

Knowledge, Attitudes and Practices Towards Onchocerciasis among Children and Adolescents in the Formerly Endemic Foci of Mexico: A Cross-Sectional Survey in the Post-Verification Period

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Abstract

Background

Mexico was verified free of onchocerciasis transmission in 2015 by the World Health Organization (WHO), yet sustaining community awareness remains important for post-verification surveillance. This study assessed knowledge, attitudes and practices (KAP) regarding onchocerciasis among children and adolescents in two formerly endemic regions, Oaxaca and Chiapas.

Methods

A cross-sectional survey using a structured questionnaire was conducted among participants aged 8–17 years in former endemic region of Oaxaca and Chiapas between November 2024 to October 2025. A proxy was allowed to assist those aged between 8 and 13 years old. Data were managed in Microsoft Excel and analyzed using IBM SPSS Statistics. Categorical variables were summarized as frequencies and percentages, and associations between demographic characteristics and knowledge or practice items were assessed within each region using the chi-square test with significance set at $p < 0.05$.

Results

Awareness of onchocerciasis was low in both regions, with only 36.0% of participants in Oaxaca and 20.1% in Chiapas reporting that they were familiar with the disease. Knowledge of its mode of transmission was even lower, with only 32.1% of participants in Oaxaca and 10.7% in Chiapas reporting that they knew how the disease is transmitted. Among all respondents, only 9.3% of participants in Oaxaca and 4.3% in Chiapas correctly named the blackfly as the vector. Many referred to a generic "fly," while 17.5% and 7.7% of participants, respectively, incorrectly named mosquitoes as the vector. Knowledge of disease transmission increased significantly with age in Oaxaca ($p = 0.009$) and with educational level in Chiapas ($p < 0.001$). Attitudes toward onchocerciasis control were generally favourable, with most participants indicating that they would complete treatment, notify vector brigades, and accept visits from health personnel. A substantial proportion of participants reported exposure to blackfly breeding sites (69.3% in Oaxaca and 38.6% in Chiapas). Although protective clothing was commonly reported, the use of other preventive measures remained limited. Self-reported diagnoses and clinical signs of onchocerciasis were rare, as expected in a post-verification setting.

Conclusion

Knowledge of onchocerciasis was low and vector misconceptions common, although attitudes towards control were favorable. These findings indicate limited onchocerciasis-specific knowledge among children and adolescents in this post-elimination setting and reinforce the need for sustained health

education alongside post-verification surveillance to help protect the gains of onchocerciasis elimination in Mexico.

Introduction

Human onchocerciasis is a neglected tropical disease (NTD) of significant global public health importance which manifests clinically as subcutaneous nodules, dermatological pathology including onchodermatitis, lymphatic dysfunction, epilepsy, and visual impairment that can culminate in irreversible blindness (WHO, 2025; Adeleke et al., 2026). Onchocerciasis is caused by the filarial nematode *Onchocerca volvulus*, and blackflies of the genus *Simulium* are the vectors of the disease. In Mexico, *Simulium ochraceum* s.l. is recognized as the primary vector of *O. volvulus*, with no other blackfly species identified as having significant epidemiological importance in endemic areas (Rodríguez-Pérez et al., 2015). These vectors breed in fast-flowing rivers and streams where their immature stages develop. As a result, transmission tends to be highest in communities situated close to rivers that serve as breeding habitats for *Simulium* vectors (Noma et al., 2014). The epidemiology of onchocerciasis is shaped by the density, host-seeking behavior, and vectorial capacity of local *Simulium* populations (Dauda et al., 2025; Nwoke et al., 2023).

Human onchocerciasis persists in limited areas of Latin America and Yemen, although over 99% of the global burden is concentrated in 31 countries in sub-Saharan Africa (WHO, 2025). Following sustained elimination efforts, the World Health Organization (WHO) has verified five countries as free of the disease, namely Colombia (2013), Ecuador (2014), Mexico (2015), Guatemala (2016), and Niger (2025) (WHO, 2025). Prior to elimination verification in Mexico, onchocerciasis was confined to three endemic foci namely, Northern Chiapas (“Chamula”), Southern Chiapas (“Soconusco”), and Oaxaca (Rodríguez-Pérez et al., 2015). In Mexico, control efforts since the 1990s were based on sustained mass administration of ivermectin (Mectizan^R, donated by Merck, Sharpe & Dohme) to at-risk communities. Annual treatment of eligible individuals began in 1994 and was intensified to semi-annual distribution in 1997 (Rodríguez-Pérez et al., 2010). In the Southern Chiapas focus, the treatment strategy was further strengthened to quarterly treatments between 2003 and 2011 (Rodríguez-Pérez et al., 2015). These sustained interventions enabled the Onchocerciasis Elimination Program for the Americas (OEPA) to achieve its goal of eliminating new ocular morbidity and interrupting transmission of *O. volvulus* by 2012, leading to the cessation of mass drug administration (MDA) with ivermectin by the Mexican Ministry of Health (Rodríguez-Pérez et al., 2015).

