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Exploring legal- and health-risk messaging to reduce demand for elephant skin

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Abstract

Asian elephants (*Elephas maximus*) are poached for an illegal trade in their skins, which are used in traditional medicine in Africa and Asia. We explored whether messages about the legal and health risks of using elephant skin for medicinal purposes (stomach illness) could reduce such consumption. We conducted a randomized controlled trial intervention experiment based on a health belief model. We showed 1673 residents at China's Yunnan–Myanmar border comic strips that portrayed these risks (legal-risk and health-risk treatments and control). Respondents were then asked for their perception of benefits and risks of using elephant skin and their consumption intentions for treating stomach illness (i.e., seek elephant skin, seek animal-based traditional medicine, visit informal market, and visit hospitals). We used structural equation models to examine whether and how different messages affect consumption intentions. Compared with the control group ($n = 580$), the comics that showed the legal risks of use of elephant skin ($n = 529$) significantly reduced respondents' intentions to seek elephant skin by 24% compared with the control group, particularly when the message conveyed that its use is not a cure. The health-risk treatment ($n = 564$) increased respondents' intentions to go to the hospital when suffering from stomach illness and, unexpectedly, increased the intention of urban residents who had never heard of elephant skin as a treatment to look for it by 40% compared with those of urban residents in the control group. Our results revealed that interventions tailored to specific audience segments are necessary to prevent unintended, negative consequences of public messaging conservation interventions.

KEYWORDS
Asian elephant, demand reduction, health belief model, illegal wildlife trade, randomized controlled trial, traditional medicine

INTRODUCTION

Illegal wildlife trade (IWT) is one of the most significant threats to wildlife worldwide (UNODC, 2020). Charismatic megafauna, including rhinoceroses (e.g., *Dicerorhinus sumatrensis*), tigers (*Panthera tigris*), and elephants (e.g., *Loxodonta Africana* and *Elephas maximus*), face significant threats from the illegal trade in their body parts, for medicine, decoration, and bushmeat. Efforts combating IWT range from supply-side interventions aimed at poaching and international trafficking regulations from the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) to demand-side behavior-change interventions aimed at reducing consumption (Challender et al., 2015; Veríssimo & Wan, 2019).

Poaching and IWT are a major threat to Asian elephants (*Elephas maximus*) (Williams et al., 2020), in particular, and this was especially the case before China's domestic ivory trade bans (Gao & Clark, 2014). Illegal poaching of Asian elephants

for their skin has increased since 2014 in Myanmar, and illegal markets for elephant skin beads and medicinal powder are concurrently emerging in China, posing an additional threat to this species (Elephant Family, 2019; Nijman & Shepherd, 2014; Sampson et al., 2018). Elephant skin is traditionally used as medicine in Tanzania and across the Great Mekong River regions and countries (Kioko et al., 2015; Shepherd & Nijman, 2018). Consumers in the Great Mekong River region specifically believe elephant skin is an effective remedy to treat skin cuts or stomach ailments (Sampson et al., 2018). However, due to the clandestine nature of the trade and the difficulty in authenticating products, accurate estimates of the volume and impact of illegal elephant skin consumption in China are lacking (Williams et al., 2020).

Globally, IWT demand-reduction interventions have often taken the form of public communication campaigns (Doughty et al., 2021; Olmedo et al., 2018) that have traditionally emphasized illegality (education). Communication strategies have become increasingly informed by insights from behavioral sciences (Baynham-Herd et al., 2020). Recent studies from outside the conservation field show that norm appeals (emphasizing social expectations) and risk warnings (making personal costs more salient) are two of the most effective communication strategies for behavior change (MacFarlane et al., 2022; Sheeran et al., 2014). However, in the context of IWT demand reduction specifically, studies evaluating the impact of risk warnings are few, and the results have been mixed (Moorhouse et al., 2017, 2020; Veríssimo & Wan, 2019). For example, legal- and health-risk warnings effectively reduce the intention to buy illegal exotic pets (Moorhouse et al., 2017) and to use wild animal medicinal products (Hu et al., 2024). However, similar message-based interventions were ineffective at influencing respondents' intentions to purchase traditional medicines (TMs), possibly because the intervention message clashed with consumer beliefs about legal and health risks, and thus people did not perceive the message as credible (Moorhouse et al., 2020). Further research on the efficacy of intervention messages tailored to consumer perceptions and experience, as well as on messages that redirect people to substitutes, is needed.

One reason why reducing demand for illegal TM is so challenging is that interventions can clash with long-term cultural norms and beliefs (Acemoglu & Jackson, 2017; Cheung et al., 2021; Moorhouse et al., 2020). Moreover, communication campaigns addressing illegal wildlife products can backfire if they, for example, prompt an emotional reaction (e.g., defense of the behavior) or unintentionally increase awareness and consideration of the products (Gilbert, 2020; Thomas-Walters et al., 2020). A 2019 large-scale public communication campaign focused on pangolin scales in China generated controversy among some conservationists. They argued that the campaign risked unintentionally raising the demand for pangolin scales as TM by trying to challenge its supposed medicinal effect (WildAid, 2019). A meta-analysis of the effectiveness of four types of interventions to manage IWT showed that laws and regulations have mostly positive effects but may result in an increase in illegal trade if market dynamics and demand change (Öckerman et al., 2024). However, the actual impact of such exposure to information about wildlife products on consumption intention and behavior has not been assessed quantitatively. How treatment effect varies among audiences because their cognitive pathways differ is underexplored. Promoting the sustainable use of wildlife products might generate spillover behaviors that unintentionally increase the volume of IWT (Margulies et al., 2019; Tittensor et al., 2020; Wang et al., 2022). A system-thinking approach or the use of tailored, context-based, demand-reduction tactics to address IWT has been called for (Cheung et al., 2021; Naito et al., 2022; Thomas-Walters et al., 2020, 2021).

