Journal of Racial and Ethnic Health Disparities
https://doi.org/10.1007/s40615-025-02442-5

# The Role of Medical Mistrust in Vaccination Decisions in Rural, Indigenous Namibian Communities

**Sean Prall**[1] · **Brooke Scelza**[1] · **Helen Elizabeth Davis**[2]

Received: 4 July 2024 / Revised: 18 March 2025 / Accepted: 10 April 2025


## Abstract

**Objectives** Substantial inequalities in access to healthcare are common in rural and marginalized populations in the Global South, and these inequalities can drive health disparities. Historical mistrust of healthcare institutions can further impact healthcare behaviors, including vaccination. Here, we apply the concept of medical mistrust, which has been widely applied to healthcare decisions in industrialized countries, across a rural–urban spectrum of communities in Namibia, and assess its utility in understanding vaccination decisions.

**Methods** Otjiherero-speaking indigenous communities of Kunene, Namibia, were surveyed to assess medical mistrust. Participants also answered questions about COVID-19 vaccination status, vaccine safety, and interest in a hypothetical malaria vaccine. Bayesian multilevel models were used to compare medical mistrust across communities and its influence on vaccination and vaccine perceptions.

**Results** The level of medical mistrust varied across contexts, with the highest level of mistrust in peri-urban communities. Medical mistrust predicted beliefs about vaccine safety and interest in the malaria vaccine, but not COVID-19 vaccine status, which was largely driven by access to the vaccine. For rural and peri-urban Himba, participants also expressed disinterest in the COVID-19 vaccine and worries about its safety.

**Conclusion** Addressing global health disparities requires understanding how locally contextualized social and ecological experiences shape healthcare and vaccination decisions. Results of this study show fundamental differences in medical mistrust by community, which may be contributing to beliefs about vaccines. Understanding how medical mistrust varies across these contexts, and how it impacts perceptions about vaccination, can inform health communication and public policy in underserved communities.

**Keywords** Medical mistrust · Vaccination · COVID-19 · Healthcare decisions · Pastoralists

## Introduction

Substantial inequalities exist in infectious disease burdens. From the highly virulent 1918 H1N1 virus to COVID- 19, marginalized groups and groups from low socio-economic settings have long suffered from higher transmission and mortality [1–3]. This pattern holds true internationally, where countries in the Global South have elevated infectious disease and parasite burdens [4]. One example of these inequalities is in differential access to vaccines, which was notable during the COVID- 19 pandemic [5] and resulted in substantial variation in vaccination rates by education level and socio-economic status [6]. These inequalities tend to be exacerbated in indigenous communities, where disease burdens tend to be higher, access to vaccinations and adequate healthcare is lower, and healthcare is stymied by discrimination, marginalization, and the impacts of colonialism [7–13]. Where vaccines are available, anxiety about vaccines continues to negatively impact uptake [14, 15]. These patterns indicate that medical mistrust may be a key contributor to health inequalities and the uptake of care across marginalized indigenous populations in the Global South.

Medical mistrust is defined as distrust of the healthcare system and its providers [16, 17]. It is believed to be the product of histories of discrimination and social and economic injustices, particularly in minority populations [18], and is viewed as a

✉ Sean Prall
sprall@anthro.ucla.edu

[1] Department of Anthropology, University of California, Los Angeles, CA, USA

[2] School of Human Evolution and Social Change, Arizona State University, Tempe, AZ, USA

Published online: 21 April 2025

rational protective response to historical and structural inequalities and discrimination at various levels [17]. In one key example, the Tuskegee Syphilis study has been described as a historical driver of systemic medical mistrust in African Americans, as its effects went well beyond those directly affected by the study [19–21]. However, individual-level experiences with physicians and perceptions of discrimination can also drive mistrust of healthcare systems [22]. Where elevated levels of medical mistrust fall along racial or ethnic lines, these experiences can further drive health disparities [23]. Consequently, medical mistrust can lead to group-level disparities through either direct or indirect experiential pathways.

Medical mistrust has demonstrable impacts on health and healthcare, from perceptions of healthcare efficacy and participation in clinical trials to individual testing and screening [24–29]. In addition to delays in testing and screening, which can impact diagnosis and the timing of health interventions, medical mistrust is associated with general underutilization of healthcare services and ignoring medical advice, failure to fill prescriptions, and postponing needed care [30]. Medical mistrust also impacts vaccination decisions. For example, it has been associated with COVID- 19 vaccine hesitancy, belief in COVID- 19 misinformation, and a decrease in COVID- 19 vaccination [31–35]. These results make clear that medical mistrust has profound impacts on health and healthcare and needs to be better integrated into studies of health disparities, particularly since medical mistrust is most often experienced by minority communities.

To date, most studies of medical mistrust have been with US populations, with little work applying the concept towards populations in the Global South. However, there is considerable evidence that mistrust generally impacts healthcare behaviors, and that mistrust of healthcare systems in low- and middle-income countries is common [36]. Perhaps, the most notable example is the role of mistrust in both government and healthcare systems impacting healthcare compliance and recommendations during Ebola outbreaks in West Africa [37]. Individual negative experiences with healthcare personnel can also impact adherence to healthcare recommendations [38, 39]. More broadly, healthcare systems were often developed under colonial policies, with histories of conflict and exploitation with colonial governments that are ripe for mistrust of majority outgroup populations, governments, and healthcare authorities. Current conditions of social and economic inequality and underfunded healthcare systems add to these histories. Additionally, hospitals in urban areas often serve multiple ethnic groups, and so can become visible manifestations of existing tensions and disparities. In one example, Athias and Macina [40] find that historical experience with the slave trade resulted in lower childhood measles vaccination, particularly in more traditional (and matrilineal) families. They argue that historical experiences with slavery shaped the cultural transmission of traits, including cultural mistrust, impacting present-day vaccination decisions. While this evidence is compelling, more studies are needed to explore the drivers and outcomes of medical mistrust across different types of populations. With only a few notable exceptions [32, 41–44], measuring medical mistrust via validated instruments is underutilized in the Global South.

The COVID- 19 pandemic and the push for fast-paced, global immunization provide an interesting case study for understanding how medical mistrust affects healthcare decisions. Rural and marginalized communities in the Global South often have lower vaccination rates than their country's averages. Children in rural areas of sub-Saharan Africa have lower childhood immunization rates than those in urban areas, due in part to lower household wealth and greater distance to healthcare facilities [45]. Similar associations between SES and vaccine rates are found in industrialized countries, where vaccines are widely available and often free [46–49]. Education levels are often lower in rural and underserved areas, and education can influence the accuracy of disease perceptions, as well as rates of healthcare utilization and preventative measures [50–54]. This may be particularly important in the case of COVID- 19 in Africa, as the rates of infection in these countries were lower than elsewhere in the world [55]. In some indigenous African communities, evidence suggests a substantial lack of knowledge about vaccines or vaccine safety [56, 57]. The combination of predominantly rural communities, with high social inequality, low levels of formal education, and little vaccine knowledge, makes COVID- 19 responses in rural Africa an important test case for the role of mistrust in vaccine decisions.

