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Attitudes and acceptance of vaccination against neglected tropical diseases: A multi-country study in Asia

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ABSTRACT

This study aims to explore the willingness of individuals to be vaccinated against NTDs in Asian countries and China. Between June and December 2023, an anonymous cross-sectional survey was carried out in five Asian countries alongside China. Overall, 48.4% indicated being somewhat willing and 29.2% expressing extreme willingness to receive NTDs vaccination. High attitude scores (adjusted odds ratio [aOR] = 1.54, 95% confidence interval (CI): 11.35–1.75) was associated with higher willingness to be vaccinated against NTDs. The odds of accepting the NTDs vaccine increased among individuals without occupational exposure to NTDs (aOR = 1.46, 95% CI: 1.27–1.68). Those residing in very clean environments exhibited heightened odds of willingness (aOR = 2.94, 95% CI: 2.10–4.11), whereas individuals in somewhat dirty environments demonstrated reduced odds of willingness (aOR = 0.74, 95% CI: 0.56–0.98) compared to the baseline group (very dirty local environment). Moreover, a higher score in sanitation facilities also correlated with increased odds of willingness to receive the NTDs vaccine (aOR = 1.41, 95% CI: 1.21–1.64). The study highlighted key strategies for improving NTDs vaccine uptake in Asian countries, including China, such as fostering positive attitudes toward the vaccine and enhancing perception of infection risks.

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Background

Neglected tropical diseases (NTDs) encompass a cluster of infectious diseases categorized as "neglected" due to their historical lack of prioritization by global governments and health organizations. NTDs pose a significant burden on public health, particularly in low- and middle-income countries. They are prevalent in tropical and subtropical regions, frequently impacting impoverished and marginalized communities.[1]

More than one billion individuals worldwide are affected by one or more NTDs.[2] Over 830 million children in developing nations being among the afflicted[3] with one or more of the most common NTDs, namely Ascariasis (roundworm), transmitted via contaminated food or water, leading to intestinal inflammation, obstruction, and malnourishment; Trichuriasis (whipworm), spread through contaminated food or water, resulting in growth delays, malnutrition, and anemia; and Hookworm, entering the body through skin exposure to larvae in contaminated soil, causing effects similar to Trichuriasis; Lymphatic filariasis (elephantiasis), transmitted by mosquitoes, induces swelling in body parts, especially the arms and legs, causing disfigurement and permanent disabilities; Onchocerciasis (river blindness), transmitted by infected black flies, leads to blindness and skin lesions. Schistosomiasis (snail fever), carried by freshwater snails, can cause anemia, malnutrition, and extensive organ damage; and Trachoma, an eye infection caused by the bacterium Chlamydia trachomatis, stands as the foremost preventable cause of blindness globally.[3] Notable, left untreated, these diseases can lead to illness, disability, and stigma, hindering children's education and limiting adult productivity.

Vaccination is one of the most efficient ways in prevention and control of infectious diseases and history has shown that many serious infections can be prevented by immunization.[4–6] Despite numerous advances in vaccine technology over the past few decades, the development of a safe and effective vaccine remains a significant challenge.[7] Various obstacles, such as ensuring antigen stability, safety, and immunogenicity, can impede the development of novel antigen delivery technologies.[8] Furthermore, challenges vary across diseases; for instance, the emergence of new strains or rapidly evolving

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pathogens.[9,10] Currently, there are no preventive nor therapeutic vaccines available for the vast majority of NTDs; nonetheless, several vaccines against NTDs have been developed, with some already in use or under development.[11] Examples include the yellow fever vaccine, which is highly effective against mosquito-borne viruses prevalent in tropical regions of Africa and South America.[12,13] Vaccines also exist for Japanese encephalitis,[14] cholera,[15] typhoid fever,[16] meningococcal meningitis,[17] and dengue fever.[18] Research is ongoing on vaccines against other NTDs such as schistosomiasis,[19] leishmaniasis,[20] and malaria.[21,22]

While vaccines for certain NTDs are currently available and others are in the process of development, the primary obstacle may lie in the acceptance and uptake of these vaccines. Vaccine confidence has consistently presented challenges,[23] particularly in the context of NTDs where acceptance may be further complicated by their neglected status. There is limited literature addressing the acceptance of vaccines for NTDs, which could play a crucial role in enhancing global health, especially among the world's most impoverished population.[24] Hence, it is crucial to comprehend the confidence surrounding NTD vaccines. Moreover, some individuals may deem NTD vaccines unnecessary due to their perceived rarity, thus attitudes toward NTD vaccines themselves also impact acceptance. Considering its rarity, an individual who is free from occupational risks resides in a hygienic environment, or consistently practices preventive behaviors may foster the perception that vaccination is unnecessary. Therefore, understanding the factors that influence vaccination acceptance unavoidably entails considerations of knowledge and risk perception[25,26] which similarly applied to the acceptance of NTDs vaccines in the present study.

A recent report highlighted that the prevalence of NTDs remains significant in both China and several Asian countries such as Bangladesh, Malaysia, Thailand, Cambodia, and Lao PDR, disproportionately impacting vulnerable and impoverished communities, including children under 5 y old and individuals aged 60 and above.[27,28] Hence, this study carried out a multinational investigation across several Asian countries and China to evaluate the diverse perspectives and levels of acceptance concerning vaccination against NTDs.

Methodology

Study design and participants

A survey was conducted on the general population of six countries, comprising five Asian countries (Malaysia, Vietnam, India, Pakistan, Bangladesh) and China. Data were collected through a self-administered online survey questionnaire, using a nonprobability convenience sampling method. Data collection was carried out during the period from June to December 2023. The inclusion criteria were that individuals had to be 18 y or older, a citizen of the included countries.

Sample sizes for each country were determined using the formula: $n = Z^2 P(1 - P)/d$.[2] With a 0.05 margin of error, a 95% confidence interval, and a response distribution of 50%, the calculated sample size was 384. This size was then multiplied by the predicted design effect of two to accommodate convenience sampling and an online survey.[29] Consequently, the minimum survey sample size for each country was set to 768 (384×2) participants.

