presence of children under 5 years old or pregnant women in the household did not appear to strongly influence knowledge levels, although households with children <5 years showed a slightly lower proportion of positive attitudes (32.9% negative *vs* 28.4% negative in their absence). Regarding practices, differences between sub-groups were minimal, with positive practices around 32-35% across all groups.

Discussion

The present study revealed that 98% of participants had heard of malaria, reflecting widespread awareness campaigns in Djibouti. However, despite this high level of exposure, 60% were unaware of the actual modes of transmission of the disease and did not identify mosquito bites as the main vector. From a Health Belief Model perspective, this disconnect suggests that general

Table 6. Multinomial regression analysis of the practices index.

Practices index	Neighbourhood estimate	p	Native language estimate	p	Education level estimate	p
No practice	Reference		Reference		Reference	
Low practices	-0.375	< 2e-16	0.271	0.009	0.071	0.113
Medium practices	0.002	0.995	0.725	0.534	0.325	0.482
High practices	0.096	0.003	0.365	0.001	-0.095	0.029
Advanced practices	0.334	0.088	-0.460	0.308	-0.465	0.025

Table 7. Distribution of knowledge, attitude and practice by sub-groups.

Sub-groups	n	Low knowledge (%)	High knowledge (%)	Negative attitude (%)	Positive attitude (%)	Negative practice (%)	Positive practice (%)
Household head age							
< 65 years	1307	132 (10.1)	1175 (89.9)	414 (31.7)	893 (68.3)	866 (66.3)	441(33.7)
≥ 65 years	37	4 (10.8)	33 (89.2)	9 (24.3)	28 (75.7)	25 (67.6)	12 (32.4)
Household head gender							
Male	560	71(12.7)	489 (87.3)	180(32.1)	380 (67.9)	374(66.8)	186(33.2)
Female	784	64(8.2)	720 (91.8)	243 (31.0)	541(69.0)	517 (65.9)	267 (34.1)
Children under 5 years in the household							
Presence	908	103(11.3)	805 (88.7)	609(67.1)	299 (32.9)	605(66.6)	303(33.4)
Absence	436	33(7.6)	403(92.4)	124 (28.4)	312(71.6)	286(65.6)	150 (34.4)
Pregnant women in the household							
Presence	254	34(13.4)	220(86.6)	92(36.2)	162(63.8)	185(72.8)	69(27.2)
Absence	1090	102(9.4)	988(90.6)	331 (30.4)	759(69.6)	706(64.4)	384 (35.2)