In addition to looking at how medical mistrust may have affected recent vaccination decisions, there is also potential to see how it might be impacting people's beliefs about new vaccines. After decades of development, malaria vaccines have recently been approved for widespread use in children living in high malaria transmission areas, with additional vaccines currently in development. So far, these vaccines have proven effective in reducing child morbidity and mortality, have a strong safety profile, and are cost-effective [58], although production and delivery remain a challenge [59]. Malaria vaccine acceptance appears quite variable. One recent review found that survey respondent's willingness to be vaccinated ranged from 32 to 96% across countries and studies [60]. Acceptance rates for the malaria vaccine appear higher than for COVID- 19 vaccines, potentially because many populations have long histories of malaria, whereas COVID- 19 is novel [61]. As with other vaccines, fears about side effects from malaria vaccines, alongside perceptions of healthcare services and prior experience with vaccines, impact refusal [60]. These include issues related to medical mistrust, such as rumors of misdeeds by healthcare workers, negative interactions with healthcare workers, and fear and distrust of pharmaceutical companies [62–64]. As these vaccines are deployed in sub-Saharan Africa, there is an

urgent need to evaluate how these vaccines are perceived by local communities. As with other vaccines and healthcare behaviors, perceptions of mistrust of healthcare workers and institutions may mediate perceptions of malaria vaccines and slow the deployment of vaccines to communities where they are most needed.

Sub-Saharan Africa, with its high proportion of low- and middle-income countries, rural living populations, and cultural and historical experiences with colonialism, may be acutely susceptible to the manifestation of medical mistrust in the context of vaccination. Namibia, where this study takes place, suffers from many of these issues. According to the World Bank, Namibia is one of the most economically unequal countries in the world [65]. Its low population density and high proportion of rural and indigenous communities make vaccination outreach campaigns time-consuming and costly. Despite these hurdles, Namibia has been generally successful in its vaccination outreach attempts, particularly in rural areas. Vaccination rates are high in both rural areas and low socio-economic status households [45, 66], and the prevalence of full immunization status in children is high compared to other sub-Saharan African countries [45]. Namibia has been successful in other vaccination campaigns too, including childhood vaccination of hepatitis B [67]. Unfortunately, as with many other sub-Saharan African countries, COVID-19 misinformation, concerns about safety, and trust in healthcare institutions appear to be impacting Namibians' vaccination decisions [68–70]. This included conspiracy beliefs about 5G wireless towers, requiring a telecommunications company to address the rumors publicly [71]. The latest statistics indicate that only about 24% of Namibians have been vaccinated against COVID- 19 [72]. Some have argued that urban areas in Africa may have greater access to higher quality health information, which can counter COVID- 19 misinformation [73]. Other studies find that COVID- 19 vaccine hesitancy in some African countries is higher in urban areas [74]. Access to multiple forms of media, including social media, may increase distrust, particularly in places with historical mistrust of government and healthcare institutions. Understanding these issues requires evaluating perceptions of diseases, vaccines, and healthcare institutions in underserved populations across the rural to urban gradient.

To understand how medical mistrust varies across rural and urban communities, and how medical mistrust impacts beliefs and perceptions of vaccines across different contexts, we conducted a study of vaccine beliefs and experiences in the Kunene region of northwest Namibia. Here, we focus on Himba and Herero pastoralists. These closely related ethnic groups have differing levels of socio-economic status, ruralness, and experiences with the national healthcare system. Across a set of urban, peri-urban, and rural communities, we explore how medical mistrust shapes COVID- 19 vaccination, perceptions of vaccine safety, and for comparison, interest in the new malaria vaccine. We also collected qualitative data on vaccine experiences to better understand how rural living pastoralists think about COVID- 19 vaccines. Understanding how medical mistrust varies across these contexts, and how it impacts perceptions about vaccination, can inform health communication and public policy in underserved communities.

## Methods

### Study Population and Sampling

This study focuses on the Kunene region of Namibia. This region is extremely dry and arid, and ethnic groups continue to rely on pastoralism and small-scale horticulture for subsistence [75]. Household-level measurements indicate that the Kunene region has high levels of deprivation and poverty [76]. This area also has very low human development scores and very high levels of inequality [77]. In many parts of Kunene, access to clinics and hospitals is difficult, and Kunene residents tend to live farther than average from hospitals and clinics [65, 78]. The only hospital in the region is in Opuwo, the regional capital. However, as with other regions of Namibia, staffing is an issue; and the doctor-to-patient ratio in the Opuwo hospital is three times the WHO recommended level [79]. Although Namibia has public healthcare, many of the poorest households cannot afford medical care given the cost of travel, medicine, and clinic fees [65, 80]. There are approximately 20 small rural clinics operating in the region, as well as a rudimentary ambulance service to help residents access medical treatment. For many rural indigenous residents, few of whom own vehicles, travel and access to medical care remain a significant hurdle.

Residents of this region consist largely of Himba, Herero, and several other closely related ethnic groups, including the Twe, Themba, and Tjimba. Notably, Himba have very different experiences with regional and national governments. The Himba have experienced historical social and economic marginalization, which has influenced their interactions with majority populations, described as "colonial encapsulation" [81]. Himba also tend to have much less material wealth, and their livestock holdings have been compromised by a recent decade of drought [82]. In contrast, Herero are much more market integrated, practicing trade, farming, and business, while maintaining familial connections to rural villages and homesteads [83–85].

Data for this study was collected across several locations in the Kunene and across two ethnic groups: Himba and Herero (Table 1). The rural sample was collected largely in one Himba village consisting of approximately 45

**Table 1** Sample demographics by sampling location

| | Rural ($n = 89$) | Peri-urban ($n = 59$) | Urban ($n = 50$) |
|---|---|---|---|
| Average age (sd) | 34.9 (15.8) | 39.2 (15.3) | 28.3 (7) |
| % Female | 71.9% | 61% | 46% |
| Tribe | 100% Himba | 88.1% Himba<br>10.2% Herero<br>1.7% Other | 74% Herero<br>14% Himba<br>12% Other |
| Medical mistrust avg score (sd) | 2.65 (0.8) | 3.26 (0.5) | 2.79 (0.3) |

households that have been the focus of long-term anthropological research on demography and health. Here, access to healthcare is largely limited to a single regional clinic 15 km away, or else paying for a ride to Opuwo hospital. Households were also sampled 15–20 km from Opuwo, comprising the peri-urban sample. Here, residents have easier access to the local hospital and markets. Finally, a sample of largely Herero residents from Opuwo were interviewed. This sample tended to be younger and more educated, with easy access to the regional hospital.

### Medical Mistrust Index

To measure medical mistrust, participants completed a modified version of the Medical Mistrust Index (MMI) [30]. This seven-item survey was developed in the USA to measure individual-level distrust in healthcare personnel, organizations, and institutions. This survey has been widely deployed in a variety of US settings and has been found to be associated with underutilization of healthcare, including COVID-19 vaccination [16, 30, 35, 86]. To better fit the cultural context, survey items were slightly modified to aid in translation and interpretation [see 43]. Previous work with rural Himba indicates that the results of this survey accurately reflect negative perceptions and experiences with healthcare personnel [43].

### Vaccination Questions

All participants answered a series of quantitative questions on disease and vaccine beliefs and experiences. Participants were asked about their concerns over COVID-19 ("How worried are you about getting COVID-19?"), and if they know anyone who had become sick or who had died from COVID-19. Participants were also asked if they believed the vaccine was safe and if vaccines were generally safe. They were asked about their vaccine status for themselves and their children. Participants were also asked about their interest in receiving a malaria vaccine, should it become available. To better understand barriers to vaccination, participants were also asked a set of open-ended questions about why they did or did not receive the vaccine, and if they had declined to be vaccinated, what motivated this decision. Questions and additional methodological details are further described in the supplemental material.