Researchers from all countries were briefed to disseminate the survey link across various cities in their respective countries. Data collection utilized Google Forms, which were circulated through social media channels (including repeated posts on Facebook, Twitter, WhatsApp, and WeChat).

Measures

Participants completed an online questionnaire (S1 File) that contained assessments of (1) demographic background, (2) occupational risk, (3), environment hygiene, (4) sanitation facilities, (5) preventive behavior related to risk of acquiring NTDs, (6) attitudes toward vaccination against NTDs, and (7) acceptance NTDs vaccine.

Demographic inquiries encompass four questions that inquire about age, gender, marital status, and residential area. Occupational risk questions investigate whether participants are currently employed in agriculture, forestry, fisheries-related occupations, or other related sectors. Questions on environmental hygiene are a one-item question that evaluated participants' perception of cleanliness in their local surroundings. Response options included "very clean," "somewhat clean," "somewhat dirty," and "very dirty." Four questions were used to assess the level of wastewater in the local environment, covering areas such as human or animal feces, domestic waste, agricultural waste, and water stagnation. Participants indicated their frequency of observation using options: "never," "rarely," "sometimes," and "always," corresponding to scores of 0, 1, 2, and 3, respectively. Each question was scored individually, leading to a total possible score ranging from 0 to 12.

Inquiries regarding sanitation facilities involved participants describing the amenities present in their residences, including availability of clean water, waste disposal systems, wastewater management, and trash handling facilities. They were asked to evaluate these amenities using a scale ranging from poor to excellent, with scores of 1 to 4, respectively. The resulting assessment allowed for a total score range of 4 to 16, where higher scores indicated better sanitation facilities.

Behavioral questions evaluate participants' practices in preventing NTDs through a set of five questions. These questions gauge practices such as handwashing before meals, handwashing after using the restroom, walking barefoot outside, consuming clean drinking water, and consuming unwashed, raw, or unhygienically prepared fruits and vegetables. Participants select responses from options: "never," "rarely," "sometimes," and "always," corresponding to scores of 0, 1, 2, and 3, respectively. Each item is scored, resulting in a total possible score ranging from 0 to 15, where a higher score indicates a greater degree of positive behavior. In this context, one question item was scored in reverse.

Attitudes toward vaccination against NTDs consists of five self-developed questions assessing participants' views about NTDs vaccination. Questions include asking participants if NTDs vaccination is needed as NTDs are not commonly heard in the community, NTDs vaccination is

not needed as it is not a serious risk to public health, NTDs vaccination is not needed as the risk of infection is low, alternative to vaccination such as medicine or drugs are much safer, and vaccination against NTDs may result in immunity that lasts for a long time. Participants select responses from options: strongly disagree, disagree, agree, and strongly agree, corresponding to scores of 1, 2, 3, and 4, respectively. Each item is scored, resulting in a total possible score ranging from 5 to 20, where a higher score indicates a higher positive attitude toward NTDs vaccines. Four question items were scored in reverse. The final section of the questionnaire evaluates participants' willingness to vaccinate themselves against NTDs under the condition of free vaccination. Option response 'extremely willing,' 'somewhat willing," "undecided," "somewhat not willing," and "not willing."

The questionnaire was initially formulated in English. For surveys conducted in China, Malaysia, Vietnam, and Bangladesh, respondents had the option to answer the questions in their native language. However, in surveys conducted in India, the English version of the questionnaire was utilized. The questions underwent content validation by subject matter experts. Translation into target languages followed a standard forward-backward translation process conducted by native speakers. Additionally, the translated questionnaire underwent validation by independent bilingual native speakers. Pilot testing of all translated versions of the questionnaire was conducted in their respective countries prior to administration. To ensure valid and reliable responses, we conducted data cleaning on the survey prior to data analysis. This process involved removing instances of straightlining and duplicate responses.

Statistical analysis

Descriptive statistics were calculated for the sample demographic characteristics, and the independent variables. The categorical variables are presented as frequencies and percentages, whereas the quantitative variables are presented as means and standard deviations when they were normally distributed; otherwise, they are shown as medians and interquartile ranges (IQRs). Pearson's chi-square test was used for the categorical variables, and Fisher's exact test was applied in cases where the frequency of one of the analyzed groups was less than 5.

The relationships between the factors and NTDs vaccine acceptance are presented as odds ratios (ORs) and 95% confidence intervals (CIs). Univariate and multivariable analyses were used to determine the factors associated with willingness to be vaccinated against NTDs (1 = extremely/somewhat willing; 0 = undecided/somewhat/not willing and undecided). The prediction model was constructed by multivariable logistic regression analysis. All factors that gave results in the univariate analyses below the significance level of 0.05 were included in a multivariate analysis. Hosmer – Lemeshow goodness-of-fit tests were used to ensure that the models adequately fit the data. Statistical significance was established at a p value < 0.05. All analyses were also conducted using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

Results

In total, 5951 responses from 5 Asian countries (namely Bangladesh, India, Malaysia, Pakistan, and Vietnam) and China were received. The sample size of the participatory countries ranges from 760 (India) to 1700 (China). The demographics of the overall participants and the descriptive responses to the survey questions are shown in the first and second columns of Table 1. Most of the participants in the study fall within the age range of 18–30 y (52.8%) and 31–50 y (40.7%). On the whole, majority (72.7%) reported current job not related to agriculture, forestry, or fisheries. The majority perceived the level of cleanliness of their local environment as somewhat clean (44.5%) or dirty (31.1%).

The overall levels of wastewater in the local environment across countries are detailed in Figure 1, while country-specific findings are presented in Supplement 2 (S2 File). The responses across countries indicate a moderate level, with nearly equal proportions reporting either sometimes/always or never/rarely across all four items. The scores for items related to wastewater in local environments range from 0 to 12, with a median of 6. Wastewater contamination levels varied significantly across countries. As shown is Supplement 2, India, Pakistan, and Vietnam had high wastewater contamination, Bangladesh, and Malaysia showed moderate levels, and China had the lowest contamination. India and Pakistan reported the highest levels, with human and animal feces frequently observed as "always" (78.4% in India, 7.0% in Pakistan) or "sometimes" (67.3% in Pakistan). Domestic waste was also highly prevalent, with 46.8% of respondents in India and 21.3% in Pakistan reporting "always." Vietnam also showed high contamination, particularly for agricultural (51.1% "always") and domestic waste (57.0% "always"). Bangladesh and Malaysia exhibited moderate levels, with human/animal feces "always" present in 28.9% and 17.2% of cases, respectively, while stagnant water was frequently observed in both countries (34.6% in Bangladesh, 23.6% in Malaysia). China reported the lowest contamination levels, with most respondents indicating "never" or "rarely" across all categories, such as human/animal feces being "never" observed by 34.7% and "rarely" by 47.7%.

