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Context dependent preferences in prestige bias learning about vaccination in rural Namibian pastoralists

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Abstract

Extensive work in the social sciences suggests that vaccination decisions are subject to incentives, biases, and social learning processes, including prestige bias transmission. High status figures, like doctors and public health officials, can be effective messengers for vaccination information and uptake under certain conditions. In communities where there is significant medical mistrust and less interaction with markets and formal medical systems, prestige bias social learning may operate through different channels. Here, we examine the role of prestige bias on vaccine decisions in two ethnic groups (Himba and Herero) with varying levels of market integration and experiences with formal healthcare systems. Participants completed a ranking task, comparing the influence of four prestigious individuals on vaccine decisions and a survey on medical mistrust. Using Plackett-Luce models, we compare the influence of location, ethnic affiliation, and other covariates on rankings. A multi-level model compared the influence of those within and outside one's ethnic group, as well as specialist (doctor/healer) and generalist (chief/governor) prestige figures. Results indicate changes in the rank of prestigious individuals across the rural-urban gradient. Our results demonstrate significant variability in prestige-biased social learning about vaccine decision making. Medical mistrust did not impact rankings. Contrary to previous work, we find that whether a prestigious individual is locally prominent is more important than their expertise in the relevant domain (health and healing). These findings emphasize the need for more context-specific studies of prestige bias, which can improve our understanding of healthcare decision-making and guide public health messaging across diverse contexts.

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Ethics approval and consent to participate
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. The authors confirm that verbal informed consent was obtained from all individuals participating in the study, as approved by the UCLA IRB, as the study population is non-literate. All methods were carried out in accordance with relevant guidelines and regulations.

Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2024.117461.

Declaration of competing interest
The authors have no conflicts of interest to declare.

1. Introduction

Vaccines remain one of the most effective tools to reduce morbidity and mortality from infectious diseases and have been at the heart of global health efforts for decades. Despite their successes, there are numerous barriers to vaccine uptake. In low- and middle-income countries, limits on vaccine supplies, manufacturing, storage, and delivery impede progress toward vaccination goals (Excler et al., 2021). Alongside these systemic issues, vaccine hesitancy and individual barriers to uptake have become acutely evident following the global COVID-19 pandemic. Concerns about the increase in vaccine hesitancy, including the increasing prevalence of parents refusing to follow recommended vaccination schedules, anti-vaccination campaigns, and the spread of vaccine-related conspiratorial beliefs has resulted in what some are calling "the golden age of anti-vaccine conspiracies" (Stein, 2017). The WHO lists vaccine hesitancy as one of ten important global health threats (World Health Organization, 2019), and some now argue that it is vaccine hesitancy, not access, which is the primary barrier to vaccination in many industrialized countries (Larson et al., 2016). Researchers have identified numerous sources of vaccine hesitancy, and have highlighted considerable variation in acceptance by race, class, and gender, as well as by individual-level factors like risk aversion and trust in authority (Biswas et al., 2021; Hudson and Montelpare, 2021; Kreps and Kriner, 2021).

One potential mechanism for overcoming vaccine hesitancy is to improve the efficacy of communication about vaccines. High status figures, like government and public health officials, can be effective messengers for vaccination information and uptake (Johnson et al., 2022), but in other cases distrust can hinder messaging, and become a barrier to vaccination (Lee et al., 2016). Evidence suggests that the type, source, and content of vaccine information, including the type of messenger, may induce changes in behavior (Jiménez et al., 2018; Kuru et al., 2021; Motta et al., 2021; Salali and Uysal, 2021). In addition, messengers are linked to the larger systems and ideologies they represent. For example, vaccine hesitancy among African Americans has been linked to long histories of endemic racism and structural health inequalities (Batelaan, 2022; Dong et al., 2022), with similar findings in Europe and Australia (Graham et al., 2022; Kyprianidou et al., 2023; Paul et al., 2022). However, much of our knowledge comes from studies in the Global North. In the Global South, particularly in rural areas, we still know little about how and why individuals decide to trust relevant sources, and the potential drivers of trust in different types of experts and non-experts.

In areas where there is limited public health infrastructure and access to public health messaging, locally prestigious individuals may be more influential in vaccination and healthcare decisions. This may be particularly true in rural areas, and where people lack access to national forms of media, and information is passed largely through local networks. During Ebola outbreaks in countries where skepticism in government officials was high, religious leaders often became trusted sources of information and were crucial in mediating behavior change to reduce the spread of the virus (Marshall, 2017). In the Democratic Republic of Congo during the 2018 Ebola outbreak, as trust in the healthcare system and in government authorities eroded, traditional healers were instead relied on as sources for information and treatment (Muzembo et al., 2020). This can be problematic when these

same figures argue *against* efficacious biomedical treatments and recommended preventative measures (Turse, 2019). Distrust and misinformation are not unique to the Global South, but continue to stimy efforts to address health issues in countries where national healthcare systems are often underfunded (Prall, 2024). In these cases, better understanding of the ways in which people seek out and listen to prestigious individuals for healthcare information may be useful to public health outreach and policy.