### Analysis

A set of Bayesian multilevel models were used to predict medical mistrust and vaccine-related outcomes via the *brms* package in R using RStudio [87–89]. A truncated distributional Gaussian model, with varying intercepts for location, was used to assess differences in medical mistrust across sampling locations. Similarly, Bernoulli models were used to predict binary vaccine outcomes, while Likert scale responses indicating interest in the malaria vaccine required a cumulative ordered logit model. In all models, fixed effects for age and sex and varying effects for age and sex by location were assessed, and all models used regularizing priors. Below, we report posterior medians and 95% credible intervals (95% CI). Other packages used for data cleaning, modeling, and visualization included *tidyverse*, *janitor*, *tidybayes*, *modelr*, and *patchwork* [90–94]. Additional modeling details and all posterior predictions are presented in the supplementary materials. Responses to open-ended questions were evaluated by study authors and manually coded for thematic analysis.

## Results

A total of 198 participants completed the survey across sampling locations. Across all locations, 74.7% of the total sample identified as Himba. Several individuals identified with a closely related ethnic group to Himba. As these groups share similar levels of market integration, lifestyle, and interaction with healthcare, we coded these seven individuals as "Himba." Of the total sample, 21.7% identified as Herero. An additional seven urban or peri-urban individuals identified with an ethnic group that is not closely related to either Himba or Herero and were coded as "other." Table 1 describes participant characteristics by sampling location.

Participant responses to questions about COVID-19 varied by location (Fig. 1). Rural respondents showed the highest degree of worry about COVID-19, but the lowest frequency of both knowing someone who became sick and knowing someone who died of COVID-19. Conversely, urban respondents showed less anxiety over becoming infected with COVID-19, but almost all urban respondents knew someone who had been infected and knew someone who had died. Peri-urban participant responses were intermediate between rural and urban. Participants also

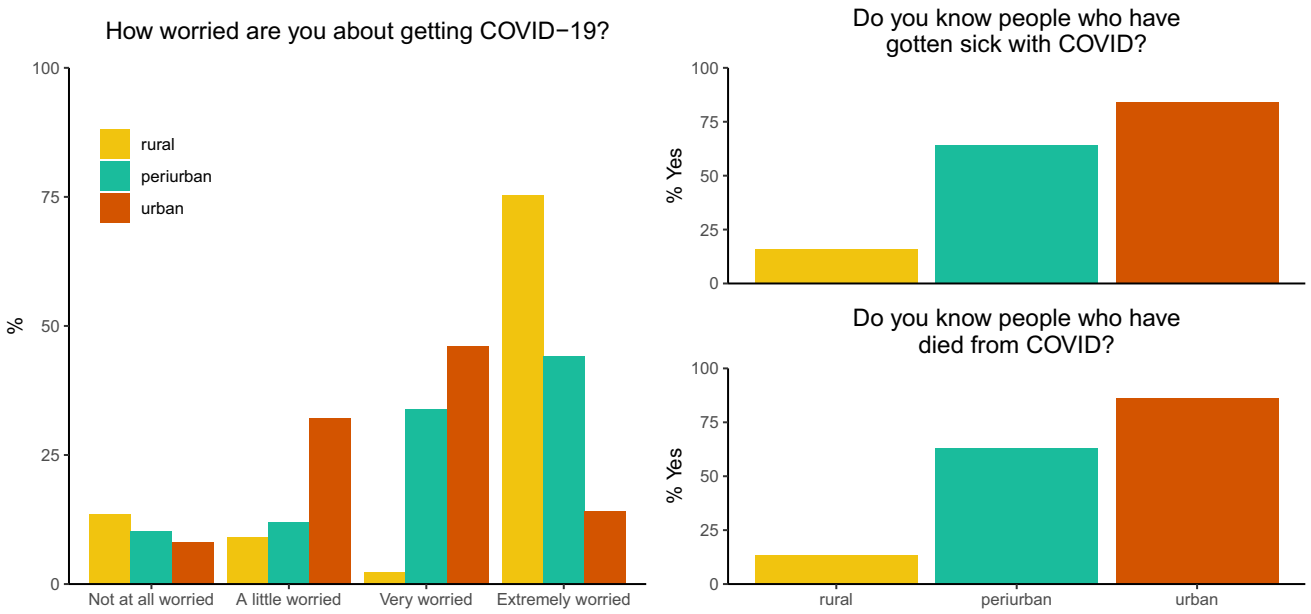


**Fig. 1** Reported COVID- 19 experiences by location. Left plot shows the percentage of Likert responses by location. Right plots show the percentage of respondents who agree to the prompts by location

responded to questions on vaccinations. A majority of urban and peri-urban participants had received a COVID- 19 vaccination (64% and 62.7% respectively), while only 30.3% of rural respondents reported receiving a vaccine. A large majority reported that they felt vaccines generally were safe (90.9%, 84.7%, and 84% from rural to urban respectively).

## Medical Mistrust

Most items in the MMI were weakly positively correlated except for items 1 and 5 (Figure S2). Medical mistrust scores varied by location, with peri-urban respondents having higher average MMI scores and rural participants having

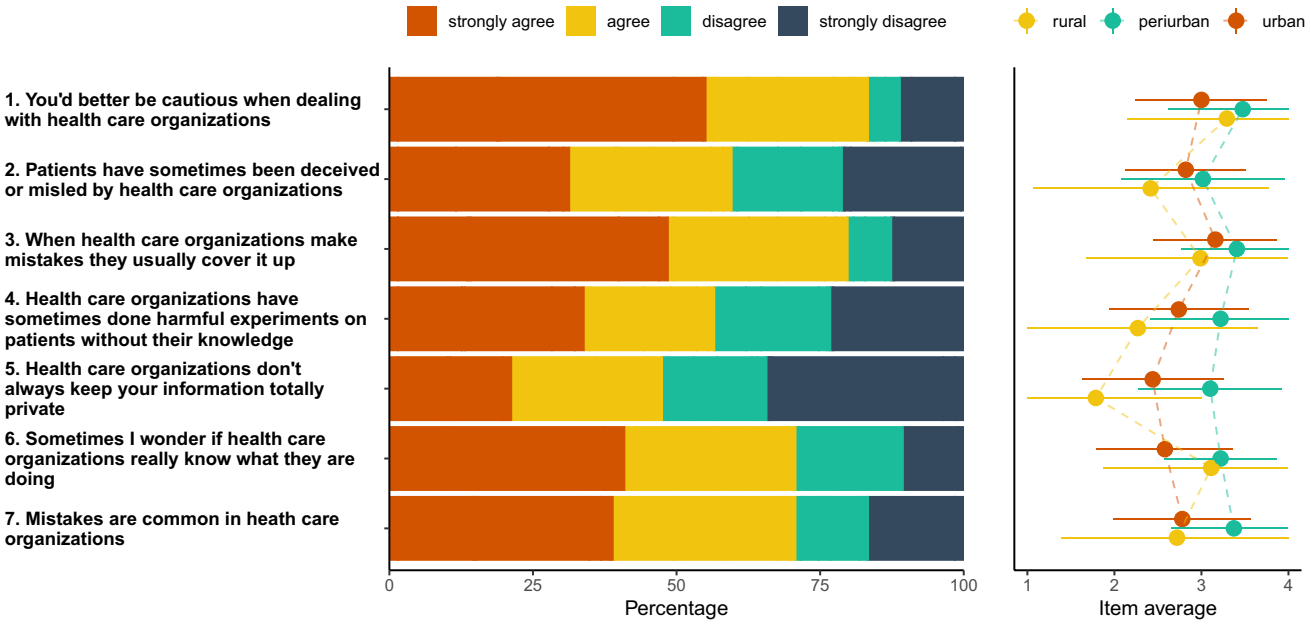


**Fig. 2** Medical mistrust responses and question averages by sampling location. Left plot shows responses to each item on the MMI. Right plot shows item mean and standard deviation by location

more variable responses (see Table 1, Figure S3). Figure 2 illustrates responses by question, overall, and by geographic groups. Modeling indicates that peri-urban respondents had significantly higher medical mistrust average scores, whereas urban and rural scores were similar (Figure S5). Age and sex had little impact on MMI (Figure S6).