Post-treatment entomological surveillance was conducted three years after the final ivermectin distribution across the three endemic foci. None of the over 100,000 *S. ochraceum* s.l. collected from first-line and supplementary surveillance communities tested positive for *O. volvulus* DNA by PCR-ELISA, and the upper bound of the 95% confidence interval for the infective rate remained well below the WHO threshold of one infective fly per 2,000 examined (Rodríguez-Pérez et al., 2015). On this basis, WHO verified Mexico as free of onchocerciasis in 2015. However, verification of elimination does not mark the end of programmatic responsibility. The WHO 2016 guidelines for stopping mass drug administration

and verifying elimination of human onchocerciasis define three distinct phases of programme activity (WHO, 2016). These consist of an intervention phase, a post-treatment surveillance phase lasting three to five years, and a post-elimination surveillance (PES) phase.

Post-elimination surveillance (PES) conducted between 2016 and 2019 in the former Southern Chiapas focus, covering more than 60% of the previously at-risk population, identified 34 individuals with suspected nodules. Parasitological assessment, however, detected no active infections, with only one individual who had migrated from a previously endemic focus found to harbor a single non-fertile adult female worm (Fernández-Santos et al., 2020). These findings are consistent with expectations that a small proportion of individuals ineligible for treatment during MDA may retain residual, non-transmissible infections for a limited period after cessation of drug pressure, and may not be an indication of recrudescence.

In onchocerciasis epidemiology, serological surveillance in young children is a sensitive indicator of potential transmission resurgence. WHO guidelines recommend assessing exposure to *O. volvulus* in children under 10 years of age, who, in the absence of ongoing transmission, are expected to remain unexposed and seronegative (WHO, 2016). Their serological status therefore provides a proxy measure of recent transmission. The Ov16 IgG4 immunoassay is widely validated for this purpose. Children born after interruption of transmission in blackfly vectors should test negative, and any seroconversion in this group would indicate renewed transmission; in contrast, Ov16 positivity in adults could be due to persistence of antibodies from infection in the remote past. However, the epidemiology of onchocerciasis suggests that transmission dynamics within a local transmission zone can shift even in the apparent absence of the parasite. The re-introduction of an infected individual with a high microfilarial load and high *S. ochraceum* s.l. biting could re-establish transmission and potentially trigger recrudescence.

Children and adolescents born after the cessation of MDA have limited knowledge of onchocerciasis. Unlike older individuals who experienced active transmission and participated in control programmes, this group has grown up entirely in the post-elimination period, with limited exposure to interventions and little direct experience with the disease. Maintaining elimination gains therefore requires ensuring that adolescent populations in previously endemic areas retain adequate knowledge of the disease, including its vectors, symptoms, and prevention, to elicit appropriate attitudes and practices. However, data on knowledge, attitudes, and practices among children and adolescents in post-verification settings remain limited, particularly in endemic foci within the Americas that have been verified as having eliminated onchocerciasis. This study was conducted to address this epidemiological gap. It was designed as a cross-sectional survey to assess the knowledge, attitudes, and practices of children and adolescents, with the aim of evaluating the risk of onchocerciasis recrudescence across the three formerly endemic regions of Mexico. The findings will provide evidence to inform national health programs on existing knowledge gaps, behavioral risk factors, and levels of preparedness relevant to post-verification surveillance and the prevention of disease re-emergence across these regions.

Materials and Method

Human Ethics and Consent to Participate

The study protocol was reviewed and approved by the Research Ethics Committee of Promotora Médica Aguascalientes (Ref. No. 2897.ceipma.2024). Written informed consent was obtained from a parent or legal guardian of each participant after a clear explanation of the study's objectives, procedures, the voluntary nature of participation, and the right to withdraw at any time without consequence. In addition, age-appropriate written assent was obtained from each child before enrolment. All data were collected anonymously, handled confidentially, and used solely for the purposes of this study. The study was conducted in accordance with the principles of the Declaration of Helsinki (1964) and its subsequent revisions.

Study areas

The study was conducted in the former endemic foci of Oaxaca and Chiapas in southeastern Mexico, the only regions in the country with a history of onchocerciasis endemicity. The sampled localities are shown in Fig. 1. In Oaxaca, sustained semi-annual ivermectin treatment initiated in 1997 led to the interruption of transmission by 2008, with zero microfilarial prevalence subsequently recorded in both human and vector populations (Rodríguez-Pérez, et al. 2010). In Chiapas, study sites were selected from both the Southern Chiapas focus, the largest and historically most endemic focus in Mexico, and the Northern Chiapas focus. Semi-annual mass drug administration (MDA) covering all endemic communities began in 1998; in some communities in Southern Chiapas quarterly treatment was undertaken in the final years on the elimination program. The last confirmed case of onchocerciasis in Mexico was reported in 2011 (Rodríguez-Pérez et al., 2013). Mexico received WHO verification of national onchocerciasis elimination in 2015. Given that transmission was confirmed to have been interrupted in 2011 and both Oaxaca and Chiapas are now under post-verification surveillance (PVS), the children and adolescents aged 8–17 years included in this study represent a cohort expected to have had little or no direct exposure to active transmission (Fig. 1).