Findings on sanitation facilities are shown in Figure 2. Among the overall respondents, 15.4% indicated poor disposal facilities, while 35.3% reported them as fair. There is an almost equal proportion, approximately 42%, of respondents rated their clean water, wastewater disposal, and trash facilities in their residences as either poor or fair. The total score of sanitation facilities ranges from 4 to 16, with a median of 11. Given that the median score is slightly above the upper end of the range, it suggests that, on the whole, the sanitation facilities are relatively good. The country-specific findings are presented in Supplement 3 (S3 File). Sanitation facility quality varied across countries. China and Malaysia had the best overall sanitation, with the majority rating their clean water, disposal, wastewater, and trash facilities as "good" or "excellent." Bangladesh showed moderate sanitation, with mixed

Table 1. Factors associated with the willingness to be vaccinated against neglected tropical diseases (NTDs) ($N = 5951$).

		Univariable analysis			Multivariable analysis
	Frequency (%)	Undecided/Somewhat not willing/Not willing ($n = 1334$)	Extremely willing/ Somewhat willing ($n = 4617$)	p-value	Extremely willing/ Somewhat willing vs Undecided/Somewhat not willing/Not willing
					aOR (95% CI)
Socio-demographic characteristics					
Age group (y)					
18–30	3145 (52.8)	734 (23.3)	2411 (76.7)	.002	1.20 (0.92–1.57)
31–50	2420 (40.7)	494 (20.4)	1926 (79.6)		1.36 (1.06–1.75)*
>50	386 (6.5)	106 (27.5)	280 (72.5)		Reference
Gender					
Male	3158 (53.1)	737 (23.3)	2421 (76.7)	.071	
Female	2793 (46.9)	597 (21.4)	2196 (78.6)		
Marital status					
Ever married	3144 (52.8)	651 (20.7)	2493 (79.3)	.004	1.24 (1.06–1.45)**
Never married	2807 (47.2)	683 (24.3)	2124 (75.7)		Reference
Residence area					
Urban	2861 (48.1)	587 (20.5)	2274 (79.5)	p<.001	1.30 (1.10–1.53)**
Sub-urban	1921 (32.3)	369 (19.2)	1552 (80.8)		1.78 (1.49–2.12)***
Rural	1169 (19.6)	378 (32.3)	791 (67.7)		Reference
Occupational risks					
Current job related to					
Yes	1624 (27.3)	457 (28.1)	1167 (71.9)	p<.001	Reference
No	4327 (72.7)	877 (20.3)	3450 (79.7)		1.46 (1.27–1.68)***
Environment hygiene					
Perceived level of cleanliness in local environment					
Very clean	1133 (19.0)	105 (9.3)	1028 (90.7)	p<.001	2.94 (2.10–4.11)***
Somewhat clean	2650 (44.5)	565 (21.3)	2085 (78.7)		1.12 (0.85–1.48)
Somewhat dirty	1849 (31.1)	583 (31.5)	1266 (68.5)		0.74 (0.56–0.98)*
Very dirty	319 (5.4)	81 (25.4)	238 (74.6)		Reference
Wastewater in local environment					
Total score					
0–5	2263 (38.0)	427 (18.9)	1836 (81.1)	p<.001	0.93 (0.80–1.09)
6–12	3688 (62.0)	907 (24.6)	2781 (75.4)		Reference
Sanitation facilities					
Total score					
4–10	3207 (53.9)	861 (26.8)	2346 (73.2)	p<.001	Reference
11–16	2744 (46.1)	473 (17.2)	2271 (82.8)		1.41 (1.21–1.64)***
Behavior					
Preventions against NTDs infections					
Total score					
3–11	2276 (38.2)	482 (21.2)	1794 (78.8)	.073	
12–15	3675 (61.8)	852 (23.2)	2823 (76.8)		
Attitudes towards NTD vaccines					
Total attitude score					
5–12	2370 (39.8)	671 (28.3)	1699 (71.7)	p<.001	Reference
13–20	3581 (60.2)	663 (18.5)	2918 (81.5)		1.54 (1.35–1.75)***

* $p < .05$, ** $p < .01$, *** $p < .001$; Hosmer–Lemeshow test, chi-square: 13.467, p-value: .097; Nagelkerke R^2: 0.097.

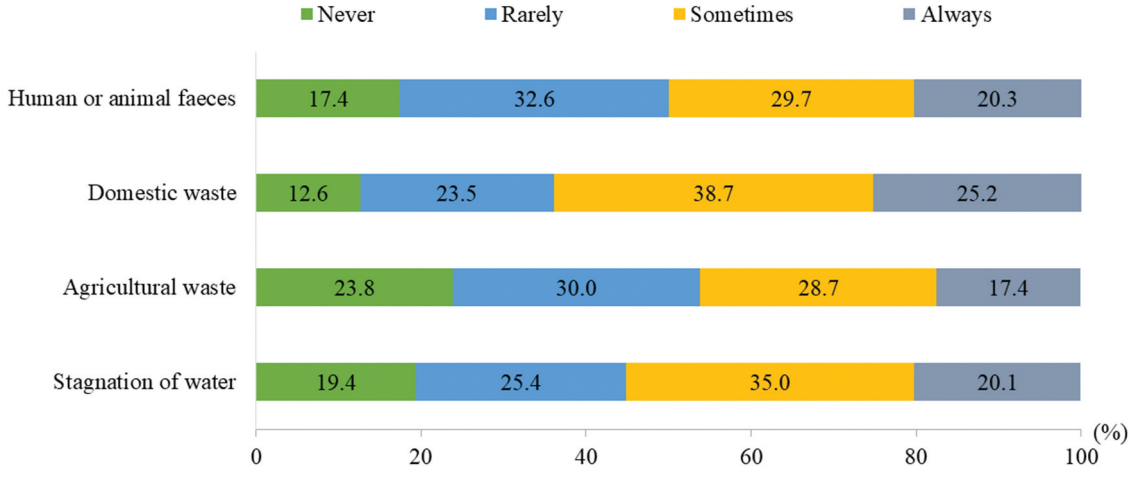

Figure 1. Level of wastewater in local environment ($N = 5951$).