A series of multilevel models predicted the impact of medical mistrust on vaccine-related questions (Fig. 3). First, MMI had a very weak negative effect on the probability of reporting being vaccinated for COVID- 19 ($\beta = -0.15$, 95% CI = − 0.86 to 0.67), although this varied by location, with the strongest effect in rural participants ($\beta_{rural} = -0.37$, CI = − − 1.22 to 0.22, see Figure S7). Men in the rural sample also had higher rates of vaccination, although across locations there was little impact of age on vaccination status (Figure S8-S9). Higher medical mistrust lowered the likelihood that participants believed vaccines were generally safe across all locations ($\beta = -0.87$, 95% CI = − 1.68 to −0.10), while sex and age had little impact (Figure S10-S12). Lastly, medical mistrust was used to predict the likelihood of receiving a malaria vaccine when it becomes available. Interest in a malaria vaccine was generally high, with 82.3% of the total sample responding that they were either "likely" or "very likely" to receive the vaccine if available. Rural participants were more likely to be interested in the vaccine (Figure S13). However, medical mistrust lowered the probability of being interested in the malaria vaccine ($\beta = -0.90$, 95% CI = − 1.84 to 0.01). This effect was stronger in rural and urban participants, whereas MMI had little impact on interest in the malaria vaccine in the peri-urban sample (Figure S14). Participant sex had little impact, while older participants tended to show greater interest in the malaria vaccine (Figure S15-S16).

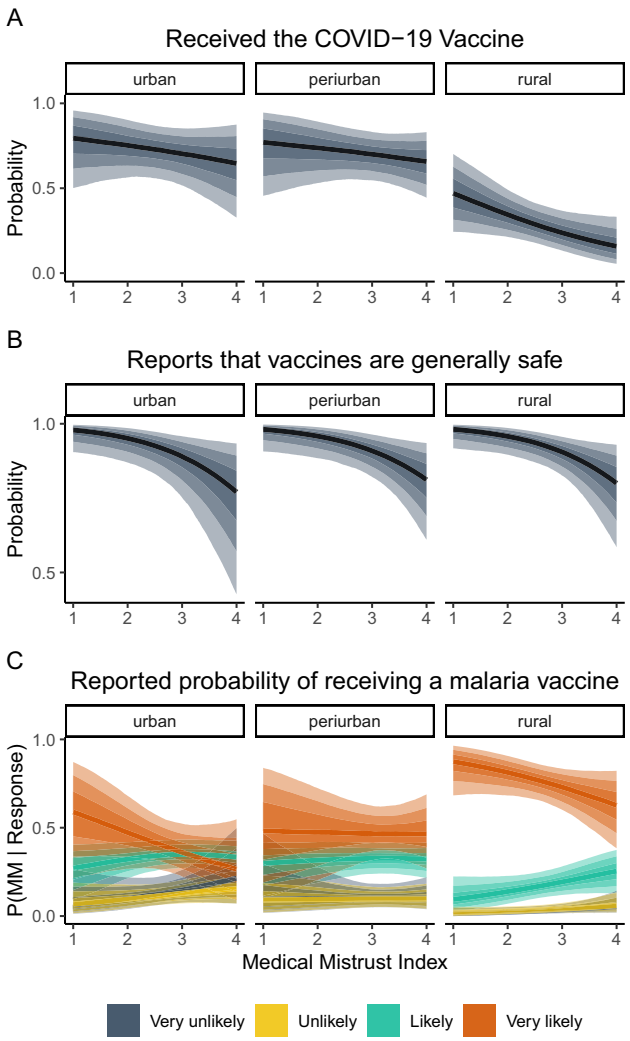


**Fig. 3** Medical mistrust on vaccination. Each plot shows the posterior predictions of the effect of MMI on vaccine outcomes by location. Shading represents 50%, 80%, and 95% credible intervals respectively. Predictions for plots A and B show the probability the question was answered in the affirmative, while C shows the probability of each Likert response

## Qualitative Data on COVID- 19 Vaccination

To better understand vaccine decisions, we asked participants who did not receive the COVID-19 vaccine to explain their decision. Responses to this question fell into three general categories: lack of access, lack of interest, and concerns about safety (Fig. 4). In rural Himba, where the vaccination rate is low, most respondents (65.6% of non-vaccinators) noted that vaccination was a matter of access, not rejection of the vaccine. Participants explained that they were not around or available when vaccination outreach took place, or that vaccination outposts were too far away to access. For example, one woman reported that "it was only my husband who got vaccinated. I was staying far away but my husband

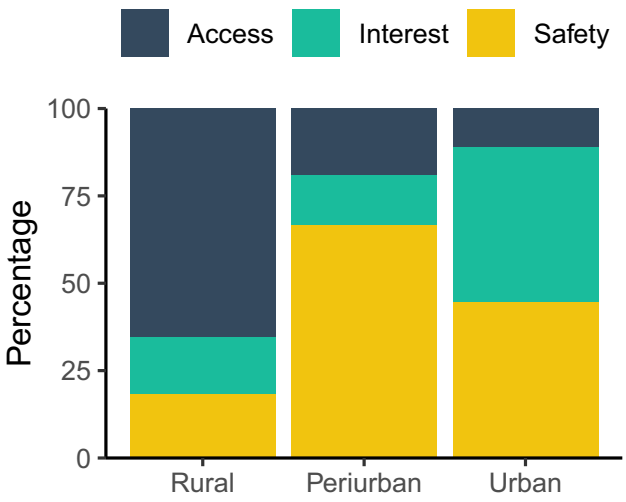


**Fig. 4** Reasons for not vaccinating by location

went to the place." This quote may reflect the slight gender difference in COVID-19 vaccinations in the rural sample, suggesting that men's freedom of mobility may make it easier for them to travel to receive the vaccine. Others noted that "the vaccination point was far away" or "I was on the mountain when they came to give them." These responses reflect the difficulty of delivering vaccines to rural living pastoralist communities where travel with livestock is common. In contrast, only 19% of peri-urban and 11.1% of urban respondents suggested access was a hindrance to vaccination, with respondents noting that they happened to be traveling or were otherwise unavailable to receive the vaccine.

For participants who did not report that access was the reason they had not been vaccinated, responses largely fell into two general categories: lack of interest and concerns about safety. A subset of those reporting a lack of interest indicated that they did not believe that COVID-19 was a risk. For example, one Himba participant noted that "the mountains are saying they don't want the Himba people to get vaccinated… Himba won't get sick. Elders have said this much." Another noted that "the Himba will be fine. They follow protocols in town, but in the villages they are safe." As worries about being infected were generally high in the rural sample, lack of interest responses reflected a minority of rural respondents who did not feel that COVID-19 was a major health concern for Himba. In contrast, 44% of urban and 14.3% of peri-urban non-vaccinators reported a lack of interest in the vaccine. These respondents noted that they had not had the chance or reported that vaccination was not needed, or they otherwise were not interested in being vaccinated.