Study design and sample size determination

This was a cross-sectional, questionnaire-based survey conducted between November 2024 and October 2025 in the formerly endemic foci of Oaxaca and Chiapas, Mexico. A structured questionnaire was used to assess onchocerciasis-related knowledge, attitudes and practices among children and adolescents, with the aim of characterizing community awareness and identifying behavioral factors of potential relevance to recrudescence during the post-elimination period. Children and adolescents were purposively selected on the basis that this age group, having been born during or after the cessation of MDA, represents a sentinel population with little or no prior programmatic ivermectin exposure, whose behavioral practices could constitute a direct and as yet uncharacterized determinant of risk of

recrudescence. Children younger than eight years were excluded because the questionnaire required a level of comprehension and may be unable to validly respond to the questions.

The sample size was based on Cochran's formula for estimating a single population proportion:

$$n_0 = \frac{Z^2 p(1 - p)}{d^2}$$

where $p = 0.50$ denotes the expected proportion of the primary KAP outcome, with a 95% confidence level ($Z = 1.96$) and 5% absolute precision ($d = 0.05$). This gave a minimum of 385 participants per focus.

Data Collection

For children aged 8–13 years, the questionnaire was administered with the assistance of a parent or legal guardian, who served as a proxy respondent to facilitate responses, given the limited knowledge and decision-making capacity typically associated with this age group. Participants aged 14 years and above completed the questionnaire independently. The use of proxy respondents introduces a potential source of information bias, as caregiver-assisted responses may not fully reflect the child's individual knowledge, attitudes, or practices; this limitation was considered in the interpretation of findings. Prior to questionnaire administration, sociodemographic data including age, gender, and educational status were collected. The questionnaire comprised four sections: (i) knowledge of onchocerciasis, (ii) attitudes towards onchocerciasis, (iii) practices related to onchocerciasis, and (iv) epidemiological and clinical history (Supplementary file 1). The questionnaire was administered by trained researchers through face-to-face interviews to ensure consistency and completeness of responses. The questionnaire was developed in Spanish, the local language, to facilitate participant understanding. Responses were subsequently translated into English using Google Translate and independently verified by bilingual members of the research team to ensure translation accuracy and consistency.

Data Analysis

Data were entered into Microsoft Excel (version 2021) and analyzed using the Statistical Package for the Social Sciences (SPSS version 2021). Categorical variables were summarized as frequencies and percentages. Associations between demographic characteristics and knowledge or practice items were assessed within each region separately using Pearson's chi-square test, with statistical significance set at $p < 0.05$.

Results

Demographic information of participants

A total of 1,265 participants aged 8–17 years were recruited from the two study regions, including 658 (52.0%) from Oaxaca and 607 (48.0%) from Chiapas. In both states, children aged 8–11 years constituted the largest age group, representing 389 (59.1%) participants in Oaxaca and 316 (52.1%) in Chiapas, whereas adolescents aged 15–17 years formed the smallest group, accounting for 28 (4.3%) and 39 (6.4%) participants, respectively. The gender distribution was comparable across both regions, with a slight predominance of females in Oaxaca, 339 (51.5%), and Chiapas, 317 (52.2%). Educational attainment varied between states. In Oaxaca, middle school students constituted the largest proportion of participants, 316 (48.0%), followed by those in elementary school, 267 (40.6%). In contrast, elementary school students predominated in Chiapas, 304 (50.1%), followed by middle school students, 264 (43.5%). High school students represented the smallest educational category in both Oaxaca, 75 (11.4%), and Chiapas, 39 (6.4%) (Table 1).

Table 1
Participant demographic information

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
Age group	8–11 years	389 (59.1%)	316 (52.1%)
	12–14 years	241 (36.6%)	252 (41.5%)
	15–17 years	28 (4.3%)	39 (6.4%)
Gender	Female	339 (51.5%)	317 (52.2%)
	Male	319 (48.5%)	290 (47.8%)
Education level	Elementary	267 (40.6%)	304 (50.1%)
	Middle school	316 (48.0%)	264 (43.5%)
	High school	75 (11.4%)	39 (6.4%)