Cultural evolutionary theory provides a useful framework to consider how and why people might bias their social learning strategies toward particular individuals, including high status figures (Panchanathan, 2024). Prestige bias is a mode of cultural transmission where individuals preferentially learn from and copy the behaviors of high-status people (Boyd and Richerson, 1985; Henrich and Gil-White, 2001). This is a useful strategy because it acts to short-cut the potentially laborious and costly task of assessing the success of multiple individuals in a particular domain. If successful individuals are more likely to be copied by others, then they would be more likely to receive prestige from the population as a whole (Henrich and Gil-White, 2001). Rather than assay the success of individuals for competence in a domain, it is more efficient to simply model the behaviors of those that are considered prestigious (Panchanathan, 2010). This is not to say that prestige bias transmission is always optimal, and can even be detrimental when individuals learn sub-optimal or harmful behaviors from prestigious others. In an online experiment using a general knowledge quiz, people tended to model hypothetical others with prestige cues, even when information about whether prestige cues actually mapped onto success was hidden (Brand et al., 2020). Prestige bias transmission may be particularly important when the individuals in question achieved prestige in an area relevant to the learner's needs. This has been termed domain-specific prestige, where a model's influence is specific to the domain in which they are successful, as opposed to domain-general prestige, where a person is influential more generally (e.g. a successful actor having influential political views). Experimental evidence has shown that when given a choice between domain-general and domain-specific prestige cues, participants favored domain-specificity; however, when only domain-general cues were given, these were still preferred over random copying (Brand et al., 2021). However, some areas of social learning may be more sensitive to domain-general prestige bias. Jiménez and Mesoudi (2019) predict that under conditions of high variability in skill or knowledge, or when cues of success are noisy and difficult to interpret, learners may lean on domain-general prestige cues, or assume that success in a different domain may indicate success in the domain in question. Additionally, they propose that some traits like intelligence or perseverance may lead to success across domains, which learners may cue into when assessing competence or success.

Another form of social learning bias that has been shown to impact people's decision-making is bias towards the in-group. Parochialism has been argued to be common across human societies, fundamental to the evolution of human cooperative endeavors, and may explain widespread cultural features like inter-group warfare and violence (Böhm et al., 2020; Choi and Bowles, 2007). Social or ethnic markers can be important signals underlying group membership, and function to signal membership, allowing for ingroup favoritism as a means to solve coordination problems among members with similar norms (Efferson et al., 2008). In-group bias appears to be foundational to human interactions, and is present and

motivates behavior even in preschool aged children (Buttelmann and Böhm, 2014). These in-group biases need not be taught, but can be socially learned through observation and non-verbal cues (Skinner et al., 2020). In-group preference can impact interactions with outgroup members, making the outgroup feel less trustworthy (Brewer and Kramer, 1985). However, parochialism varies based on the costs and benefits of intergroup competition and intragroup cooperation (Pisor and Ross, 2024). For example, Jha (2013) argues that institutions to support trade drove medieval Muslim and Hindu cooperation in ports, resulting in more historic inter-ethnic tolerance and trust across ethnically and religiously diverse communities. Market integration may provide such incentives, increasing the degree and frequency of interaction with and reliance on out-group members (Colleran, 2020). These interactions with out-groups may also lead to increased trust and cooperation with strangers (Henrich et al., 2005). When Orma pastoralists engage in wage labor, they are more generous with strangers in economic games (Ensminger, 2004). Incentives like market integration may dilute in-group bias and shift perceptions of out-group members to be more favorable, potentially leading to increased interaction with and social learning from individuals from different ethnic backgrounds.

Healthcare decisions like vaccination may be particularly sensitive to social learning biases like these. When individuals lack expertise in a specific high-stakes domain, they may instead rely on prestigious others, particularly when those others have content specific knowledge (Henrich and Gil-White, 2001; Jiménez and Mesoudi, 2019), in this case the domain of health and healing. Other social learning biases, like success biases, may be very difficult to assess in the context of health and healing. Health outcomes can be idiosyncratic and particular to the individual and their underlying condition. Even when success can be ascertained, experimental evidence suggests that people rely on prestige bias as frequently as success bias as a social learning strategy, including instances where prestige behaviors were poor models for successful outcomes (Atkisson et al., 2012). Social learning may be particularly germane in the case of novel diseases like COVID-19, or novel treatments and preventative measures like vaccinations, where relevant costs and benefits are difficult to evaluate (Arnot et al., 2020). Similarly, in-group bias may be a useful strategy in the context of healthcare decision making, even when domain-specific experts are available, when there is general distrust of governmental authorities and international non-governmental organizations, or even local healthcare institutions.

While the social learning literature shows promise from a theoretical perspective, it is rarely applied in real-world contexts (see Hoppitt and Laland, 2013 for a review), so extensions of social learning to healthcare decisions are limited. However, there have been a few studies which show potential for their strong explanatory power in understanding healthcare decisions. Hagen and Scelza (2020), in a study examining social transmission of perinatal care behaviors, found that women were more likely to prefer, plan, and practice medical recommendations when they viewed those recommendations as more common in their community. Similarly, other work has shown how perceptions of community level family planning and the opinions of friends and family shape contraceptive decisions (Colleran and Mace, 2015; Dynes et al., 2012). In an online study of prestige bias on COVID-19 vaccine incentives, participants were most likely to be influenced by an "expert scientist" getting vaccinated, suggesting both prestige and expertise may play a role in social learning (Salali

and Uysal, 2021). However, in the same study, friends and family receiving the COVID-19 vaccine, and perceptions of risk of the disease also influenced respondents' likelihood of vaccination, suggesting that other social learning biases also play a role. Elsewhere, evidence indicates no differences in whether communication was via subject experts or laypersons (Motta et al., 2021). Other work highlights how salient messages from laypersons can overwhelm less emotional messages from prestigious experts (Jiménez et al., 2018). Theorists have noted that multiple biases are likely to co-occur, so we should expect a mix of social learning strategies in the context of vaccine decisions (Boyd and Richerson, 1985).

In this study, we aim to address gaps in the current literature on the social learning of vaccine related decision making. In particular, we compare the influence of in-group versus out-group, and domain-general versus domain-specific prestige bias figures using a ranking task. We also explore the role of individual level factors like mistrust of formal healthcare, predicting that higher medical mistrust will shift preferred prestige bias away from establishment medical figures. We conduct this study with a sample of rural Namibian pastoralists representing several ethnic groups, and across a rural to urban gradient. This allows us to compare how ethnic identity and ruralness (which are linked to access to healthcare and interaction with markets) impact which prestigious figures are preferred as models for vaccine decision-making. We predict that individuals closer to town, and members of more market integrated ethnic groups should have a weaker preference for in-group prestigious figures. Understanding these differences, and the variables driving who is regarded as important in relaying vaccine related information, can usefully inform public health messaging and outreach.