Another frequent reason for not getting vaccinated was distrust of the vaccine, with 66.7% and 44% of unvaccinated peri-urban and urban residents respectively reporting concerns about safety. Here, participants expressed explicit belief that the vaccine itself was harmful or unsafe. For example, one respondent said that "people tell us when you get vaccinated, you will get sick." Another expressed concern for the novelty of the vaccine in comparison to the childhood polio and MMR vaccines saying "I'm not ready for it. It's my belief that it's not safe. Other vaccines that the kids take, they will be very healthy but the corona [vaccine] we grow up without using it and we don't know about it. The others we have used for a long time." Others, putting a finer point on the sentiment of risk, reported that "the vaccine is not for treatment, it's for killing," and noted that they "saw people dying and getting sick from it."

## Discussion

In this study, we examine medical mistrust and vaccine perceptions in rural *Otjiherero*-speaking indigenous groups in Kunene, Namibia. We find that rural and urban communities have different experiences with disease and different rates of vaccination. Our results also indicate that medical mistrust differs across communities, and that this might be influencing vaccination beliefs and perceptions but does not seem to mediate actual rates of COVID-19 vaccination. Instead, low COVID-19 vaccination rates seem to be driven largely by access to the vaccine in rural areas and by disinterest and distrust in peri-urban and urban communities.

Looking first at how geography affects perceptions of disease, we found a surprising dichotomy: people living in rural areas were highly concerned about being infected, but had relatively little direct experience with the disease, while those in the urban sample were less concerned about getting COVID-19, but more than three-quarters of respondents stated that they knew of someone who had died from the disease. Similar results were found in focus group discussions about COVID-19 experiences, where Herero living near town reported knowledge of people infected and killed, while rural Himba had little knowledge or direct experience with the disease [57]. Africa is believed to have fared comparatively well in the COVID-19 pandemic. Explanations for this have included lower rates of co-morbidities, younger demographics, and environmental differences like more arid ecologies and more outdoor living [55]. Namibia's response to the pandemic was swift, and received praise from the WHO [95], although it suffered similar incidence and mortality rates to neighboring countries [96]. Substantial efforts were made to limit interaction between urban areas with high rates of infection with rural areas [97]. The low rate of rural participants who report knowledge of COVID-19 infections or deaths suggests that mitigation efforts may have been successful in the Kunene, although disparities in testing and access to accurate healthcare information make this difficult to confirm.

In urban areas of Namibia, case rates are still relatively low. As of August 2021, there had only been 3378 COVID-19 cases reported in the Kunene region (0.03% of the population) and 70 deaths [97]. Therefore, it is surprising that almost three-quarters of our sample reported knowing someone who had died. There are several possibilities for this. One is that word spreads quickly in these close-knit urban communities, so that knowledge of a few deaths could spread widely. Another possibility is that non-COVID-19 deaths are being attributed to COVID-19 and reported to us as such. The former possibility fits with the idea that people in the urban population are not as worried about COVID-19 as those in rural areas. They may be viewing these deaths (rightfully) as rare events.

Next, we focused on how medical mistrust manifests across the rural to urban spectrum and how it might be impacting perceptions of disease and vaccination. Here, we

found that medical mistrust was highest in the peri-urban sample. In previous work focusing on a rural sample of Himba, we found that negative interactions with healthcare personnel seemed to mediate mistrust [43]. Perceptions of incompetence, maltreatment, and discrimination were linked to greater medical mistrust in rural Himba. Qualitative data suggest that Himba's distinctive garb, traditional use of ochre, low levels of education, and low socio-economic status may place them at risk of poor treatment in healthcare settings. Elsewhere in Namibia, mothers report that negative experiences with healthcare personnel also impact decisions to seek childhood vaccines [98]. Peri-urban participants may be at particular risk for negative interactions with healthcare, as they are close enough to town to have ready access to the hospital, but still maintain traditional rural pastoralist lifestyles, including their dress. In contrast, those living in rural areas have less frequent interaction with healthcare personnel, particularly at the regional hospital. Marginalized and traditional populations who have increased exposure to wealthier urban populations may suffer psychological costs as well. For example, the Peruvian Matsigenka saw a decline in subjective health as the result of pressures of acculturation and the integration of new prestige goods altering markers of social class [99]. Ready access to both town and hospital may place peri-urban pastoralists at greater risk for negative interactions with the majority of outgroup individuals and may explain why they exhibit the highest level of medical mistrust in our sample.

As found in other studies, medical mistrust predicted sentiments about the safety of vaccines and interest in a future malaria vaccine. In previous studies in industrialized countries, medical mistrust was associated with vaccine trial participation, vaccine intention, vaccine hesitancy, and vaccination in various contexts [33–35, 100, 101]. We found that across the rural to urban gradient, greater medical mistrust was associated with more skepticism about vaccine safety. We also found that medical mistrust predicted people's interest in the forthcoming malaria vaccine, indicating the importance of addressing sources of mistrust in future rollouts of vaccination campaigns. In contrast, however, medical mistrust did not predict COVID- 19 vaccination status. Instead, vaccination was largely mediated by access in rural communities. These results are similar to findings elsewhere in sub-Saharan Africa, showing that COVID- 19 vaccine acceptance is high but stymied by access at the local level [102], and remoteness and distance to receive vaccines have been highlighted as a barrier to vaccination in other contexts [103, 104]. In peri-urban and urban areas, where vaccination rates were generally higher, refusal of the vaccine was more likely to be linked to distrust and fear of vaccinations, as shown in the qualitative results. Focus group discussions collected in this same area support the deep feelings of mistrust of the vaccine, but indicate that many decided to vaccinate despite these concerns due to government policies about vaccination and anxiety about the disease [57]. Fears about the vaccine continue to impede vaccination across sub-Saharan Africa [68], including Namibia [97], highlighting the continued need for more effective health communication.

We note several limitations to our study. First, we rely on a relatively small non-random convenience sample across locations, limiting our ability to generalize results to the larger population. The medical mistrust survey used here was designed principally for industrialized populations like the USA [30], and its efficacy in a cross-cultural context has not been formally evaluated. However, a previous application of this survey in a rural Himba sample indicates that the Medical Mistrust Index does map onto negative healthcare experiences [43]. Second, Himba participants tended to be rural living, whereas *Otjiherero*-speaking peoples in town tended to be Herero. This collinearity between ethnic groups and location makes it difficult to disentangle the different effects of ethnic group identity and placement on the rural–urban spectrum. Other results from this region suggest that norms surrounding social learning operate at the level of the ethnic group [105]. Similarly, distance to town does not impact outgroup norm adoption in a study of perinatal care norms in Himba women, suggesting that ethnic identity might be more important to healthcare decision-making than geography in that realm [106]. Future work should consider the ways in which cultural norms and beliefs alongside previous experiences with healthcare providers impact medical mistrust and how these beliefs and experiences change across ethnic groups, levels of market integration and acculturation, and the rural–urban gradient.

Decades of public health research indicate substantial inequalities in health and access to healthcare, particularly in rural and indigenous communities in the Global South. One way to address these disparities is to understand how motivation to seek formal healthcare varies. Here, we highlight the role of medical mistrust in influencing beliefs about vaccination. Medical mistrust reflects both individual- and group-level experiences and predicts the future pursuit of healthcare. As described by Leach et al., feelings about vaccinations are "embedded in often sophisticated understandings and reflections that make sense amidst their social and historical contexts and experiences" [107]. In the case of rural Namibian pastoralists, medical mistrust is likely influenced by historical processes of marginalization and negative interactions with majority outgroup medical personnel. In our study, we find that medical mistrust varies by sampling location and mediates beliefs about vaccinations. However, actual COVID- 19 vaccination seems to be a product of access and secondly fear and mistrust of the vaccine. By engaging in cross-cultural research to understand the individual- and cultural-level drivers of medical mistrust, and how medical mistrust manifests in healthcare

decisions, we can better address health disparities in these rural and marginalized communities.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s40615-025-02442-5.