Knowledge of onchocerciasis

Overall, awareness of onchocerciasis was limited, particularly in Chiapas. Only 237 (36.0%) participants in Oaxaca and 122 (20.1%) in Chiapas reported being familiar with onchocerciasis or *mal morado*. Knowledge of mode of transmission was similarly low, with 211 (32.1%) respondents in Oaxaca and just 65 (10.7%) in Chiapas reporting knowledge of how the disease is transmitted. In Oaxaca, this knowledge increased significantly with age ($p = 0.009$), but did not differ by gender or education; in Chiapas it was instead associated with educational level ($p < 0.001$), being highest among participants with high-school education. When asked to specify how onchocerciasis is transmitted, only 61 (9.3%) participants in Oaxaca and 26 (4.3%) in Chiapas correctly named the blackfly as the vector. Few of the respondents in Oaxaca, 215 (32.7%), and 80 (13.2%) in Chiapas referred only to a generic ‘fly’ without specifying the vector species. Notably, 115 (17.5%) participants in Oaxaca and 47 (7.7%) in Chiapas incorrectly named mosquitoes as the vector responsible for transmission. Awareness of disease symptoms was also poor,

with only 139 (21.1%) participants in Oaxaca and 75 (12.4%) in Chiapas having knowledge of disease symptoms. Knowledge of onchocerciasis control measures was limited, with only 179 (27.2%) participants in Oaxaca and 32 (5.3%) in Chiapas reporting awareness of methods to prevent or control the disease. In Oaxaca, this awareness likewise increased with age ($p = 0.029$), whereas no demographic factor was significantly associated with it in Chiapas. Awareness of elimination status was also low, although higher in Oaxaca, where 271 (41.2%) participants reported having been informed that onchocerciasis had been eliminated from their area compared with 105 (17.3%) in Chiapas (Table 2).

Table 2
Knowledge of onchocerciasis

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
Are you familiar with the term onchocerciasis or 'mal morado'?	Yes	237 (36.0%)	122 (20.1%)
	No	421 (64.0%)	485 (79.9%)
Do you know how onchocerciasis is transmitted?	Yes	211 (32.1%)	65 (10.7%)
	No	447 (67.9%)	542 (89.3%)
How is the disease transmitted?	Blackfly or 'mosca colorada o rodadora'	61 (9.3%)	26 (4.3%)
	Unspecified fly	215 (32.7%)	80 (13.2%)
	Mosquito	115 (17.5%)	47 (7.7%)
	No response	267 (40.6%)	454 (74.8)
Do you know the symptoms caused by onchocerciasis?	Yes	139 (21.1%)	75 (12.4%)
	No	519 (78.9%)	532 (87.6%)
Do you live in an area where onchocerciasis is endemic?	Yes	298 (45.3%)	68 (11.2%)
	No	184 (28.0%)	185 (30.5%)
	Don't know	176 (26.7%)	354 (58.3%)
Do you know any way to control onchocerciasis?	Yes	179 (27.2%)	32 (5.3%)
	No	479 (72.8%)	575 (94.7%)
Have you been informed whether onchocerciasis has been eliminated in your area?	Yes	271 (41.2%)	105 (17.3%)
	No	265 (40.3%)	302 (49.8%)

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
	Don't know	122 (18.5%)	200 (32.9%)
Have you been informed why ivermectin treatment was stopped?	Yes	201 (30.5%)	45 (7.4%)
	No	338 (51.4%)	359 (59.1%)
	Don't know	119 (18.1%)	203 (33.4%)
Do you know about traps for blackflies or 'moscas coloradas, rodadoras'?	Yes	8 (1.2%)	10 (1.6%)
	No	618 (93.9%)	404 (66.6%)
	Don't know	32 (4.9%)	193 (31.8%)
Have you seen health education programmes in your community?	Yes	349 (53.0%)	202 (33.3%)
	No	267 (40.6%)	150 (24.7%)
	Don't know	42 (6.4%)	255 (42.0%)
Have you received information or treatment from health brigades?	Yes	293 (44.5%)	153 (25.2%)
	No	311 (47.3%)	191 (31.5%)
	Don't know	54 (8.2%)	263 (43.3%)

Attitude towards onchocerciasis

The attitudes of participants toward onchocerciasis prevention and control were generally positive, particularly in Oaxaca. Most respondents indicated that they would seek care from formal health services if they experienced symptoms suggestive of onchocerciasis, with 634 (96.4%) participants in Oaxaca reporting that they would visit a health center or clinic, while 524 (86.3%) participants in Chiapas indicated that they would seek assistance from the same. Similarly, willingness to adhere to treatment was high, with 628 (95.4%) respondents in Oaxaca and 464 (76.4%) in Chiapas reporting that they would take all prescribed medications if diagnosed with onchocerciasis. Participants also demonstrated strong support for surveillance activities. A total of 622 (94.5%) respondents in Oaxaca and 415 (68.3%) in Chiapas stated that they would notify the vector brigades if they detected nodules or other suspicious masses consistent with onchocercomas. Acceptance of health interventions was similarly high, with 638

(97.0%) participants in Oaxaca and 345 (56.8%) in Chiapas expressing willingness to receive visits from health personnel addressing onchocerciasis (Table 3).