2. Methods

2.1. Study population

This study was conducted in the Kunene region of Namibia, a particularly arid region of the country. The region is also known to have high levels of inequality and very low human development scores (NHDR, 2019). While the region is home to many ethnic groups, our study focuses on Himba and Herero, who share a common history, language, and many social norms and customs (Malan, 1995). Among Himba, who tend to live in more rural areas, semi-nomadic pastoralism is still the major mode of subsistence, in conjunction with the maintenance of small gardens. Historically, Himba have been marginalized by colonial governments in various ways, limiting both sales of livestock and access to the larger market economy (Bollig, 1998). More recently, severe droughts combined with the erosion of traditional pasturage management systems have further harmed traditional livelihoods (Bollig, 2013, 2023; Inman et al., 2020; Prall and Scelza, 2023). In contrast to Himba, many Herero practice farming, trade, and business, have more formal education, and are well integrated into a market economy (April et al., 2014; Malan, 1995; Schwieger and Mbidzo, 2020). This is particularly true in Opuwo, where Herero work wage labor jobs while still maintaining connections to rural villages.

Access to healthcare in many parts of the Kunene remains difficult, with residents tending to live further from healthcare facilities than the national average (Levine et al., 2008; World Bank, 2019). Residents in rural areas have access to clinics where basic medical care is

available, although access to these is quite variable, depending on distance to major roads. Otherwise, residents must drive to the regional hospital in Opuwo, which can be up to 200 km away. Even those who live in or near town face hurdles to accessing healthcare, due to long wait times and staff shortages at the hospital (Mwinga et al., 2022).

Experiences with COVID-19 vary across the rural-urban spectrum in this region. We recently surveyed COVID experiences in the region and found that while rural residents were much less likely than their urban counterparts to know someone who was sick or died from COVID, they expressed more worry about the disease (Prall et al., in review). Lower direct experience with COVID in rural areas may reflect a national strategy to limit interactions between urban and rural residents during the pandemic (Awofolu and Niikondo, 2024), while relatively low rates of morbidity and mortality across sub-Saharan Africa, may be mitigating the perceived risk for urban residents who have more experience with the disease (Smith-Sreen et al., 2022).

While inequality in healthcare persists in Namibia, the country has been generally successful with its vaccination campaigns, showing relatively high rates of childhood vaccination in both rural areas and low socio-economic status households (Ameyaw et al., 2021; Bobo et al., 2022). This is reflected in the ethnographic interviews we have conducted, where most people express a general trust in vaccines (Prall et al., in review). COVID-19 vaccination campaigns have not fared quite as well (Ackah et al., 2022; Mushaandja and Ithindi, 2023; Shikwambi, 2023). Overall across the country, about 24% of Namibians have been vaccinated against COVID-19 (Dong et al., 2020). In the Kunene region we recently found that rural and urban communities had different concerns about the COVID-19 vaccine (Prall et al.,., in review). For rural residents, lack of access to the vaccine was the most commonly cited reason for not getting vaccinated, while unvaccinated urban and peri-urban residents were more likely to cite a lack of interest in the vaccine and safety concerns.

4.2. Sampling

Data for this study was collected across several locations in the Kunene region of Namibia (N = 198). Participants range from 18 to 80 years old, with the majority of respondents being female (Table 1). Approximately 89 individuals were sampled in the rural focal community, of Omuhonga, comprising 45% of the total sample. This community has been the focus of a long-term demographic and health project we have been running since 2010, so most individuals surveyed for this part of the sample were familiar with the research team. The community consists of 40–50 households and is located approximately 150 km northwest of the regional capital of Opuwo. In this location, seven individuals from several ethnolinguistic groups closely affiliated with Himba were also sampled (Hakaona, Themba, Tjimba, Zemba). Since these groups have very similar lifestyles, wealth, and access to markets, they were grouped with Himba for this analysis. Coding these individuals separately yielded similar results with no meaningful differences. As a comparison to rural Himba from Omuhonga, sampling also took place in peri-urban Himba compounds 15–20 km from Opuwo. These households are similar to the rural sample but differ in their distance to town and ability to access markets and shops, which affects their exposure to out-group

norms. They also have easier access to the hospital. Finally, sampling also took place in urban Opuwo, where our sample is largely comprised of urban Herero.

Clumping of rural Himba and urban Herero limit comparison somewhat between ethnic group and location, so we added additional categories for comparison between Himba and Herero: Herero urban/periurban, Himba urban/periurban, and Himba rural. This breakdown allows us to examine the influences of both ethnic group and location while maintaining adequate sample sizes in each category. Fig. 1 shows results by rank for each category.

4.3. Ranking task

The primary outcome for this study is a ranking task of individuals who may influence vaccination decisions. This method was chosen as a simple and effective way to ascertain beliefs about the influence of prestigious community figures. Best practices in ethical research with marginalized communities suggest designing studies that have succinct instruments, limit privacy violations, and are accessible to most members of the community (Potnis et al., 2017). This ranking task was quickly and easily learned, took about 5 min to complete, and could ascertain preferences without needing to ask about personal opinions of authority figures. Pilot data using interviews and Likert scales indicated that all individuals used in the ranking task are perceived as both prestigious and influential in making healthcare decisions. Translators speaking in *Otjiherero* described four types of people: a community chief, a traditional healer, a doctor in Opuwo, and the Governor of Kunene. Notably, nurses and doctors in Opuwo are typically not Himba or Herero, and belong to other ethnic groups (e.g. Ovambo), so would be considered outgroup members for either Himba and Herero participants. The governor is known to virtually all Kunene residents, including those in rural locations and without formal education. This structure allows us to compare two ingroup members (chief and traditional healer, who would be members of any respondent's ethnic group) with two outgroup members (doctor and governor, who would not be members of any respondent's ethnic group), and two people with domain-specific knowledge of health (doctor and healer) against two domain-general prestigious figures (chief and governor). Participants were asked which of these four people were most influential in their decision to get vaccinated. The type of vaccine was not specified, although this task was completed after a set of questions about vaccination experiences with COVID-19. After the initial selection, the process was repeated until the four types of people were ranked. All participants fully ranked the four options (1 being the highest rank), and ties were not allowed. Of the 198 individuals sampled, 183 completed the ranking task.