**Acknowledgements** The authors would like to thank the community of Omuhonga for continued support and the individuals who participated in this study. We would also like to thank John Jakurama, Clementine Louis, and Aparicio "Chinho" Lopes who assisted with translations and data collection.

**Funding** This research was funded by the National Science Foundation (BCS- 2438025) and the Social Science Research Council's Mercury Project.

**Data Availability** Data and R code used in this study are available at the Open Science Framework at https://osf.io/etys9/.

## Declarations

**Ethics Approval** The study received ethics approval from the Institutional Review Board (IRB) of the University of California, Los Angeles (IRB #10–000238). Within the community, permission was granted by the local chiefs and heads of household where the study was conducted. This project was also approved by the Namibian Department of Home Affairs (#0011122005863) and was conducted in collaboration with the Hizetjitwa Indigenous People's Organization (HIPO). All methods were carried out in accordance with relevant guidelines and regulations.

**Consent to Participate** The authors confirm that verbal informed consent was obtained from all individuals participating in the study, as approved by the UCLA IRB, as the majority of the study population is non-literate.

## References

1. Grantz KH, Rane MS, Salje H, Glass GE, Schachterle SE, Cummings DAT. Disparities in influenza mortality and transmission related to sociodemographic factors within Chicago in the pandemic of 1918. Proc Natl Acad Sci USA. 2016;113:13839–44.
2. Khanijahani A, Iezadi S, Gholipour K, Azami-Aghdash S, Naghibi D. A systematic review of racial/ethnic and socioeconomic disparities in COVID-19. Int J Equity Health. 2021;20:248.
3. Mamelund S-E, Dimka J. Social inequalities in infectious diseases. Scand J Public Health. 2021;49:675–80.
4. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020;396:1204–22.
5. Wei CR, Kamande S, Lang'at GC. Vaccine inequity: a threat to Africa's recovery from COVID-19. Trop Med Health. 2023;51:69.
6. Ali HA, Hartner A-M, Echeverria-Londono S, Roth J, Li X, Abbas K, et al. Vaccine equity in low and middle income countries: a systematic review and meta-analysis. Int J Equity Health. 2022;21:82.
7. Gracey M, King M. Indigenous health part 1: determinants and disease patterns. The Lancet. 2009;374:65–75.
8. Machado FCG, Ferron MM, Barddal MTDM, Nascimento LA, Rosalen J, Avelino-Silva VI. COVID-19 vaccination, incidence, and mortality rates among indigenous populations compared to the general population in Brazil: describing trends over time. The Lancet Regional Health - Americas. 2022;13.
9. Marcelin JR, Swartz TH, Bernice F, Berthaud V, Christian R, Da Costa C, et al. Addressing and inspiring vaccine confidence in black, indigenous, and people of color during the coronavirus disease 2019 pandemic. Open Forum Infectious Diseases. 2021;8:ofab417.
10. McIntyre PB, Menzies RI. Immunisation: reducing health inequality for Indigenous Australians. Med J Aust. 2005;182:207–8.
11. Paradies Y. Colonisation, racism and indigenous health. J Pop Research. 2016;33:83–96.
12. Tollefson D, Bloss E, Fanning A, Redd JT, Barker K, McCray E. Burden of tuberculosis in indigenous peoples globally: a systematic review. Int J Tuberc Lung Dis. 2013;17:1139–50.
13. Valeggia CR, Snodgrass JJ. Health of Indigenous peoples. Annu Rev Anthropol. 2015;44:117–35.
14. Gerretsen P, Kim J, Quilty L, Wells S, Brown EE, Agic B, et al. Vaccine hesitancy is a barrier to achieving equitable herd immunity among racial minorities. Front Med. 2021;8.
15. Mosby I, Jaris Swidrovich. Medical experimentation and the roots of COVID-19 vaccine hesitancy among indigenous peoples in Canada. Can Med Assoc J. 2021;193:E381.
16. Williamson LD, Bigman CA. A systematic review of medical mistrust measures. Patient Educ Couns. 2018;101:1786–94.
17. Benkert R, Cuevas A, Thompson HS, Dove-Medows E, Knuckles D. Ubiquitous yet unclear: a systematic review of medical mistrust. Behav Med. 2019;45:86–101.
18. Jaiswal J, Halkitis PN. Towards a more inclusive and dynamic understanding of medical mistrust informed by science. Behav Med. 2019;45:79–85.
19. Gamble VN. Under the shadow of Tuskegee: African Americans and health care. Am J Public Health. 1997;87:1773–8.
20. Gaston GB, Alleyne-Green B. The impact of African americans' beliefs about HIV medical care on treatment adherence: a systematic review and recommendations for interventions. AIDS Behav. 2013;17:31–40.
21. Thomas SB, Quinn SC. The Tuskegee Syphilis Study, 1932 to 1972: implications for HIV education and AIDS risk education programs in the black community. Am J Public Health. 1991;81:1498–505.
22. Hammond WP. Psychosocial correlates of medical mistrust among African American men. American J of Comm Psychol. 2010;45:87–106.
23. Carlisle BL, Murray CB. The role of cultural mistrust in health disparities. The Wiley Encyclopedia of Health Psychology. Wiley Online Library; 2020. p. 43–50.
24. Adams LB, Richmond J, Corbie-Smith G, Powell W. Medical mistrust and colorectal cancer screening among African Americans. J Community Health. 2017;42:1044–61.
25. Guadagnolo BA, Cina K, Helbig P, Molloy K, Reiner M, Cook EF, et al. Medical mistrust and less satisfaction with health care among Native Americans presenting for cancer treatment. J Health Care Poor Underserved. 2008;20:210–26.
26. Hammond WP, Matthews D, Mohottige D, Agyemang A, Corbie-Smith G. Masculinity, medical mistrust, and preventive health services delays among community-dwelling African-American men. J Gen Intern Med. 2010;25:1300–8.
27. LaVeist TA, Nickerson KJ, Bowie JV. Attitudes about racism, medical mistrust, and satisfaction with care among African American and White cardiac patients. Med Care Res Rev. 2000;57:146–61.
28. Powell W, Richmond J, Mohottige D, Yen I, Joslyn A, Corbie-Smith G. Medical mistrust, racism, and delays in preventive health screening among African-American men. Behav Med. 2019;45:102–17.