Table 3
Attitude towards onchocerciasis

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
If you experience symptoms of onchocerciasis, where would you seek care?	Health Centre/Vector brigade	634 (96.4%)	524 (86.3%)
	Natural remedies	2 (0.3%)	6 (1.0%)
	Don't know	22 (3.3%)	77 (12.7%)
If you tested positive for onchocerciasis, would you take all prescribed medications?	Yes	628 (95.4%)	464 (76.4%)
	No	8 (1.2%)	107 (17.6%)
	Don't know	22 (3.3%)	36 (5.9%)
If you detected nodules or suspicious masses (onchocercomas), would you notify the Vector Brigades?	Yes	622 (94.5%)	415 (68.3%)
	No	26 (4.0%)	106 (17.5%)
	Don't know	10 (1.5%)	86 (14.2%)
Do you agree with visits from health personnel to address onchocerciasis?	Yes	638 (97.0%)	345 (56.8%)
	No	17 (2.6%)	84 (13.8%)
	Don't know	3 (0.5%)	178 (29.3%)
Are there people in your community who treat onchocerciasis (traditional healers)?	Yes	22 (3.3%)	17 (2.8%)
	No	412 (62.6%)	269 (44.3%)
	Don't know	224 (34.0%)	321 (52.9%)

Practice regarding onchocerciasis

Many of the participants in Oaxaca, 456 (69.3%) indicated that they had visited rivers, streams, or other sites where blackflies are commonly found, compared with 234 (38.6%) in Chiapas. Exposure to these vector breeding sites increased significantly with educational level in Oaxaca ($p < 0.001$) and increased

marginally in Chiapas ($p = 0.050$). Despite observed exposure to breeding sites, the adoption of personal protective measures against biting was generally poor in both regions. Only a small proportion of participants reported previous treatment with ivermectin, with 39 (5.9%) respondents in Oaxaca and only 12 (1.9%) in Chiapas indicating prior treatment. Most participants reported never having received treatment, while uncertainty regarding treatment history was particularly common in Chiapas, where 248 (40.9%) respondents were unable to recall whether they had previously received ivermectin. Additionally, the use of mosquito nets or repellents was reported by only 92 (14.0%) participants in Oaxaca and 77 (12.7%) in Chiapas, while regular use of insect repellents was even less common, reported by just 60 (9.1%) and 34 (5.6%) respondents, respectively. Wearing protective clothing outdoors was relatively common in Oaxaca, reported by 449 (68.2%) participants, but by only 204 (33.6%) in Chiapas. The factors associated with this behavior differed between the two regions. In Oaxaca, the use of protective clothing increased significantly with educational level ($p < 0.001$). In Chiapas, by contrast, the practice declined significantly with age ($p < 0.001$). Gender was not associated with this practice in either state ($p > 0.05$) (Table 4).

Table 4
Practice regarding onchocerciasis

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
Have you been near rivers, streams, or sites where blackflies are commonly found?	Yes	456 (69.3%)	234 (38.6%)
	No	157 (23.9%)	168 (27.7%)
	Don't know	45 (6.8%)	205 (33.8%)
Have you previously received treatment with ivermectin/antiparasitics?	Yes	39 (5.9%)	12 (1.9%)
	No	565 (85.9%)	347 (57.2%)
	Don't know	54 (8.2%)	248 (40.9%)
Do you use mosquito nets or repellents against flies or mosquitoes?	Yes	92 (14.0%)	77 (12.7%)
	No	566 (86.0%)	530 (87.3%)
Do you apply insect repellent regularly?	Yes	60 (9.1%)	34 (5.6%)
	No	598 (90.9%)	573 (94.4%)
Do you wear protective clothing when outdoors?	Yes	449 (68.2%)	204 (33.6%)
	No	209 (31.8%)	403 (66.4%)
Do you routinely use protection measures against fly bites?	Yes	139 (21.1%)	19 (3.1%)
	No	519 (78.9%)	588 (96.9%)
Do you use traps to reduce fly bites?	Yes	13 (2.0%)	19 (3.1%)
	No	613 (93.2%)	392 (64.6%)
	Don't know	32 (4.9%)	196 (32.3%)
Do the doors and windows of your house have screens?	Yes	54 (8.2%)	72 (11.9%)
	No	604 (91.8%)	535 (88.1%)
Do you keep doors and windows closed during the day?	Yes	129 (19.6%)	115 (18.9%)
	No	529 (80.4%)	492 (81.1%)

Epidemiology and Clinical history of onchocerciasis

History of onchocerciasis was rare in both study regions. Only 12 (1.8%) participants in Oaxaca and 6 (1.0%) in Chiapas reported ever having been diagnosed with the disease, while reports of affected family members were similarly uncommon, accounting for 19 (2.9%) and 23 (3.8%) participants, respectively. Likewise, few respondents reported having observed individuals in their communities with signs or symptoms suggestive of onchocerciasis, with only 16 (2.4%) participants in Oaxaca and 8 (1.3%) in Chiapas reporting such observations. Clinical manifestations potentially associated with onchocerciasis were also uncommon. Self-reported symptoms compatible with onchocerciasis were also infrequent. Skin itching, a non-specific symptom with many possible causes, was the most commonly reported 48 (7.3%) in Oaxaca and 32 (5.3%) in Chiapas, whereas subcutaneous nodules, pigmentary and skin changes, lymph-node swelling, and sensations of moving nodules were each reported by fewer than 1% of participants in both regions. Reports of visual problem were likewise infrequent, occurring in 27 (4.1%) participants in Oaxaca and 5 (0.8%) in Chiapas (Table 5).