4.4. Medical mistrust survey

All participants completed an amended version of the 7-item Medical Mistrust Index (MMI) (LaVeist et al., 2009). This survey was developed to measure an individual's propensity to distrust medical personnel and institutions and has been primarily used in industrialized countries like the US. Previous research indicates high MMI scores are associated with underutilization of healthcare in various contexts (Hammond, 2010; Morgan et al., 2022; Williamson and Bigman, 2018). Previous work in the Kunene illustrates that MMI scores are associated with negative healthcare experiences, avoidance of healthcare, and perceived

discrimination among Himba (Prall et al., 2024). MMI scores were calculated by averaging item responses creating a bounded scale from 1 (low mistrust) to 4 (high mistrust).

4.5. Consent and ethics procedures

Our team has worked in the Kunene region for more than a decade, conducting both quantitative and qualitative investigations of cultural and family dynamics, health, and reproduction. The methods developed for this study build from the ethnographic knowledge gained during this time, and were designed to be easily understandable within both the rural community, where people have limited formal education, as well as the more urban areas where some schooling is more common. Card games such as the ranking task used here have been successfully used in these communities in the past by our team, and tend to work well as they provide a combination of visual and verbal stimuli, and break up the more formal, written parts of the interview. The medical mistrust survey was piloted in the rural community with a set of known interlocutors. Slight adjustments to the wording of questions were made to make translation and interpretation suitable to the cultural context (see Prall et al., 2024 for exact translations used).

Oral consent was used in all areas, because of both limited literacy and due to discomfort with formal forms and contracts. All recruitment, consent and study materials were translated and back-translated with a local research team, and the study was conducted in participants' native language. In each of the locations the decision to participate in the study was left open to community members. Recruitment and description of the study was provided at the group level within households or at local meeting points like boreholes and sandwells. Individuals could then choose whether they wanted to participate. The study itself took about 20 min and participants were compensated for their time with household goods (e.g. sugar, washing powder), similar to previous studies conducted in both rural and peri-urban settings in previous years. All interviews were conducted privately (typically outdoors under a tree) to ensure confidentiality in responses.

4.6. Analysis

Plackett-Luce models via the *PlackettLuce* R package were used to analyze and compare ranked outcomes. This approach allows for flexible comparison and analysis of ranked data, including the ability to assess the impact of covariates between subgroups via model-based partitioning (see Turner et al., 2020 for further details). First, we estimate the probability of receiving the highest rank using the full sample. Next, we examine how individual predictors may impact specific rank outcomes with Plackett-Luce models with covariates via the *pmr* package (Finch, 2022; Lee and Yu, 2022). Individual predictors include age, sex, ethnic group, MMI, location, and an ethnic group by location variable that breaks down these two variables into three categories; Herero urban/-periurban, Himba urban/periurban, and Himba rural. We also assess and plot the influence of these covariates on rank outcomes using the *pltree* function in the *PlackettLuce* package to generate Plackett-Luce trees, which provide a method to examine how various subgroups derived from covariates differ in rank estimates. To assess the relationship between ranked items, a 2-dimensional unfolding multidimensional scaling (UMDS) model was used via the *smacof* package in R (Leeuw and Mair, 2009; Mair et al., 2022).

To compare differences of domain specific/general and ingroup/outgroup individuals on ranked outcomes, data was converted to long format and individual rank responses were predicted using a multilevel cumulative ordered logit model via the *brms* package (Bürkner, 2017). This approach assumes that ranked data is ordinal, but allows for a comparison of the influence of these two domains. Varying intercepts were included for group (ingroup vs outgroup) and type (domain specific vs domain general). For each of these intercepts we estimated a varying slope by ethnic group as a dummy variable (Himba vs Herero, Herero as the index variable). Lastly, a varying intercept for item type was included, to correct for biases in individual items, allowing better estimation of the influence of these domains. Additional modeling details are described in the supplementary information.

3.   Results

Calculating mean ranks across the whole sample indicates that chief has the highest mean rank, followed by doctor, governor, and healer. Examination of marginal rank frequencies support this ordering (Table S2). Chief was ranked first approximately 50% of the time, but last only 8% of the time. Raw percentage rankings comparing Himba rural, Himba periurban/urban, and Herero periurban/urban are shown in Fig. 1, whereas Plackett-Luce modeling predicting the probability of each item across the entire sample is shown in Fig. 2. In the Herero sample, doctor is most frequently ranked first in more than 50% of respondents. Governor is the most frequent second rank, followed by chief and healer, which dominate the third and fourth rank respectively. Himba periurban/urban and rural samples are fairly similar, where chief is the most common first rank. The second, third, and forth ranks are much more evenly split compared to the conformity of the Herero sample. In the periurban/urban sample, governor is the most frequent second rank, while in the rural sample healer is the most frequent. Healer is increasingly common in lower ranks in the periurban/urban sample, whereas it is more evenly split in the rural Himba. Alternate plots showing raw differences by location only or by ethnic group only are show in in Figs. S1 and S2 respectively.