29. Thompson HS, Valdimarsdottir HB, Winkel G, Jandorf L, Redd W. The Group-Based Medical Mistrust Scale: psychometric properties and association with breast cancer screening. Prev Med. 2004;38:209–18.
30. LaVeist TA, Isaac LA, Williams KP. Mistrust of health care organizations is associated with underutilization of health services. Health Serv Res. 2009;44:2093–105.
31. Charura D, Hill AP, Etherson ME. COVID-19 vaccine hesitancy, medical mistrust, and mattering in ethnically diverse communities. J Racial and Ethnic Health Disparities. 2023;10:1518–25.
32. Nah S, Williamson LD, Kahlor LA, Atkinson L, Ntang-Beb J-L, Upshaw SJ. COVID-19 vaccine hesitancy in Cameroon: the role of medical mistrust and social media use. J Health Commun. 2023;28:619–32.
33. Thompson HS, Manning M, Mitchell J, Kim S, Harper FWK, Cresswell S, et al. Factors associated with racial/ethnic group–based medical mistrust and perspectives on COVID-19 vaccine trial participation and vaccine uptake in the US. JAMA Netw Open. 2021;4.
34. Allen JD, Fu Q, Shrestha S, Nguyen KH, Stopka TJ, Cuevas A, et al. Medical mistrust, discrimination, and COVID-19 vaccine behaviors among a national sample U.S. adults. SSM Popul Health. 2022;20:101278.
35. Morgan KM, Maglalang DD, Monnig MA, Ahluwalia JS, Avila JC, Sokolovsky AW. Medical mistrust, perceived discrimination, and race: a longitudinal analysis of predictors of COVID-19 vaccine hesitancy in US adults. J Racial Ethn Health Disparities. 2023;10:1846–1855.
36. Prall SP. Quantifiable cross-cultural research on medical mistrust is necessary for effective and equitable vaccination in low- and middle-income countries. J Epidemiol Glob Health. 2024;14:1771–7.
37. Woskie LR, Fallah MP. Overcoming distrust to deliver universal health coverage: lessons from Ebola. BMJ. 2019;l5482.
38. Essendi H, Mills S, Fotso J-C. Barriers to formal emergency obstetric care services' utilization. J Urban Health. 2011;88:356–69.
39. Helova A, Akama E, Bukusi EA, Musoke P, Nalwa WZ, Odeny TA, et al. Health facility challenges to the provision of Option B+ in western Kenya: a qualitative study. Health Policy Plan. 2016;czw122.
40. Athias L, Macina M. Demand for vaccination in sub-Saharan Africa: the vertical legacy of the slave trade. Soc Sci Med. 2022;293.
41. Comfort AB, Asiimwe S, Amaniyre G, Orrell C, Moody J, Musinguzi N, et al. Social networks and HIV treatment adherence among people with HIV initiating treatment in rural Uganda and peri-urban South Africa. SSM - Population Health. 2024;25.
42. Jarolimova J, Yan J, Govere S, Ngobese N, Shazi ZM, Khumalo AR, et al. Medical mistrust and stigma associated with COVID-19 among people living with HIV in South Africa. AIDS Behav. 2021;25:3967–77.
43. Prall SP, Scelza BA, Davis HE. Medical mistrust, discrimination, and healthcare experiences in a rural Namibian community. Glob Public Health. 2024;19:2346207.
44. Şengül H, Bulut A. Determination of the relationship between physician trust, medical mistrust, and self-confidence in the health services provided in Turkey. HumanSciences. 2020;17:1222–34.
45. Ameyaw EK, Kareem YO, Ahinkorah BO, Seidu A-A, Yaya S. Decomposing the rural–urban gap in factors associated with childhood immunisation in sub-Saharan Africa: evidence from surveys in 23 countries. BMJ Glob Health. 2021;6.
46. Ayers CK, Kondo KK, Williams BE, Kansagara D, Advani SM, Smith M, et al. Disparities in H1N1 vaccination rates: a systematic review and evidence synthesis to inform COVID-19 vaccination efforts. J Gen Intern Med. 2021;36:1734–45.
47. Bocquier A, Ward J, Raude J, Peretti-Watel P, Verger P. Socioeconomic differences in childhood vaccination in developed countries: a systematic review of quantitative studies. Expert Rev Vaccines. 2017;16:1107–18.
48. Lucyk K, Simmonds KA, Lorenzetti DL, Drews SJ, Svenson LW, Russell ML. The association between influenza vaccination and socioeconomic status in high income countries varies by the measure used: a systematic review. BMC Med Res Methodol. 2019;19:153.
49. Vukovic V, Lillini R, Lupi S, Fortunato F, Cicconi M, Matteo G, et al. Identifying people at risk for influenza with low vaccine uptake based on deprivation status: a systematic review. Eur J Public Health. 2018;30:132–141.
50. Barr M, Raphael B, Taylor M, Stevens G, Jorm L, Giffin M, et al. Pandemic influenza in Australia: using telephone surveys to measure perceptions of threat and willingness to comply. BMC Infect Dis. 2008;8:117.
51. Lo CC, Laurent-Simpson A. How SES may figure in perceptions of zika risks and in preventive action. Sociol Spectr. 2018;38:295–311.
52. Na L, Banks S, Wang PP. Racial and ethnic disparities in COVID-19 vaccine uptake: a mediation framework. Vaccine. 2023;41:2404–11.
53. Raude J, Peretti-Watel P, Ward J, Flamand C, Verger P. Are perceived prevalences of infection also biased and how? Lessons from large epidemics of mosquito-borne diseases in tropical regions. Med Decis Making. 2018;38:377–89.
54. Teklehaimanot HD, Teklehaimanot A, Yohannes M, Biratu D. Factors influencing the uptake of voluntary HIV counseling and testing in rural Ethiopia: a cross sectional study. BMC Public Health. 2016;16:239.
55. Bamgboye EL, Omiye JA, Afolaranmi OJ, Davids MR, Tannor EK, Wadee S, et al. COVID-19 pandemic: is Africa different? J Natl Med Assoc. 2021;113:324–35.
56. Shattuck EC, Forman J, Shiju S, Herlosky KN, Mabulla IA, Crittenden AN. Vaccine knowledge and acceptance among hadzabe hunter-gatherers in Tanzania. American J Hum Biol. 2025;37.
57. Prall S, Lopes A. "Better to die trying": vaccine perceptions and COVID-19 experiences in rural Namibian pastoralists. Vaccine. 2025;55:127061.
58. El-Moamly AA, El-Sweify MA. Malaria vaccines: the 60-year journey of hope and final success—lessons learned and future prospects. Trop Med Health. 2023;51:29.
59. Willyard C. The bumpy road to malaria vaccination. Nature. 2022;S48–9.
60. Chutiyami M, Saravanakumar P, Bello UM, Salihu D, Adeleye K, Kolo MA, et al. Malaria vaccine efficacy, safety, and community perception in Africa: a scoping review of recent empirical studies. Infection. 2024;52:2007–2028.
61. Mumtaz H, Nadeem A, Bilal W, Ansar F, Saleem S, Khan QA, et al. Acceptance, availability, and feasibility of RTS, S/AS01 malaria vaccine: a review. Immunity Inflam & Disease. 2023;11.
62. Kabir Sulaiman S, Isma'il Tsiga-Ahmed F, Sale Musa M, Kabir Sulaiman A, Muhammad Dayyab F, Ab Khan M, et al. Prevalence, determinants, and reasons for malaria vaccine hesitancy among caregivers of under-five children in Nigeria: results from a nationwide cross-sectional survey. Vaccine. 2023;41:1503–12.
63. Achieng F, Rosen JG, Cherop RY, Kariuki S, Hoffman SL, Seder R, et al. Caregiver and community perceptions and experiences participating in an infant malaria prevention trial of PfSPZ Vaccine administered by direct venous inoculation: a qualitative study in Siaya County, western Kenya. Malar J. 2020;19:226.