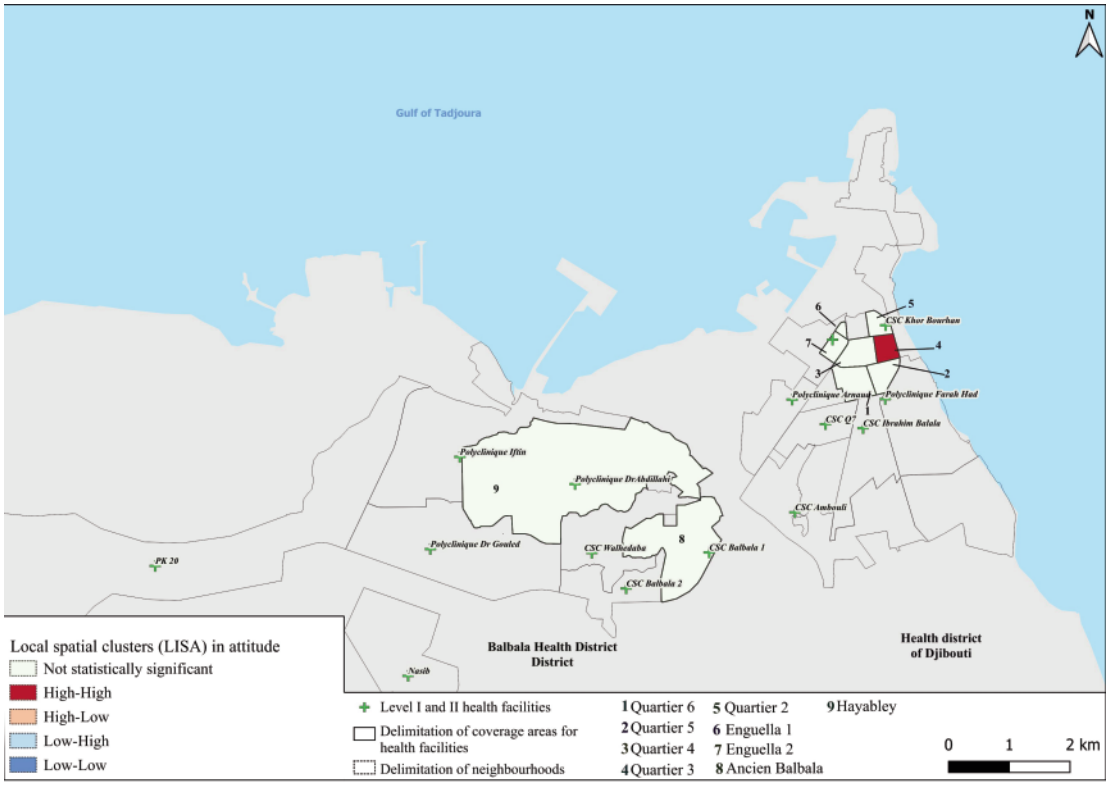

Figure 4. Map of Djibouti City showing local spatial clusters in terms of attitude. Dark blue areas indicate 'low-low' clusters and light blue areas indicate 'low-high' clusters; orange areas indicate 'high-low' clusters; red areas indicate 'low-high' clusters; light green areas are not statistically significant; green crosses represent Level I and II health facilities. The black lines delimit the neighbourhoods and coverage areas of the health facilities.