The UMDS model calculated 2 dimensions, explaining 73.6% of the variance in rankings. These two dimensions are plotted in Fig. 3, showing the relative position of the four ranked items, along with the relative (jittered) position of all respondents. Chief falls towards the center of the plot, indicating its importance across all participants. Chief also falls closer to healer, indicating Dimension 1 largely reflects the difference between healer and doctor/ governor, with the latter two falling very close to each other, indicating that participants who rank governor highly also tend to rank doctor highly. Dimension 2 reflects a difference between governor and doctor, and indicates that participants who rate chief highly are also more likely to rank healer highly.

To examine whether either ethnic group or location statistically influences ranks, we used Plackett-Luce models with the two covariates independently. Since the sample size for other ethnic groups outside of Himba and Herero are quite small, we exclude those in this analysis (n = 176). Location includes rural/urban/peri-urban as a covariate. Comparison of AIC model fit metrics indicates that both variables improve model fit from a model without covariates (AIC = 1024.5), but that the information criterion estimates for either location

or ethnic group are roughly equivalent (AIC = 957.6 and 961.7 respectively). Contrary to predictions, medical mistrust has no impact on rankings.

To better understand how these covariates impact rank, we use a series of Plackett-Luce trees with different combinations of variables across the full sample (Table 2). In the first model, comparing individual level predictors, only age was a significant predictor of rank (p = 0.047), where individuals younger than 45 gave high ranks to doctor and chief, but individuals older than 45 tended to rank only chief highly (Fig. S4). For all models that contain ethnic group, only this predictor was significant (p < 0.001), with the Plackett-Luce trees indicating that Himba are more likely to rank chief first followed by doctor, whereas Herero/Other are more likely to rank doctor first, followed by governor (Figure S5 and Figure S7). To better get a comparison of Himba and Herero across rural and urban/peri-urban, a subsample with this variable as a category and individual level predictors indicate similar results, where Himba rural and Himba periurban/urban fall in a single node (Fig. S8). In no model did sex or medical mistrust have any significant impact on rankings. This remains true if Himba and Herero are modeled individually.

Finally, we compare whether ranks are driven by in-group/out-group distinctions or by domain-general/domain-specific distinctions across rater items (data converted from wide to long format, n = 732). Examining varying intercepts and slopes from the multilevel cumulative ordered logit model indicates little influence of domain specific or domain general intercepts or slopes for rank outcomes on Himba or Herero (the index group) respondents (Fig. 4). However, varying intercepts and slopes for ingroup/outgroup indicate that Herero tend to rank outgroup items higher, while Himba rank ingroup items higher (posterior predictions are plotted in Fig. S9).

4.   Discussion

In this study we investigate how different types of prestigious individuals influence vaccine decision-making, as well as how factors like ethnic group and ruralness affect decisions on who is considered influential. Our results indicate that ingroup/outgroup distinctions are important to the ranking of individuals influential in vaccination decisions, while domain specialist versus domain generalist distinctions are not. This is not to say that medical/health specialists were not ranked highly – doctor was the highest ranked figure in the urban sample – but that there was no general contrast between specialist and generalist items in the multilevel model results. Furthermore, these ingroup/outgroup distinctions cluster by both ethnic group and locality, with primarily rural and periurban Himba selecting "chief" as most influential, while periurban and urban Herero more likely to favor "doctor" and "governor." The multidimensional scaling analysis, which allows us to assess how items cluster, further supports this result indicating that in-group and out-group items clump together, whereas specialist items and generalist items do not.

Our results deviate somewhat from previous experimental work and observational research, where domain-specific expertise was favored over domain-general expertise (Brand et al., 2021), including studies examining vaccination (Salali and Uysal, 2021). However, other studies have shown that domain specificity can be tempered by other factors. For

example, age and vaccine hesitancy impacted whether participants learned more factual COVID-19 information from a prestigious public health official (Johnson et al., 2022). In another study fictional emotional stories of individual experiences about vaccination were transmitted more effectively than views held by a doctor in an experimental social learning study (Jiménez et al., 2018). In our study, domain specific knowledge may also be being influenced by other social learning biases and individual factors.

Two particularly strong influences on our rankings were tribal affiliation and locality, which are strongly correlated. First, we show that ingroup/outgroup preference is mediated by ethnic group – Himba prefer in-group individuals for vaccine information, Herero prefer out-group individuals. These results highlight the flexibility of in-group bias, and the potential for parochialism to be shaped by factors that change the costs and benefits to cooperating with and trusting outgroup individuals (Pisor and Ross, 2024). In this case, our results may be explained by two features of the study population. First, Herero are highly market integrated, and in this sample, live in town close to the hospital. Previous literature suggests that market integration is associated with trust in outgroup individuals (Henrich et al., 2005). Herero more frequently come into contact and cooperate with a variety of different ethnic groups, and frequently engage in market-based transactions. This level of market integration may lower the propensity for in-group favoritism and/or outgroup distrust. Second, urban market-integrated lifestyles may diminish the influence of traditional prestige figures, such as chiefs. The view of traditional healers may be particularly sensitive to changing norms, as they may be viewed as antiquated and out-of-step with more educated, urban lifestyles. Previous work in Africa has shown that urban populations view traditional healing practices less favorably (Abdullahi, 2011; Winkler et al., 2010), whereas in rural areas traditional systems of healing are more widely practiced even when used in conjunction with biomedical care (Kiringe, 2005). In our urban sample, not a single participant ranked traditional healer first. Anecdotally, some upwardly mobile Opuwo residents spoke negatively about the use of traditional healers, which was seen as indicative of the traditional lifestyles they were moving away from.