64. Bingham A, Gaspar F, Lancaster K, Conjera J, Collymore Y, Ba-Nguz A. Community perceptions of malaria and vaccines in two districts of Mozambique. Malar J. 2012;11:394.
65. World Bank. Namibia health sector public expenditure review. World Bank. 2019. Available from: https://elibrary.worldbank.org/doi/abs/. https://doi.org/10.1596/32111
66. Bobo FT, Asante A, Woldie M, Dawson A, Hayen A. Child vaccination in sub-Saharan Africa: increasing coverage addresses inequalities. Vaccine. 2022;40:141–50.
67. WHO. Namibia reaches key milestone in eliminating mother-to-child transmission of HIV and hepatitis B [Internet]. WHO Africa. 2024. Available from: https://www.afro.who.int/news/namibia-reaches-key-milestone-eliminating-mother-child-transmission-hiv-and-hepatitis-b
68. Ackah BBB, Woo M, Stallwood L, Fazal ZA, Okpani A, Ukah UV, et al. COVID-19 vaccine hesitancy in Africa: a scoping review. Glob Health Res Policy. 2022;7:21.
69. Mushaandja T, Ithindi S. Vaccine or no vaccine: a critical analysis on how information on COVID-19 vaccine is communicated in Namibia. NJLC. 2023;16:77–90.
70. Shikwambi PK. The challenges of communicating global pandemics as a national security issue: a case study of COVID-19 in Namibia. University of Namibia; 2023.
71. Ngutjinazo O. MTC slams 5G rumours. The Namibian [Internet]. 2020; Available from: https://www.namibian.com.na/mtc-slams-5g-rumours/#:~:text=In%20a%20press%20statement%20issued,the%20erection%20of%205G%20towers
72. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20:533–4.
73. Okereke M, Ukor NA, Ngaruiya LM, Mwansa C, Alhaj SM, Ogunkola IO, et al. COVID-19 Misinformation and Infodemic in Rural Africa. Am J Trop Med Hyg. 2021;104:453–6.
74. Kanyanda S, Markhof Y, Wollburg P, Zezza A. Acceptance of COVID-19 vaccines in sub-Saharan Africa: evidence from six national phone surveys. BMJ Open. 2021;11.
75. Bollig M. Risk management in a hazardous environment: a comparative study of two pastoral societies. Springer US; 2006.
76. Chamboko R, Re A, Guvuriro S. Mapping patterns of multiple deprivation in Namibia. IJSE. 2017;44:2486–99.
77. NHDR. UNDP Namibia Annual Report 2019. 2019.
78. Levine S, Roberts B, May J, Bhorat H, Duclos J, Thorbecke E, et al. A review of poverty and inequality in Namibia. Central Bureau of Statistics National Planning Commission; 2008.
79. Mwinga M, Kavezuva C, Shifidi A, Simasiku P. Opuwo economic profile. First Capital Namibia; 2022.
80. Van Rooy G, Mufune P, Amadhila E. Experiences and perceptions of barriers to health services for elderly in Rural Namibia: a qualitative study. SAGE Open. 2015;5:215824401559604.
81. Bollig M. The colonial encapsulation of the north-western Namibian pastoral economy. Africa. 1998;68:506–36.
82. Bollig M. Drought, disaster, and identity in north-western Namibia in times of global climate change. Climate change epistemologies in Southern Africa. 1st ed. London: Routledge; 2023. p. 27–48.
83. April WI, Mutumba B, Erwee P. Exploring entrepreneurship amongst the herero People in Namibia: the Otjinene Village. IJBA. 2014;5.
84. Malan JS. Peoples of Namibia [Internet]. Rhino Publishers Wingate Park; 1995.
85. Schwieger DAM, Mbidzo M. Socio-historical and structural factors linked to land degradation and desertification in Namibia's former Herero'homelands'. J Arid Environ. 2020;178.
86. Buscemi J, Arteaga N, O'Donnell A, Takgbajouah M, Bushnell A, Mirich C, et al. Factors associated with COVID-19 vaccination uptake in community health center patients. Health Psychol. 2023;42:551.
87. Bürkner P-C. brms: an R package for Bayesian multilevel models using stan. J Stat Softw. 2017;80:1–28.
88. R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation; 2020. Available from: https://www.R-project.org/
89. RStudio Team. RStudio: Integrated development environment for R. Boston, MA: RStudio, PBC; 2020. Available from: http://rstudio.com/
90. Firke S. Janitor: simple tools for examining and cleaning dirty data. 2021. Available from: https://CRAN.R-project.org/package=janitor
91. Kay M. Tidybayes: tidy data and Geoms for Bayesian models. 2020. Available from: https://doi.org/10.5281/zenodo.1308151
92. Pedersen TL. Patchwork: the composer of plots. 2022. Available from: https://CRAN.R-project.org/package=patchwork
93. Wickham H. Tidyverse: easily install and load the "Tidyverse". 2017. Available from: https://CRAN.R-project.org/package=tidyverse
94. Wickham H. Modelr: modelling functions that work with the pipe. 2020. Available from: https://CRAN.R-project.org/package=modelr
95. Venditto B, Kamwanyah NJ, Nekare C. COVID-19 and inequality in Namibia: a vicious syndemic?. Namib J Soc Just. 2022;76.
96. Smith-Sreen J, Miller B, Kabaghe AN, Kim E, Wadonda-Kabondo N, Frawley A, et al. Comparison of COVID-19 pandemic waves in 10 countries in Southern Africa, 2020–2021. Emerg Infect Dis. 2022;28:S93.
97. Awofolu OR, Niikondo A. Effectiveness and impact of Covid-19 response and vaccination challenges in Namibia: a systematic review. J Public Health Afr. 2024;14:2094.
98. Lifalaza A, Stern R, Ashipala DO. Perceptions of mothers and caregivers regarding the factors affecting low uptake of measles immunisation among children under 5 years in Nyangana District. Namibia GJHS. 2018;10:74.
99. Izquierdo C. When, "health" is not enough: societal, individual and biomedical assessments of well-being among the Matsigenka of the Peruvian Amazon. Soc Sci Med. 2005;61:767–83.
100. Dong L, Bogart LM, Gandhi P, Aboagye JB, Ryan S, Serwanga R, et al. A qualitative study of COVID-19 vaccine intentions and mistrust in Black Americans: recommendations for vaccine dissemination and uptake. Newman PA, editor. PLoS ONE. 2022;17:e0268020.
101. Tsui J, Martinez B, Shin MB, Allee-Munoz A, Rodriguez I, Navarro J, et al. Understanding medical mistrust and HPV vaccine hesitancy among multiethnic parents in Los Angeles. J Behav Med. 2023;46:100–15.
102. Wollburg P, Markhof Y, Kanyanda S, Zezza A. Assessing COVID-19 vaccine hesitancy and barriers to uptake in sub-Saharan Africa. Commun Med. 2023;3:121.
103. Bangura JB, Xiao S, Qiu D, Ouyang F, Chen L. Barriers to childhood immunization in sub-Saharan Africa: a systematic review. BMC Public Health. 2020;20:1108.
104. Metcalf CJE, Tatem A, Bjornstad ON, Lessler J, O'Reilly K, Takahashi S, et al. Transport networks and inequities in vaccination: remoteness shapes measles vaccine coverage and prospects for elimination across Africa. Epidemiol Infect. 2015;143:1457–66.
105. Prall S, Scelza B, Davis HE. Context dependent preferences in prestige bias learning about vaccination in rural Namibian pastoralists. Soc Sci Med. 2024;362.
106. Hagen RV, Scelza BA. Adoption of outgroup norms provides evidence for social transmission in perinatal care practices among rural Namibian women. Evolution, Medicine, and Public Health. 2020;2020:161–73.

107. Leach M, MacGregor H, Akello G, Babawo L, Baluku M, Desclaux A, et al. Vaccine anxieties, vaccine preparedness: perspectives from Africa in a Covid-19 era. Soc Sci Med. 2022;298.