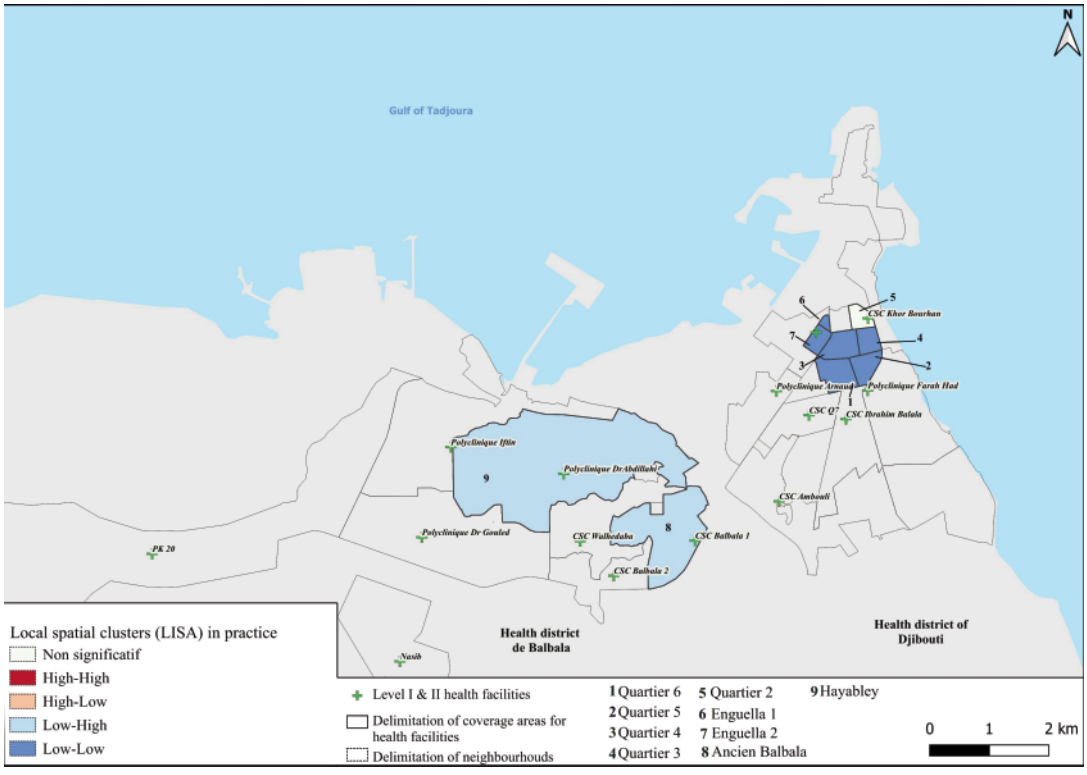

Figure 5. Map of the city of Djibouti showing local spatial clusters in practice. Dark blue areas indicate LL clusters; light blue areas indicate LH clusters; orange areas indicate 'high-low' clusters; red areas indicate 'low-high' clusters; light green areas are not statistically significant; green crosses represent Level I and II health facilities; black lines delimit the neighbourhoods and coverage areas of the health facilities.

awareness alone is insufficient to motivate preventive action – what matters is whether individuals perceive themselves as personally susceptible and understand the specific causal pathway linking mosquito bites to disease (Rosenstock, 1974; Janz & Becker, 1984). The widespread misattribution of malaria to rain, food, or animal contact further aligns with Kleinman's explanatory model framework: when culturally embedded causal narratives diverge from biomedical explanations, the logical pathway to adopting recommended preventive behaviours is severed (Kleinman, 1980). These findings suggest that information campaigns in Djibouti have successfully raised knowledge of the disease but have not displaced alternative illness narratives, which likely limits their behavioral impact. Comparable KAP studies in neighbouring countries show that Arab, Afar and Somali populations in Ethiopia and Eritrea are well aware of mosquito-borne transmission (Habtai *et al*., 2010; Abate *et al.,* 2013; Belay *et al*., 2021; Dejazmach *et al*., 2021; Addis & Gebeyehu Wondmeneh, 2023; Andegiorgish *et al*., 2023), suggesting that the transmission knowledge gap in Djibouti is not culturally inevitable but may reflect specific weaknesses in local communication strategies. In Yemen, a school-based health education programme increased transmission knowledge by 38% (Farea *et al*., 2020), illustrating the potential for targeted interventions to close this gap.

The absence of any significant association between knowledge and socio-demographic variables deviates from patterns observed in neighbouring countries, where age and education level influence malaria knowledge (Yimer *et al.*, 2015; Andegiorgish *et al*., 2023; Tomass *et al.,* 2016). Risk perception theory offers a partial explanation: in contexts of prolonged endemic exposure, populations may develop optimistic bias – normalising chronic threats and suppressing preventive motivation regardless of education or income (Slovic, 1987; Weinstein, 1980). This habituation effect may explain the relative uniformity of knowledge levels across socio-demographic groups in Djibouti. It should be noted that combining 'medium' and 'high' KAP levels may have led to an overestimation of the proportion of participants with satisfactory knowledge, attitudes and practices. However, this categorisation was intentionally adopted to distinguish individuals with clearly insufficient KAP – the priority targets for intervention – from those reaching an acceptable threshold in a context where preventive strategies are already in place. Gender and monthly income were significantly associated with attitudes, with women and higher-income participants more likely to hold positive attitudes. Within the COM-B framework, this suggests that motivational deficits drive negative attitudes among lower-income men, pointing to the need for interventions targeting motivational determinants rather than simply increasing information provision (Michie *et al.*, 2011). Household size has been associated with attitude patterns in Ethiopia, where small households were more likely to adopt negative attitudes (Dejazmach *et al*., 2021), though no comparable data exist for gender and income effects in the region.