We also predicted that medical mistrust would negatively influence the ranking of doctors, which could have contributed to the lower influence of domain specificity in our study. Elsewhere, medical mistrust is associated with reduced vaccination uptake in multiple contexts (Allen et al., 2022; Charura et al., 2023; Nah et al., 2023). However, our results did not show an effect of medical mistrust on participant's rankings of who is influential in informing vaccine decisions. In previous work, we found that Himba reported numerous negative interactions with healthcare workers that drive mistrust (Prall et al., 2024), but this doesn't seem to be influencing prestige bias in this task. For example, doctor is evenly split across all the four ranks in rural participants. Negative healthcare experiences may erode trust in medical authorities, but these results suggest that doctors are still frequently trusted in the context of vaccination. Poorer, marginalized groups, with little access to other avenues for healthcare may seek medical care in biomedical healthcare settings despite medical mistrust because they have few choices. This is emphasized in our task, where participants only had four individuals to choose from. Finally, vaccination rankings were made in the context of COVID-19, a novel disease without a cultural model or tradition of healing in indigenous communities. Prestige biased social learning may operate differently for other

diseases which have a deep cultural history, set of beliefs, and traditional treatments and healing practices.

One limitation of this study is the collinearity between ethnic identity and location; Himba tend to live in rural and peri-urban settings whereas Herero tend to live in urban ones. This makes comparisons of ethnicity vs ruralness difficult. When modeled separately, both have similar effects and information criterion estimates. When modeled together using Plackett-Luce trees, only distinction by ethnic identity was significant (Fig. S8). Similarly, in our Himba-Herero comparison, peri-urban Himba clumped together with rural Himba, not urban Herero. Previous work in this same area showed that residing closer to town doesn't influence adoption of outgroup perinatal care norms (Hagen and Scelza, 2020). These findings indicate that ethnic identity may play a more important role in healthcare decision-making than does location and access to urban services. Nevertheless, it is likely that ruralness will have some independent impact on prestige bias transmission, particularly when living in rural areas is associated with a reduction in use of healthcare facilities, high costs to access healthcare facilities, and changes in the availability of other sources of healthcare, such as traditional medicine. For example, living in or near an urban area, where interactions with outgroups in a more market integrated setting are common may make prestige biased learning of outgroup members, such as doctors, more likely. Ethnic groups that are already less parochial due to historical particularities may be particularly responsive to social context. Conversely ethnic groups with deeper histories of exploitation by majority outgroups may be less sensitive to market-based interactions or other facets of urban or peri-urban living, and maintain more strongly ingroup preferences. Future studies looking more closely at the decisions of rural and urban Kunene residents of multiple ethnic groups could help to disentangle the effects of ethnic group and locality.

Surprisingly, outside of ethnic group and location, we find little impact of individual level predictors on our ranking task. We find no sex difference in rankings, despite women having very different experiences with formal and traditional healthcare, including obstetric care and more responsibility in getting routine care and vaccination for their children. We did find some minor effects of age. When location and ethnic identity were excluded in the model, older individuals in our sample tended to rank chief more highly, whereas younger individuals were closely split between chief and doctor. This pattern remains true in peri-urban and urban locations. Other research has shown that even when a majority of people use traditional healers, younger people are more likely to use healthcare services (Berhane et al., 2001), suggesting a generational shift in perceptions of the importance of traditional healers. A recent 31 country *AfroBarometer* survey indicates that traditional leaders maintain high levels of trust compared to others like elected leaders and government figures, particularly in rural areas (Logan and Katenda, 2021). While there was little sex difference, trust in chiefs was higher among older respondents. These results suggest some positive future direction for vaccine and public health messaging. First, hospital personnel are generally well regarded in the context of vaccine information, irrespective of medical mistrust, even though there are some negative associations in other contexts (Prall et al., 2024). Secondly, inclusion of local chiefs in vaccination messaging and campaigns could be a fruitful approach to increase vaccine uptake, particularly in rural areas and with older residents. Anecdotally, in other parts of Namibia, traditional leaders have been used to

spread information about vaccination and disease prevention, counter misinformation, and increase vaccination uptake (WHO, 2023). Our results indicate that a combination of local leaders and healthcare professionals may be the most effective messengers for vaccine information across a demographically and ethnically variable population.

We note several limitations in our study. As noted earlier, the differences in ruralness between ethnic groups measured in this sample make independent comparisons of ethnic group and ruralness difficult. Our comparisons of these factors are limited by the selection of four prestigious individuals in the ranking task, which facilitated ease of measurement, but limited ability to assess differences between domains and in-group/out-group distinctions. Ranking data can be difficult to analyze, particularly in a multi-level framework. Other outcome types, like Likert scales may be useful, although piloting of Likert scales in this population yielded few distinctions between prestigious figures. Furthermore, while our study included a rural to urban spectrum, we did not sample the most rural residents of Kunene, who likely had even more difficulty accessing COVID-19 vaccines, and whose prestige biases may look even more different than their urban counterparts. Additionally, we didn't measure market integration or acculturation directly in this study, and instead relied on ruralness as a proxy. Future work should consider how frequency of interaction and quality of interaction with doctors and other outgroups influence relevant outcomes. Additional work is also needed comparing how the novelty of diseases (like SARS-CoV-2) influence sources of social learning, when compared to diseases populations have a long history with and where traditional treatments are available alongside biomedical ones.

5. Conclusions and implications

A goal of this paper is to highlight the perspectives of rural and often marginalized groups, whose views and values are often missing from the global health work that aims to help them (Pratt, 2019). Social learning biases like prestige bias are a useful framework for understanding complicated healthcare decisions where individuals lack knowledge and expertise, as in the case of vaccination-decisions for a novel virus. These models can help explain *why* information transmission might be influenced by conditions like uncertainty (Toyokawa et al., 2019), or why some individuals may be more valued agents of information than others (Boyd and Richerson, 1985; Henrich and Gil-White, 2001). Our study indicates substantial variation in the influence of prestigious figures for vaccine decision-making by ethnic identity and across the rural-urban gradient. We also find differences in the influence of in-group versus out-group figures. The results of this study have clear implications for public policy, indicating that sources of vaccine messaging may need to be tailored to ethnic identity and location. This work would be further enhanced by additional studies that mix qualitative and quantitative methods, and utilize cultural models of disease and vaccination as starting points for research design and implementation. Understanding and utilizing social learning models of healthcare decision-making may be particularly important in the Global South, where there is high inequality, variability in access to information, lower access to formal institutional healthcare, and a large rural population. Using effective messaging generated from research on social learning guided by cultural evolutionary theory may help address disparities in vaccination as well as inoculate against vaccine-related misinformation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Data availability

Data and R code used in this study are available at the Open Science Framework at http://osf.io/y49cj/.