Table 5
Clinical history and potential exposure

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
Have you ever been diagnosed with onchocerciasis?	Yes	12 (1.8%)	6 (1.0%)
	No	573 (87.1%)	396 (65.2%)
	Don't know	73 (11.1%)	205 (33.8%)
Are there other members of your family diagnosed with onchocerciasis?	Yes	19 (2.9%)	23 (3.8%)
	No	639 (97.1%)	584 (96.2%)
Have you ever seen anyone in your community with symptoms of onchocerciasis?	Yes	16 (2.4%)	8 (1.3%)
	No	642 (97.6%)	350 (57.7%)
	Don't know	0 (0.0%)	249 (41.0%)
Have you ever felt something moving (nodules/tumours) in your head, body, or eyes?	Yes	3 (0.5%)	2 (0.3%)
	No	643 (97.7%)	470 (77.4%)
	Don't know	12 (1.8%)	135 (22.2%)
Have you experienced skin itching?	Yes	48 (7.3%)	32 (5.3%)
	No	610 (92.7%)	575 (94.7%)
Have you noticed nodules or tumours under the skin?	Yes	5 (0.8%)	5 (0.8%)
	No	652 (99.1%)	576 (94.9%)
	Don't know	1 (0.2%)	26 (4.3%)
Have you observed skin pigmentation changes (dark spots or discolouration)?	Yes	6 (0.9%)	2 (0.3%)
	No	634 (96.4%)	439 (72.3%)
	Don't know	18 (2.7%)	166 (27.3%)
Have you noticed changes in skin texture (thickening or roughness)?	Yes	0 (0.0%)	1 (0.2%)
	No	648 (98.5%)	448 (73.8%)

Question	Response	Oaxaca (n = 658)	Chiapas (n = 607)
	Don't know	10 (1.5%)	158 (26.0%)
Have you noticed swelling in the neck, armpits, or groin?	Yes	2 (0.3%)	1 (0.2%)
	No	646 (98.2%)	445 (73.3%)
	Don't know	10 (1.5%)	161 (26.5%)
Have you experienced vision problems?	Yes	27 (4.1%)	5 (0.8%)
	No	622 (94.5%)	467 (76.9%)
	Don't know	9 (1.4%)	135 (22.2%)
Have you resided permanently in endemic areas in the last five years?	Yes	232 (35.3%)	84 (13.8%)
	No	238 (36.2%)	183 (30.1%)
	Don't know	188 (28.6%)	340 (56.0%)
Have you left the community to other countries or cities in the last 15 years?	Yes	25 (3.8%)	6 (1.0%)
	No	633 (96.2%)	601 (99.0%)
Do you know people who left ~ 15 years ago and have returned to live here?	Yes	50 (7.6%)	5 (0.8%)
	No	507 (77.1%)	366 (60.3%)
	Don't know	101 (15.3%)	236 (38.9%)

Discussion

This study evaluated knowledge, attitudes, and practices among children and adolescents in the former onchocerciasis-endemic states of Oaxaca and Chiapas, Mexico, within a post-verification context. Although WHO certified the elimination of onchocerciasis in Mexico over a decade ago, elimination does not mark the end of programmatic responsibility. Continued surveillance and sustained community awareness remain essential to detect any renewed transmission promptly and to support long-term elimination. Assessing KAP in this population, particularly those born around or after the time of elimination, provides insight into behavioral patterns that could influence future vulnerability and helps inform long-term prevention strategies.