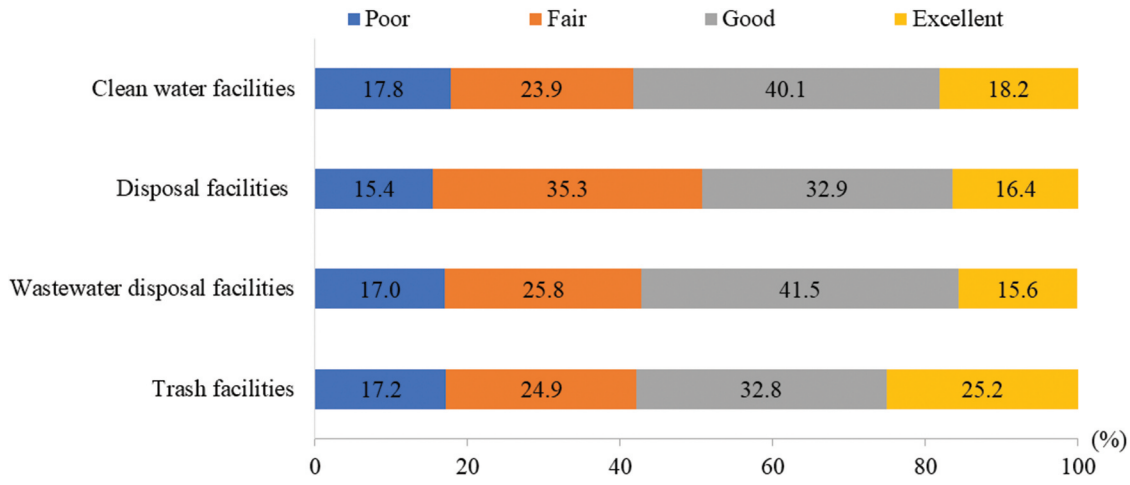

Figure 2. Sanitation facilities in residences ($N = 5951$).

responses, whereby clean water facilities were rated as "good" (42.0%) but trash facilities had a higher percentage of "poor" ratings (35.5%). India had disparities, with poor clean water facilities (64.9%) but good wastewater disposal (70.3%) and excellent trash management (66.3%). Pakistan and Vietnam had the poorest sanitation, with a significant portion reporting "poor" or "fair" ratings, particularly in disposal and wastewater facilities.

Figure 3 displays the behavioral practices aimed at preventing NTDs infection across all countries. Notably, more than half of the participants reported consistently washing their hands before eating (67.9%), after using the toilet (65.2%), and drinking clean and safe water (61.8%). The scores for these behavioral items range from 3 to 15, with a median score of 12. This median score indicates that the majority of participants are adopting behaviors to prevent NTDs infection, suggesting a commendable adherence to recommended practices. The country-specific findings are presented in Supplement 4 (S4 File). Behavioral practices against NTDs infection varied across countries. On the whole, Malaysia had the best hygiene practices, followed by India and Bangladesh, while China, Vietnam, and Pakistan had relatively lower adherence, particularly in food and barefoot practices. Malaysia showed the highest adherence to preventive practices, with 87.4% always washing hands before eating, 88.3% before using the toilet, and 91.3% drinking clean water. India also had strong handwashing behavior, with 87.5% always washing hands before eating, but only 37.8% did so before using the toilet. Bangladesh and Pakistan exhibited moderate hygiene behaviors, with a majority always washing hands before eating (72.7% and 66.5%, respectively) and drinking clean water (68.5% and 67.6%). China and Vietnam had lower adherence to hygiene practices, with only 48.9% and 56.8% always washing hands before eating and 52.6% and 59.8% drinking clean water. Walking barefoot was more common in Pakistan (57.6%) and China (44.3%), while Vietnam (62.7%) had the highest rate of sometimes walking barefoot. Consumption of unwashed or unhygienic food was highest in Malaysia (52.9%) and China (45.2%), whereas Pakistan (62.9%) had the highest rate of sometimes consuming unwashed food.

Figure 4 shows attitudes toward vaccination against NTDs across all countries. Considerable proportion reported agree or strongly agree that the vaccines are not needed as NTDs are not commonly heard of (37.5%), not a serious risk to public health (38.7%), the chance of infection is low (41.3%), and

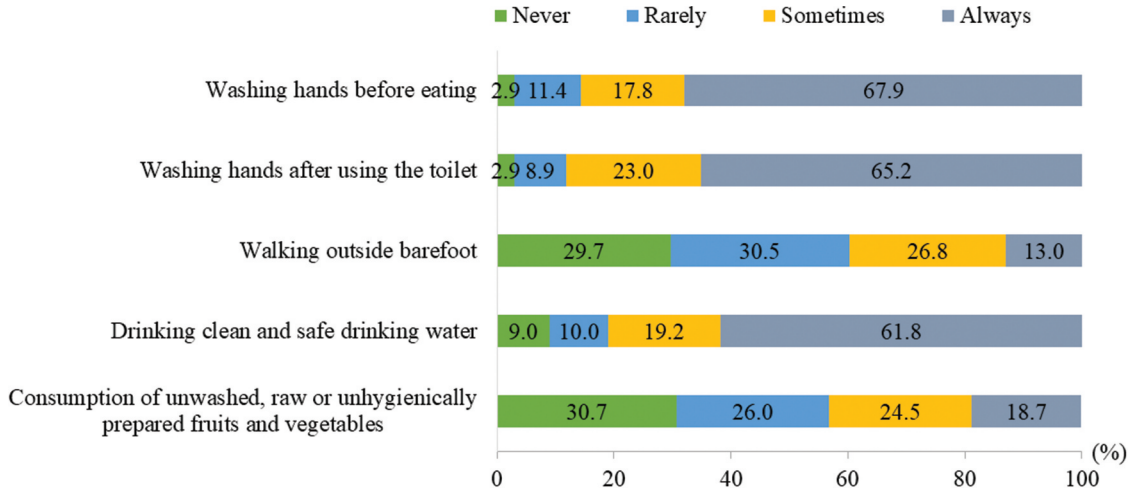

Figure 3. Behavioral practices against neglected tropical diseases (NTDs) infection ($N = 5951$).