Sixty percent of participants misunderstood the purpose of LLINs, believing they are used only to kill mosquitoes or improve sleep. Under the Health Belief Model, low perceived benefits of correct use reduce adoption even when nets are physically available (Janz & Becker, 1984). While 79% reported owning at least one LLIN, only 34% reported correct use – well below the 80% WHO threshold (WHO, 2010). Critically, LLIN use during the hot season was marginal across all neighbourhoods, suggesting that perceived thermal discomfort drives non-use precisely when transmission risk remains present. This inverse relationship between comfort-driven behaviour and actual transmission seasonality – with *Anopheles stephensi* activity peaking during the cooler season – represents a significant programmatic challenge that seasonally targeted communication campaigns should explicitly address.

The spatial clustering of practice scores is consistent with Social Cognitive Theory: health behaviours are shaped by observational learning and locally reinforced social norms (Bandura, 1986). The concentration of good practices in Ancien Balbala and Hayabley, contrasting with persistently poor practices in the Boulaos communes despite comparable knowledge levels and healthcare access, reflects broader place-based health inequalities where neighbourhood context independently shapes outcomes beyond individual characteristics (Diez Roux, 2001; Macintyre e*t al.*, 2002). This self-reinforcing cycle – where high-risk environments, poor preventive behaviours, and socio-economic disadvantage co-occur spatially – calls for geographically targeted rather than uniform interventions. In Ethiopia, practice and net use were strongly correlated with education and sex (Tomass *et al.,* 2016), and men were less compliant with net use recommendations than women (Dejazmach *et al.,* 2021), patterns that partially converge with our findings.

Applying the COM-B model, the primary deficit in Djibouti City does not lie in Capability – awareness is near-universal – nor entirely in Opportunity, given widespread LLIN distribution and free healthcare. Rather, the critical gap is Motivation: both accurate risk perception and socially reinforced habits of prevention remain insufficient to bridge the gap between resource availability and protective action (Michie *et al.,* 2011). This diagnosis suggests that future programs should prioritize norm-based and motivational approaches – community champion models, peer-to-peer communication, and locally embedded health promotion – particularly in the Boulaos communes, with linguistically tailored strategies for non-Somali speaking communities. However, the limits of such approaches must be acknowledged: motivational interventions are complex, slow to produce measurable change, and require sustained funding and trained community health workers. Vector control through larval source management and indoor residual spraying therefore remains an essential complement, particularly given the urban adaptation of *An. stephensi*.

Beyond what the data reveal, several interpretive caveats apply. Neighbourhood-level aggregation masks within-neighbourhood heterogeneity, and self-reported practices may overestimate actual behaviours due to social desirability bias. The counterintuitive negative association between education and practice likely reflects the spatial concentration of educated respondents in the Boulaos communes rather than a genuine effect of education. Spatial clusters capture where behaviours concentrate, but not why – a question requiring complementary qualitative investigation. Health-seeking behaviour was operationalized narrowly as formal facility consultation and treatment adherence. On these measures, participants performed acceptably: 82% visited a health centre and 66% completed prescribed treatment. However, this does not capture the full care-seeking spectrum in Djibouti, where traditional medicine, medicinal plants, and informal networks play an important cultural role among Somali and Afar communities. The near-absence of reported traditional remedy use should be interpreted with caution given potential social desirability bias. Nevertheless, 99% reported no preventive measures during travel – a critical unaddressed gap – and the absence of correlation between low KAP scores and healthcare proximity or cost further supports the interpretation that motivational rather than structural factors drive the knowledge-practice gap.

Finally, this study contributes to evidence on the value and limitations of quantitative KAP surveys as a methodological tool. The standardized approach enabled systematic spatial comparisons and

provided the first behavioural baseline for Djibouti City. However, closed-ended questions, the focus on household heads, and the cross-sectional design limit the depth of what can be captured. KAP surveys are best understood as a diagnostic tool identifying where gaps exist and who is most affected, rather than explaining why – a question requiring complementary qualitative research.