Awareness of onchocerciasis was low in both study regions, contrasting with the higher levels commonly reported in actively endemic settings in sub-Saharan Africa (Bernard et al., 2024; Dauda et al., 2025; Domche et al., 2021; Pierre et al., 2025). This reduced awareness is likely attributable to the post-verification context, where interruption of transmission, cessation of mass drug administration, and the absence of visible disease burden have resulted in reduced community awareness. In addition, structured health education activities have largely disappeared, particularly affecting cohorts born in the post-verification period. Knowledge of onchocerciasis increased significantly with age in Oaxaca and with educational attainment in Chiapas ($p < 0.05$), suggesting that individuals born during or shortly after the post treatment surveillance (PTS) and PES phases have comparatively better knowledge than those born in the post-verification period. A similar pattern has been reported in Cameroon, where older participants were more likely to demonstrate adequate knowledge of the disease (Domche et al., 2021). In several endemic settings where awareness of onchocerciasis is relatively high, knowledge of the disease vector remains poor, and the present findings are consistent with this pattern. When prompted to describe the mode of transmission, only 9.3% in Oaxaca and 4.3% in Chiapas correctly identified the blackfly as the vector. Approximately half referred only to a generic “fly,” while 17.5% and 7.7% of respondents in Oaxaca and Chiapas, respectively, incorrectly attributed transmission to mosquitoes. The majority were unable to correctly name the vector. Similar deficiencies in vector knowledge have been reported elsewhere. In Cameroon, only 23.3% of respondents correctly identified the blackfly as the vector despite high overall awareness of onchocerciasis (Domche et al., 2021). Another study from Cameroon found that many community members associated blackfly bites with malaria rather than onchocerciasis with only 9.2% correctly associating it with onchocerciasis (Pierre et al., 2025). Likewise, in Ethiopia, 88.8% of respondents held at least one misconception regarding the cause of the disease (Weldegebreal et al., 2014). The limited understanding of the vector observed in the present study is further reflected by the large proportion of participants who reported visiting areas near blackfly breeding sites without recognizing the associated transmission risk. While such limited knowledge of the disease and vector observed in this study is not unexpected from this demography in a post-verification setting, it remains epidemiologically important, as insufficient awareness may reduce adoption of protective behaviors against blackfly bites. Children and adolescents who do not recognize the vector are less likely to adopt protective behaviors that reduce exposure to bites. Because the principal vector, *Simulium ochraceum* sensu lato, continues to bite humans in the formerly endemic foci of Mexico, this combination of frequent exposure and minimal protection indicates that opportunities for human–vector contact persist even in the absence of transmission (Fernández-Santos et al., 2020). In the current absence of the parasite, this contact carries no transmission risk. However, should *O. volvulus* be reintroduced, low protective behavior in a population with minimal acquired knowledge could facilitate re-establishment. Similarly, reduced vaccination coverage has contributed to a resurgence of yellow fever virus given the establishment of competent mosquito species that feed on humans in Africa and South America (Lindsey et al., 2022).

Despite the limited knowledge observed, attitudes were comparatively positive in both regions. Most participants indicated that they would be willing to take prescribed medication if required, report

suspicious nodules to health authorities and receive visits from health personnel. Similar observation has been reported in Guatemala (Jr et al., 2016). These findings suggest that positive health-seeking attitudes may persist even in populations with limited understanding of the disease and its transmission. Similar observations have been reported in endemic communities in Nigeria where willingness to participate in mass drug administration (MDA) campaigns remained high despite substantial gaps in knowledge of the disease and its vector (Dauda et al., 2025). This apparent disconnect between knowledge and attitudes may reflect the enduring trust that communities place in local health systems and public health programmes. A plausible explanation for the favorable attitudes is that health personnel and vector brigades are members of the community, fostering confidence in their recommendations irrespective of participants' knowledge of onchocerciasis and transmission mode. A positive preventive measure documented in this study is the wearing of protective clothing. Limited adoption of protective measures beyond clothing has likewise been described in endemic African communities exposed to high blackfly densities (Domche et al., 2021; Weldegebreab et al., 2016; Yirga et al., 2008). The divergent determinants of protective behavior, increasing with education in Oaxaca but declining with age in Chiapas ($p < 0.05$). This is consistent with education being a recognized correlate of preventive behavior in KAP studies of onchocerciasis and other NTDs (Domche et al., 2021).

Self-reported histories of onchocerciasis and characteristic clinical manifestations were rare. Few participants reported previous diagnosis, affected family members, visual impairment, nodules, or skin changes consistent with onchocerciasis. However, these isolated responses should not be interpreted as evidence of renewed transmission because they were not clinically verified, and previous post-elimination and post-verification surveillance found no evidence of transmission in the former endemic foci (Fernández-Santos et al., 2020; Rodríguez-Pérez et al., 2015). The low occurrence of symptoms among participants provides additional indirect evidence supporting the sustained interruption of transmission. The observation that many participants were uncertain whether they had previously received ivermectin is not surprising given the age profile of the study population, as most were born after mass drug administration had ceased or were too young to recall treatment activities. This uncertainty reflects the emergence of a post-elimination birth cohort with little lived experience of onchocerciasis. As institutional and community memory of the disease fades, targeted health education is likely to become increasingly important for sustaining awareness of the disease and its vectors, and for ensuring that any re-emergent case is recognized and reported.

A limitation of this study was the use of parental or guardian assistance for younger participants, which may have introduced proxy-reporting bias and influenced their responses. Findings for this age group, particularly the observed associations between age and knowledge, should therefore be interpreted cautiously, as they may partly reflect differences in questionnaire administration rather than true differences in knowledge.

In conclusion, children and adolescents in the formerly endemic regions of Oaxaca and Chiapas had limited knowledge of onchocerciasis, with substantial misconceptions regarding its vector and transmission. Although attitudes toward surveillance and control activities were generally favorable,

preventive practices remained limited despite reported exposure to blackfly breeding sites. These findings support the integration of age-appropriate health education into sustained post-elimination surveillance to maintain community awareness and protect Mexico's long-term elimination gains.