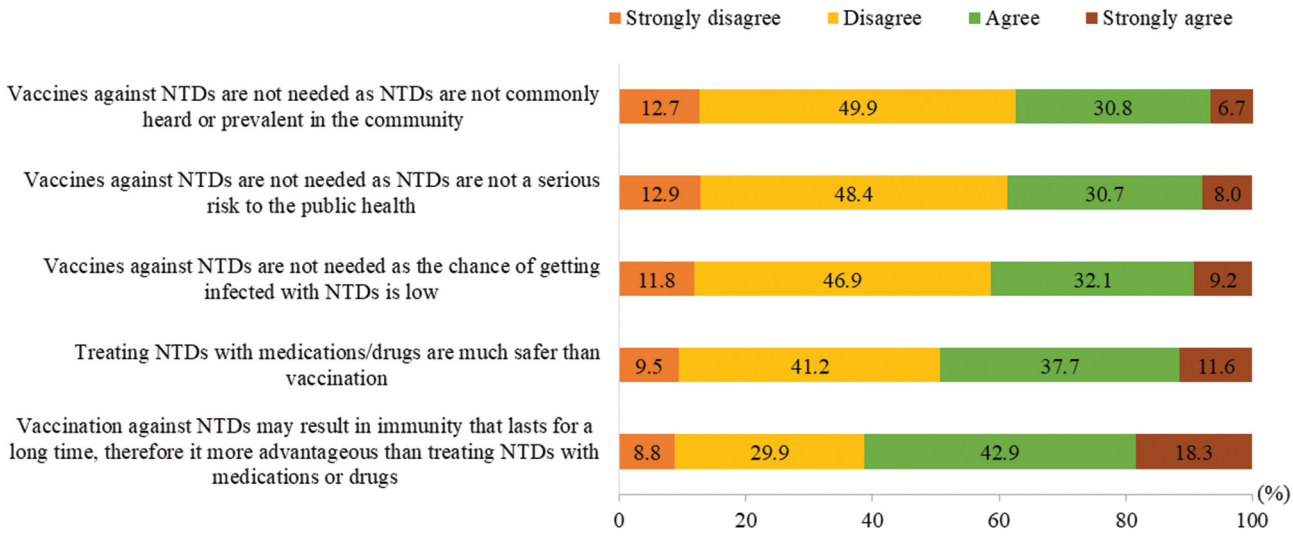

Figure 4. Attitudes toward vaccination against neglected tropical diseases (NTDs) ($N = 5951$).

treating with drugs is much safer than vaccination (49.3%). The country-specific findings are presented in Supplement 5 (S5 File). In Bangladesh, respondents were divided, with around 60% disagreeing that NTD vaccines were unnecessary due to low prevalence or risk, while 30–40% agreed with these statements. Similarly, in China, over half of respondents (52–57%) disagreed with the notion that NTD vaccines were unnecessary, but a notable minority (15–20%) agreed. India exhibited the highest level of support for NTD vaccines, with 62–82% agreeing that vaccines are needed, and only a small percentage (6–12%) disagreeing. Malaysia showed moderate skepticism, with 50–55% disagreeing that NTD vaccines were unnecessary and about 25–30% agreeing. Pakistan demonstrated the strongest rejection of the idea that NTD vaccines are unnecessary, with 71–79% disagreeing across all statements and very few (1–17%) agreeing. Vietnam showed a more mixed response, with 30–58% disagreeing and 29–49% agreeing on the necessity of NTD vaccines. Regarding treatment preferences, Bangladesh, Malaysia, and Vietnam showed moderate-to-high agreement (35–49%) that vaccines confer long-term immunity, while Pakistan showed the strongest agreement (37%), followed by India (68%) and Malaysia (54.5%).

Figure 5 displays the distribution of overall and country-specific responses regarding the willingness to receive vaccination against NTDs. The majority indicated being somewhat willing (48.4%), with 29.2% expressing extreme willingness. Meanwhile, 17.8% reported being undecided, 2.8% stated they were somewhat unwilling, and 1.8% expressing unwillingness. By individual countries, Bangladesh recorded the highest proportion of expressed willingness among participants (66.6%), followed by Malaysia (30.0%). Vietnam (23.0%) and India (23.7%) reported near similar levels of willingness, while China's willingness was slightly lower (22.2%). The lowest recorded willingness was from Pakistan (14.7%). Despite relatively lower proportions reporting willingness, a relatively high proportion of participants from India (65.3%), Pakistan (66.2%), and China (61.2%) noted being somewhat willing to receive NTDs vaccine.

Table 1 shows the univariable and multivariable analyses of factors associated with willingness to be vaccinated against