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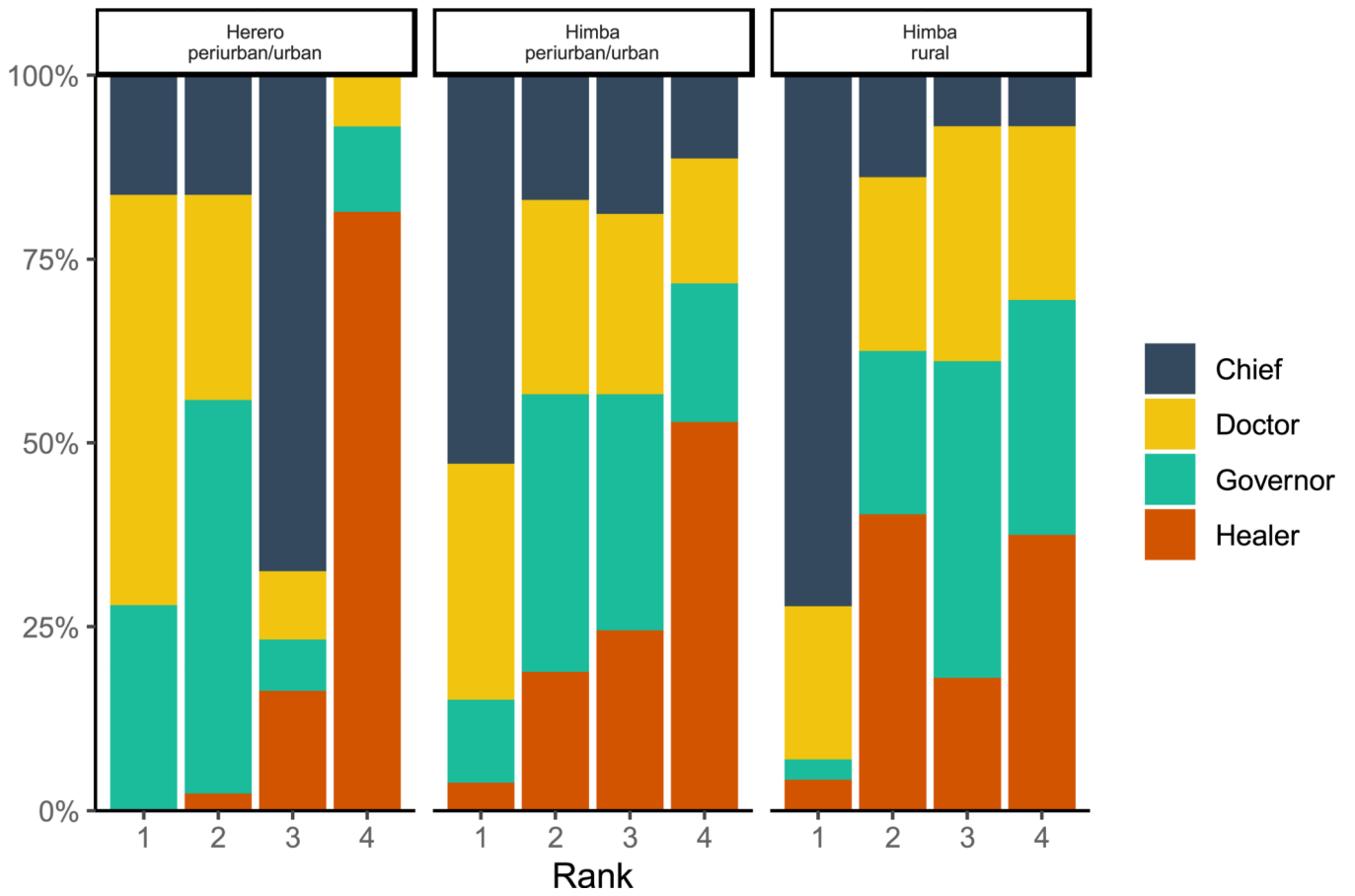World Health Organization, 2019. Ten Threats to Global Health in 2019.

Fig. 1.
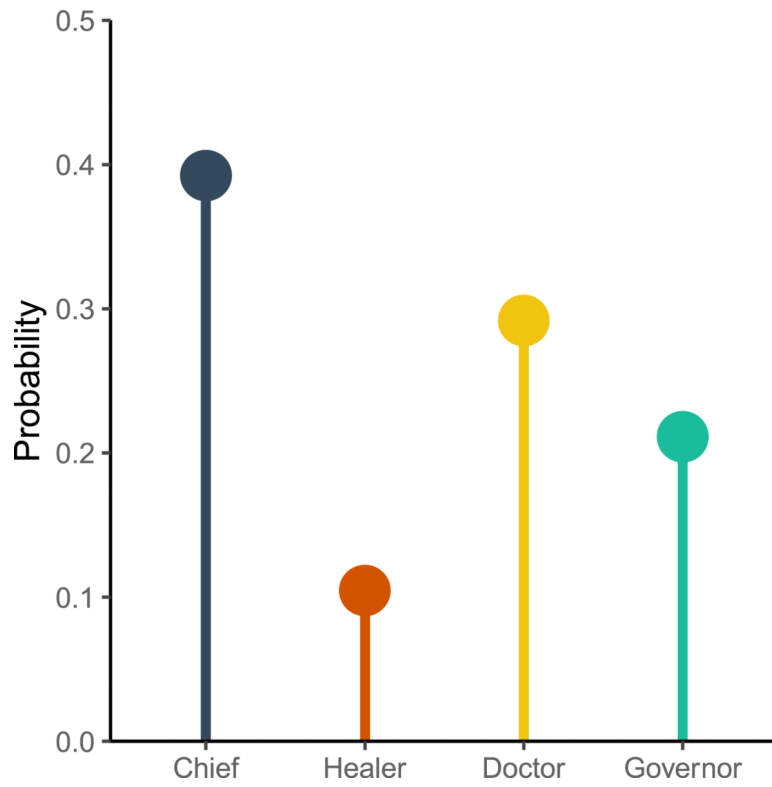Raw percentages of ranks comparing Himba rural, Himba periurban/urban, and Herero periurban/urban.