Abbreviations

World Health organization (WHO)

Neglected Tropical Diseases (NTD)

Onchocerciasis Elimination Program for the Americas (OEPA)

Mass Drug Administration (MDA)

Post Treatment Surveillance (PTS)

Post Elimination Surveillance (PES)

Post Verification Surveillance (PVS)

Declarations

Human Ethics and Consent to Participate

The study protocol was reviewed and approved by the Research Ethics Committee of Promotora Médica Aguascalientes (Ref. No. 2897.ceipma.2024). Written informed consent was obtained from a parent or legal guardian of each participant after a clear explanation of the study's objectives, procedures, the voluntary nature of participation, and the right to withdraw at any time without consequence. In addition, age-appropriate written assent was obtained from each child before enrolment. All data were collected anonymously, handled confidentially, and used solely for the purposes of this study. The study was conducted in accordance with the principles of the Declaration of Helsinki (1964) and its subsequent revisions.

Consent for publication

Not Applicable

Availability of data and materials

The dataset supporting the conclusions of this article is included within the article as Supplementary file 2.

Competing interests

The authors have declared that no competing interests exist.

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Author's contributions

NAFS and MARP designed the study methodology. NAFS and ATR performed the field work. OGD, FOR, and GLH analyzed and wrote the manuscript. MJPP, FCM, and MAPP helped design and review the questionnaire tool. MARP, CAGM, and JFVA supervised the field work and reviewed the manuscript. All authors read and approved the final manuscript.

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Figures

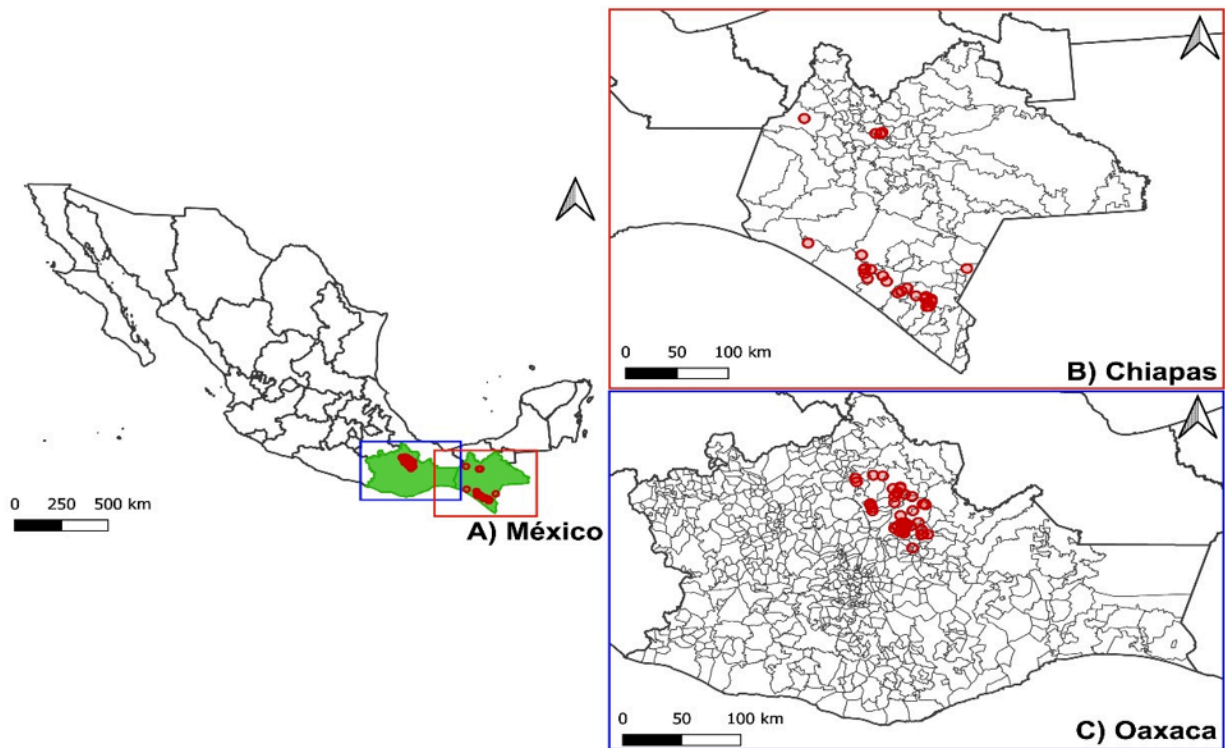


Figure 1

Geographical location of the study sites within the formerly endemic onchocerciasis foci of Oaxaca and Chiapas, Mexico. Map created with QGIS 3.44 (<https://qgis.org>) using country boundary shapefiles from Natural Earth.

Supplementary Files

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