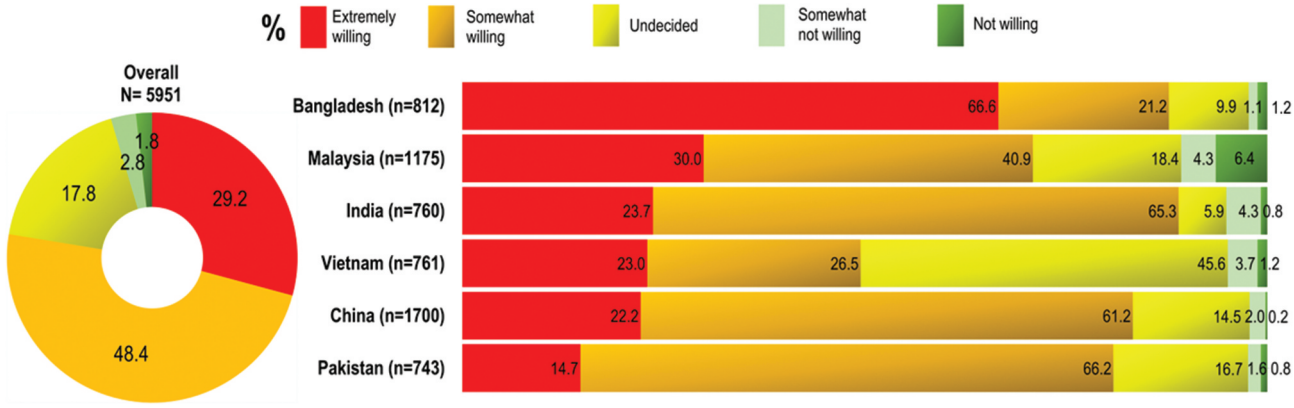

Figure 5. Overall and country-specific willingness to be vaccinated against neglected tropical diseases (NTDs).

NTDs. A total of 1334 individuals (22.4%) reported undecided/somewhat not willing/not willing, while 4617 individuals (77.6%) expressed extremely willing/somewhat willing to receive NTDs vaccination. In a multivariable analysis, the age group of 31–50 y demonstrated a greater inclination toward NTDs vaccination compared to those aged over 50 y (adjusted odds ratio [aOR] = 1.36, 95% confidence interval [CI] 1.06–1.75). A higher likelihood of being willing to be vaccinated against NTDs was observed among those who were married than never married (aOR = 1.24, 95% CI1.06–1.45). Residing in urban (aOR = 1.30, 95% CI: 1.10–1.53) and suburban areas (aOR = 1.78, 95% CI: 1.49–2.12) than in rural areas were associated with higher odds of increased willingness to be vaccinated against NTDs. The odds of willingness to accept the NTDs vaccine increased among those without occupational exposure to NTDs (aOR = 1.46, 95% CI: 1.27–1.68). There was an inconsistent trend in the level of cleanliness in the local environment and willingness to be vaccinated against NTDs, where individuals in very clean environments reported higher odds of willingness (aOR = 2.94, 95% CI: 2.10–4.11), whereas those in somewhat dirty environments reported lower odds of willingness (aOR = 0.74, 95% CI: 0.56–0.98) compared to the reference group (very dirty local environment). Higher sanitation facilities score was also associated with higher odds of willingness to be vaccinated against NTDs (aOR = 1.41, 95% CI: 1.21–1.64). Multivariable logistic regression analysis showed that individuals with attitudes scores of 13–20 had higher odds of being willing to be vaccinated against NTDs (aOR = 1.54, 95% CI 1.35–1.75) than those with scores of 5–12. Analyses of factors associated with willingness to be vaccinated against NTDs by countries are shown in Supplement 6 (S6 File). There are several common factors influencing willingness to vaccinate against neglected tropical diseases (NTDs) across countries. Perceived environmental cleanliness was a key determinant, with individuals perceiving their environment as very clean showing higher willingness in China (aOR: 7.72, 95% CI: 3.93–15.15, $p < .001$) and Pakistan (aOR: 6.91, $p < .05$). Preventive behaviors and positive vaccine attitudes consistently increased willingness across multiple countries, including China (aOR: 1.69, 95% CI: 1.20–2.38, $p < .01$; aOR: 2.70, 95% CI: 2.00–3.63, $p < .001$), Malaysia (aOR: 3.90, 95% CI: 2.95–5.16, $p < .001$), Pakistan (aOR: 2.16, $p < .01$), and Vietnam (aOR: 3.77, $p < .001$; aOR: 1.96, $p < .001$). Additionally, better sanitation facilities were associated with greater willingness in Malaysia (aOR: 1.41, 95% CI: 1.06–1.88, $p < .05$), Pakistan (aOR: 2.42, $p < .05$), and Vietnam (aOR: 5.93, $p < .001$). By demographics, marital status played a role, as ever-married individuals were more willing to vaccinate in China (aOR: 1.58, 95% CI: 1.19–2.10, $p < .01$) and India (aOR: 1.92, 95% CI: 1.15–3.19, $p < .05$), while Vietnam showed the opposite trend, with never-married individuals being more willing (aOR: 3.10, $p < .001$).

Discussion

The findings of this study highlight a positive predisposition toward NTD vaccination, with a notable proportion of respondents expressing willingness, and a substantial percentage showing strong endorsement and readiness for preventive measures. However, the presence of undecided and unwilling individuals underscores potential barriers and low level of vaccine confidence that need addressing. Understanding the underlying reasons behind this lack of confidence is crucial for developing targeted interventions to promote vaccine uptake. Future studies should focus on exploring the specific determinants influencing NTDs vaccination hesitancy and designing interventions tailored to address these factors, ultimately advancing efforts to combat NTDs effectively.

The variation in willingness across surveyed nations highlights the influence of diverse factors on vaccination against NTDs willingness. Bangladesh, for instance, exhibits high levels of willingness. Bangladesh faces a significant burden of NTDs, including lymphatic filariasis, visceral leishmaniasis, soil-transmitted helminthiasis, and dengue fever.[30,31] Lymphatic filariasis, for instance, has been a major public health problem in Bangladesh for more than a century.[32] These diseases contribute to morbidity and mortality, particularly in rural areas with poor sanitation and hygiene.[32] The burden of NTDs in Bangladesh is exacerbated by factors such as poverty, limited access to healthcare services, inadequate sanitation infrastructure, and environmental conditions conducive to disease transmission.[31] This perhaps contributes to a higher level of willingness to accept NTD vaccines.

Pakistan contributes significantly to the global disease burden of leishmaniasis, leprosy, trachoma, and soil-transmitted helminths,[33] and other NTDs such as dengue, chikungunya, and rabies are also prevalent.[34,35] Despite this, our study found that a higher proportion reported somewhat willing and a smaller proportion reported being willing to receive NTDs vaccination, hence warranting comprehensive public health campaigns to raise awareness about the importance of NTD vaccination.