Limitations

The main limitation of this study is its focus on the household head as the sole respondent. While both male and female household heads were eligible, and a responsible adult family member was selected as replacement when needed (Addis & GebeyehuWondmeneh, 2023), this approach excludes other household members who may be more vulnerable, including children under five and pregnant women, whose own knowledge, attitudes and practices could differ substantially. Importantly, a quantitative approach was chosen to enable robust statistical analysis and spatial comparisons across nine neighbourhoods, objectives best served by standardized quantitative instruments. We acknowledge that qualitative methods could provide complementary insights into the motivations, cultural beliefs, and social norms underlying observed behaviours, and recommend their integration in future research. In addition, the cross-sectional design limits the ability to capture seasonal variation in malaria-related practices. Data were collected during the cooler season only, and LLIN use patterns and risk perceptions during the hot transmission season could not be systematically assessed. Future studies should consider multi-season data collection.

Further, questions about malaria symptoms were formulated in terms of stated familiarity with closed-ended yes/no responses. While this improved comprehension across heterogeneous literacy levels, it likely overestimates actual knowledge, as respondents may confirm familiarity without accurately identifying specific symptoms. Future studies should incorporate symptom-specific questions with multiple response options. Self-reported practices may similarly overestimate actual behaviours, particularly LLIN use, where social desirability bias is well documented. The use of third-year undergraduate students as enumerators, while logistically practical, may have introduced interviewer bias – respondents may have provided socially desirable answers to younger, educated interviewers, particularly on sensitive topics such as traditional medicine use or treatment non-adherence.

Several variables relevant to malaria risk and prevention were not included in the final scoring, notably household size, household water storage practices, proximity to water bodies, use of insect repellent and protective clothing, and livestock ownership. While some were captured in the questionnaire but did not meet the weighting threshold for retention, their absence limits the depth of the risk factor analysis and the ability to identify the most vulnerable households. Traditional and informal care-seeking pathways, including the use of medicinal plants and traditional medicine, were also not systematically captured, limiting the interpretation of health-seeking behavior findings.

The improved version of the questionnaire following the pretest was not subjected to a second formal validation prior to full deployment, which is an additional methodological limitation. Finally, the purely quantitative approach, while appropriate for population-level comparisons, does not capture the motivations, cultural beliefs, and social norms underlying observed behaviours. Integration of qualitative methods in future research would provide complementary insights, particularly for exploring the explanatory models and normative dynamics identified in this study

Conclusions

Despite the many measures taken to combat malaria, it remains a public health problem. The information, education and behaviour change communication campaigns already underway are not having the desired effect. Although the institutions responsible for combating malaria carry out prevention campaigns, such as raising awareness, distributing insecticide-treated mosquito nets and indoor residual spraying, these actions seem to have little impact on the prevention practices and behaviour of Djiboutians. These results call for spatial targeting of public health messages, considering regional disparities in CAP levels. Furthermore, language and educational barriers must be recognised as locally rooted social determinants of health, requiring tailored interventions. The structures responsible for combating malaria must step up their efforts to increase the population's understanding of the actual modes of transmission of the disease, in order to improve the effectiveness of prevention and control measures., drawing on the example of Yemen, while concentrating their efforts on destroying breeding sites.

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Online supplementary materials
Supplementary data 1. KAP survey questionnaire.
Supplementary Table 1.The weighting assigned to each knowledge, attitude and practice question.
Supplementary Table 2. Score index for relevant questions selected from the study on knowledge, attitudes and practices.

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Conflict of interest: the authors declare no conflict of interest.

Ethical considerations: this study was approved by the Ethics Committee of the University of Djibouti (#WDE-123455) in October 2022. Verbal informed consent was obtained from all respondents prior to interview, in recognition of the diversity of literacy levels among the study population. Participation was voluntary, and all data were treated as strictly confidential.

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