Fig. 2.
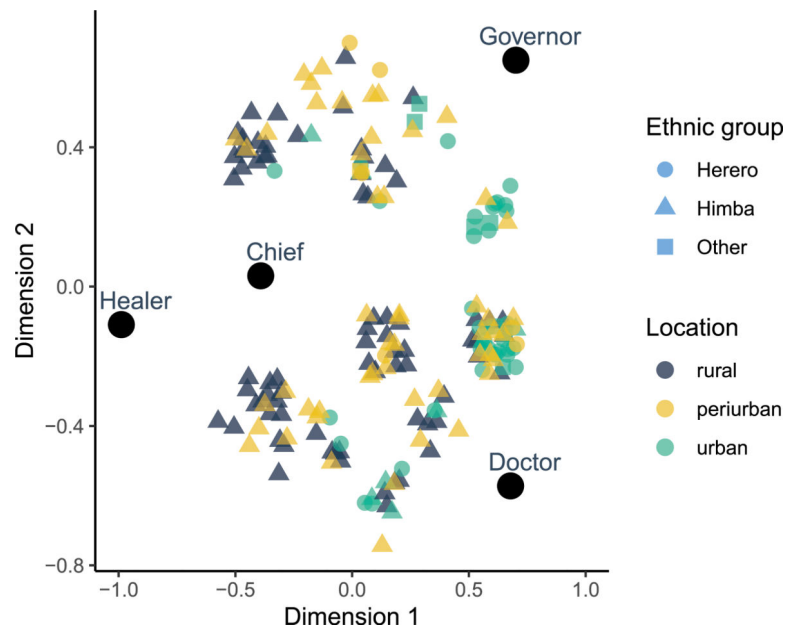Plackett-Luce model estimates of being ranked first for each item using the full sample.

Fig. 3. UMDS Joint Configuration Plot –
Plot shows labeled ranked items and study participants, jittered to avoid overplotting.
Colors indicate location across the rural-urban gradient, while shape denotes ethnic group
as identified by participants. Across items, governor and doctor fall close together on
dimension 1, while chief and healer fall close together on dimension 2. Chief falls towards
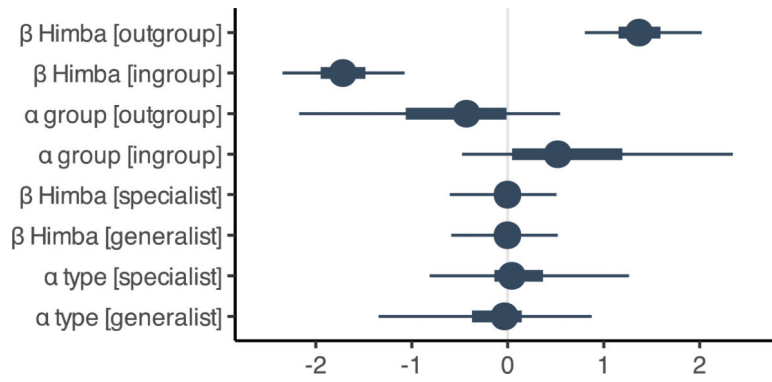the center if the plot indicating that it is the highest ranked item.

Fig. 4. Caterpillar plot of varying intercepts and slopes to illustrate ingroup/outgroup and domain specific/general in a cumulative ordered logit multilevel model.
Varying intercepts by group and type, and varying slopes by ethnic group are shown. As Herero is the index group, varying slopes coefficients show the predicted difference in Himba participants. Negative co-efficients indicate a higher rank. For example, in the top row Herero are more likely to choose outgroup figures.

Table 1

Demographics and sample characteristics.

Age	Mean	34.5
	SD	14.4
	Range	16–80
Sex	% Women	64.1%
	% Men	35.9%
Ethnic Group	% Himba	74.7%
	% Herero	21.7%
	% Other	3.5%
Location	% Rural	44.9%
	% Peri-urban	29.8%
	% Urban	25.3%

Table 2

Plackett-Luce Tree comparison table.

Model	Age	Sex	MMI	Ethnic group	Location	Himba/Herero comparison	Results
PL tree #1	✓	X	X				45 ranks doctor first then chief, >45 more likely to rank chief first
PL tree #2				✓	X		Himba rank chief first, followed by doctor, Herero/other rank doctor first, then governor
PL tree #3	✓	X	X		✓		Rural and periurban/urban >49 rank chief highly, periurban/urban 49 rank doctor and governor highly
PL tree #4	X	X	X	✓			Himba rank chief first, followed by doctor, Herero/other rank doctor first, then governor
PL tree #5	X	X	X			✓	Periurban/urban and rural Himba clump into a single node. Himba rank chief first, followed by doctor, Herero rank doctor first, then governor

An "x" indicates the predictor was included in the model, while a check mark (✓) indicates that the predictor was statistically significant (p < 0.05). MMI is the medical mistrust index score. Himba/Herero comparison only includes Himba or Herero participants, coded into three categories: Himba rural, Himba periurban/urban, Herero periurban/urban, Herero periurban/urban. All trees are plotted in the supplementary information (Figs. S4–S8).