Similarly, nearly three times as many participants in China reported being somewhat willing to receive NTDs vaccination compared to those who were willing. NTDs have been significant public health challenges in China. At least 11 NTDs, including trachoma, lymphatic filariasis, schistosomiasis, and visceral leishmaniasis, have been endemic in various regions of the country, however the burden of NTDs in China has decreased significantly.[36] China has progressively elevated public investment in neglected disease-related innovation and research.[37] Owing to the commitment of the China's government and the application of multiple strategies for disease control, China has achieved unprecedented development and achievements in the control and elimination of NTDs.[38] This perhaps influenced the higher proportion reporting a degree of somewhat willingness in this study.

Likewise other countries, NTD epidemiology in China is characterized by a higher prevalence in the North than in the South and a higher prevalence in rural areas than in urban areas.[39] It is worth noting that the majority of respondents from China reside in urban (61.2%) and suburban (27.4%) areas. This could contribute to a higher proportion reporting a degree of somewhat willingness in this study.

Malaysia, on the other hand, had a near equal proportion of willing and somewhat willing to receive vaccination against NTDs. NTDs common in Malaysia include Zika virus,[40,41]

lymphatic filariasis,[42,43] soil-transmitted helminthiasis,[44] leptospirosis,[45] dengue fever,[46] melioidosis,[47] opisthorchiasis,[48] and foodborne trematodiases.[49,50] NTDs may experience resurgence and emergence due to various factors such as changes in environmental conditions, increased human movement and migration, inadequate access to healthcare and preventive measures, or the development of drug resistance.[51] Resurgence of NTDs remains a significant challenge for populations in Malaysia, particularly in rural and aboriginal communities in East Malaysia, where limited resources and restricted access to healthcare exacerbate the burden.[52] The resurgence and emergence of NTDs can present significant challenges to global health, highlighting the necessity for sustained prevention strategies. Therefore, efforts should be intensified to effectively combat the resurgence and emergence of NTDs, particularly in Asian countries, due to the risk of resurgence, historical occurrences, and the potential for ongoing transmission.

In this study, an overwhelming majority of respondents (77.6%) expressed a positive inclination toward NTDs vaccination. Conversely, the finding that 22.4% of respondents reported being undecided or unwilling to receive NTDs vaccination highlights a relatively lower population that may harbor reservations regarding the vaccine. Multivariate analysis of overall countries data provide evidence that younger age groups are more inclined to accept NTDs vaccine. In addition, other demographic factors such as being married and urban residency have also been found to be associated with higher intentions to vaccinate against NTDs. This suggests the importance of targeted vaccination strategies tailored to older age groups (especially those above 50 y old), those who are never married and those residing in rural areas to enhance vaccine uptake. Given the particularly important impact of NTDs in rural areas where access to healthcare resources may be limited,[32] it is crucial to prioritize efforts to enhance vaccine acceptance among rural residents.

This study, it was unexpectedly found that individuals lacking occupational exposure to NTDs were more inclined to accept the vaccine. This could be attributed to lower health literacy among individuals at risk of NTDs due to their occupation, especially considering that a significant portion of those in high-risk occupations may have lower levels of education. Agriculture, forestry, and fishery sectors have traditionally played a pivotal role in driving economic and social advancement in many Asia countries.[53–55] With a significant portion of jobs still tied to these industries in many Asian countries, a considerable number of individuals are at risk of NTDs. Thus, it is crucial to prioritize initiatives aimed at enhancing NTDs vaccination among individuals at high risk due to their occupations.

Furthermore, an intriguing observation arose concerning the relationship between the cleanliness of the local environment and the propensity to receive NTDs vaccination. Individuals residing in very clean environments demonstrated higher odds of willingness, while those in somewhat dirty environments exhibited lower odds compared to the very dirty local environment. Additionally, individuals residing in areas with higher sanitation facilities also demonstrated a greater willingness to be vaccinated against NTDs. Given these remarkable findings, it is imperative to conduct further research to elucidate the underlying factors contributing to this relationship. Alternatively, it is possible to consider health literacy among impoverished populations, who often inhabit areas with inadequate sanitation facilities and may be less inclined to accept vaccination.[56]

The findings also suggest that positive attitudes significantly influence the willingness to vaccinate against NTDs. Of important note, this study uncovered several negative attitudes and misconceptions regarding NTD vaccines. In particular, there is skepticism toward the necessity and efficacy of NTD vaccines, with the lack of perceived necessity stemming from the rarity of NTDs and their perceived low risk. Risk perception refers to individuals' subjective assessment of the characteristics and severity of a specific risk, which can ultimately shape their behaviors.[57] Low-risk perception was identified as a common reason for not receiving vaccination.[58] Thus, launching targeted educational campaigns is imperative to dispel misconceptions and raise awareness about the importance of NTD vaccination, emphasizing susceptibility to NTDs.

It is important to highlight that a considerable number of individuals view treating NTDs with drugs as a safer option compared to vaccination. The findings indicate the necessity for targeted education and communication efforts to enhance positive vaccine attitudes. Vaccine hesitancy in the Asian context has been examined, revealing that the reasons behind these misconceptions varied among countries. For example, in Japan, hesitancy appeared to stem from misinformation regarding the risks associated with vaccines, while in China, it seemed to be driven by concerns arising from local vaccine scandals.[59] Therefore, tailored approaches by individual Asian countries to address these specific concerns are imperative to mitigate vaccine hesitancy and promote NTD vaccination uptake effectively.

Lastly, the country-specific factors influencing willingness to vaccinate against NTDs also suggest that a combination of environmental, behavioral, and demographic factors play a significant role in shaping vaccine acceptance across diverse Asian populations. Individuals who considered their environment very clean exhibited significantly higher odds of willingness in China and Pakistan. Preventive behaviors and positive vaccine attitudes were consistently associated with greater vaccine willingness in China, Malaysia, Pakistan, and Vietnam. Public health efforts should therefore leverage these existing health-conscious behaviors to promote NTD vaccination campaigns in these countries. Additionally, sanitation infrastructure was another crucial factor, with better facilities correlating with increased willingness in Malaysia, Pakistan, and Vietnam. This finding underscores the role of basic public health infrastructure in shaping vaccine perceptions in these countries.

Limitations

Although researchers made efforts to disseminate the survey link across various cities in their respective countries to obtain a representative sample, the study is inevitably limited by the use of convenience sampling and an online survey. The use of the convenience sampling for questionnaire distribution

potentially introduces bias and hinders the generalizability of results to broader populations. The reliance on online surveys may have exacerbated sampling bias risks. It has been well established that two important methodological constraints of online surveys are the inability to accurately describe the population to which they are distributed and the tendency for respondents with biases to self-select into the sample.[60] Another limitation to consider is the potential for biases stemming from participants' perceptions, particularly in subjective assessments like cleanliness levels. This bias may stem from individual differences in perception, comprehension, or interpretation of the question items, potentially skewing the true representation of attitudes or behaviors. Another notable limitation of this study was its cross-sectional design, which inherently lacks the ability to establish causal relationships or associations over time. This design captures only a static snapshot of vaccine attitudes at a single point, failing to account for temporal shifts influenced by evolving public health policies, emerging scientific evidence, or changing societal perceptions. As a result, fluctuations in vaccine confidence and hesitancy over time remain unexplored, limiting the study's ability to provide a dynamic understanding of attitudinal trends. It is essential to acknowledge this limitation as it could impact the validity and reliability of the study findings. To address this, the sample size was doubled from the original calculated to mitigate potential limitations and enhance the robustness of the study. Additionally, important health-related variables, such as prior NTD exposure, were not included in this study, limiting the scope of analysis. Understanding prior exposure to NTDs could have provided valuable insights into how past experiences influence current vaccine attitudes and willingness to vaccinate.

It is also important to note that while this study provides valuable insights into vaccine attitudes, the simplistic scoring approach may not fully capture the nuanced and multifaceted factors influencing vaccine acceptance, particularly the variations across different countries. Vaccine attitudes are shaped by a complex interplay of personal beliefs, cultural influences, healthcare accessibility, and trust in public health institutions, which differ significantly between countries. As a result, this limitation affects the study's ability to translate findings into specific, actionable policy recommendations tailored to individual national contexts. The last limitation of this study is the lack of rigorous psychometric validation of the survey instrument across different cultural contexts. While the questionnaire was designed based on existing literature and expert input, its reliability and validity across diverse populations in multiple Asian countries, including China, were not formally assessed. This may potentially introduce potential measurement bias and impact the consistency of responses on attitudes and willingness to vaccinate against NTDs. Future research should include a thorough validation process to ensure cross-cultural applicability and improve the robustness of findings.

Conclusion

A significant majority exhibited a positive inclination toward receiving vaccinations for NTDs, underscoring a strong overall acceptance among people in Asian and China. However, the presence of a notable minority expressing uncertainty or unwillingness highlights a segment of the population with reservations regarding NTD vaccines. The study identified several important efforts to enhance NTDs vaccine uptake in Asian countries and China. Older age group, individuals who have never married, and those residing in rural areas showed a higher level of hesitancy toward vaccinating against NTDs, suggesting the need for targeted vaccination strategies tailored to these demographics. Surprisingly, individuals lacking occupational exposure to NTDs displayed a higher inclination toward vaccination, potentially linked to lower health literacy. Considering the significant role of agriculture, forestry, and fisheries in many Asian countries, where a substantial portion of the workforce is at risk of NTDs, prioritizing vaccination initiatives among high-risk occupational groups is crucial. Additionally, intriguing findings regarding the association between local environmental cleanliness and vaccine acceptance potentially underscore the increased hesitancy among those from socioeconomically disadvantaged backgrounds. As having a positive attitude score increases the level of acceptance of NTD vaccines, addressing negative attitudes and misconceptions surrounding NTD vaccines through targeted educational campaigns is essential to combat the skepticism toward NTDs vaccines necessity and efficacy. Overall, the diversity in willingness to receive NTD vaccination among the surveyed countries underscores the complex interplay perceived risks, vaccination attitudes, and socioeconomic factors. Understanding these dynamics is crucial for designing tailored interventions to address barriers and promote vaccine acceptance in respective countries.

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Disclosure statement

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Li Ping Wong In the past 20 years of Dr Wong's career, her research has focused on social-behavioral medicine. Behavioral medicine is concerned with the integration of knowledge in the biological, behavioral, psychological, and social sciences relevant to health and illness. Dr Wong is vigilant in exploring the many aspects of behavioral health research. Her work encompasses a wide range of social behaviors and covers an extensive array of health issues and illnesses such as SARS-CoV-2, H1N1,

human papillomavirus (HPV), hepatitis E, dengue, Zika virus, and sexual reproductive health issues. When the COVID-19 pandemic emerged, Dr Wong utilized her expertise and became a pioneer in COVID-19 research in her country. She diligently mobilized collaborations with neighboring countries and successfully published important papers related to the field. Her expertise has gained international recognition, and she has demonstrated success in collaborating with diverse researchers worldwide. During the COVID-19 pandemic, Dr Wong spearheaded a series of social-behavioral studies, examining the mental health consequences during the early phase of the outbreak in Wuhan, China, Taiwan, Japan, and Malaysia. Her work provided crucial first-hand information for these countries, shaping appropriate public responses to combat the pandemic.

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Authors' contributions

LPW, HYL, HA, FNS, ZH, and YL conceptualized and designed the study. HA, FNS, DKN, AL, JA, and YL collected the data. LPW, and HA conducted the statistical analysis and interpretation. LPW wrote the first draft. All authors read and approved the final manuscript.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The lead researcher received ethical clearance to conduct the multi-country survey from the Universiti Malaya Research Ethics Committee (UM.TNC2/UMREC_2381). Furthermore, additional ethical approvals were sought from Fujian Medical University, China (FMU2023- NO.86). The principal investigator obtained ethical approval in conducting the survey in a global context from the confidentiality and anonymity about the survey responses were assured for all the participants. Informed consent was obtained from all individual participants included in the study. Consent was obtained at the beginning of the online survey by providing formal paragraph-wise information about the study and making the participant click on a button for providing consent on the same online survey platform before moving on to filling the rest of the online questionnaire.

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