In Yunnan province of China, we observed that elephant skin is mainly used in TMs and sporadically as leather products or bushmeat (unpublished data). Unlike elephant ivory consumption, which is concentrated in wealthy metropolitan areas and is a luxury good, elephant skin is consumed and traded by residents in the China–Myanmar border areas as a local good, largely due to the historical lack of adequate medical resources (Gao & Clark, 2014; Nijman & Shepherd, 2014; Shepherd & Nijman, 2018). From 2010 to 2021, about 90% of the 49 criminal cases related to IWT in elephant skin in China were in Yunnan province, and most of these originated from the Dehong Dai and Jingpo ethnic group prefecture (queried from OpenLaw, 2014). Ruili has a large port and long border with Myanmar, and Dehong prefecture has a relatively high risk of trafficking of illegal wildlife products (Appendix S1). In Dehong prefecture, our study area, efforts to combat transboundary IWT of elephant skin are limited due to weak domestic IWT regulations in Myanmar and inadequate enforcement efforts across country borders in the region (ASEAN, 2021). Demand reduction methods have been proposed for a range of similarly illegal wildlife products used in TM, such as bear bile and rhinoceros horn (Burgess, 2016; Dang Vu & Nielsen, 2021; Moorhouse et al., 2020; Veríssimo & Wan, 2019). However, the profile of elephant skin consumers and the drivers of demand for this product have been underexplored. A better understanding of the elephant skin TM market and the effects of different demand-reduction interventions will help reduce the IWT threat to Asian elephants.

We aimed to increase understanding of the impacts of risk-based, demand-reduction communications on consumer behavior in the context of IWT. We conducted an on-site randomized controlled trial intervention experiment among the residents of the Dehong prefecture in the China–Myanmar border area. We explored the effects of two warning messages relative to the illegal consumption of elephant skin for TM. One emphasized the legal risk and the other the health risk. Both messages were presented to respondents as comics, given the low literacy rates in the area. We also measured their message effect on intentions to consume other wildlife-based TMs and intentions to visit either informal TM markets or formal medicinal facilities (i.e., pharmacies or hospitals). We used chi-square tests and structural modeling or path analyses in a structural equation model (SEM) to examine whether and how different messages affected behavior intentions. We also examined how messaging influenced the perception of consuming elephant skin between rural and urban residents.

METHODS

Theory and study framework

Behavioral frameworks, such as the theory of planned behavior (TPB) (Ajzen, 1991, 2011), social cognitive theory (Bandura, 1991), health belief model (HBM) (Champion & Skinner, 2008; Janz & Becker, 1984), and the capacity opportunity motivation–behavior (COM-B) model (Michie et al., 2011), are used as the basis of examinations of the drivers of behaviors, including illegal wildlife consumption, and to design interventions to achieve sustainability and conservation goals (St John et al., 2010; Thomas-Walters et al., 2023). The TPB, HBM, and SCT use individual-centered cognitive processes to predict behavioral intentions or actual behaviors, whereas SCT also emphasizes measurement of the interactions between actual behavior and the environment. The COM-B focuses on identifying the enablers or barriers to a behavior (Green et al., 2020).

To study the targeted health-related behavior of purchasing elephant skin to treat stomach illness and the likelihood of related behavioral intentions, we used the HBM as our theoretical foundation for the development of intervention messages and for the evaluation of their effects. The HBM has been widely applied in health behavior research to explain how individual perceptions of, for example, threats, benefits, barriers, and self-efficacy shape behavioral decisions. Relative to health behaviors, these perceptions could be beyond medicinal considerations and be shaped by the physical environment and psychological cognition of the behavior. For example, perceived barriers to intentions to buy elephant skin may include perceived physical or psychological obstacles to a health-related behavior, such as financial barriers, legal restrictions, social norm barriers, inconvenience, and concern about side effects. In the preliminary phase of our study, baseline interviews were conducted with target consumers to identify psychological factors relevant to the consumption of elephant skin TM. Guided by the HBM framework, we extracted themes from these interviews, including perceived medicinal efficacy and risk perceptions related to health and legality, that were used to inform the design of the intervention messages.

Given the health risk and legal risk associated with the use of elephant skin for medicinal purposes, the HBM provides a structured and theoretically robust foundation for examining the cognitive mechanisms underlying individual decision-making. The original structure of the HBM, including all key constructs, such as perceived threat, benefits, barriers, and self-efficacy, is illustrated in Figure 1a. However, based on the contextual constraints and empirical challenges in our study, we excluded from the final framework perceived threat because it proved difficult to assess reliably among participants and perceived self-efficacy because it was highly confounded by external factors, such as pandemic-related regulatory restrictions. As a result, the final study framework (Figure 1b) contained only constructs that were both conceptually relevant and empirically measurable in the context of our study. These included perceived benefits, perceived barriers, and behavioral outcomes, which together formed the basis for our evaluation of the effects of message-based interventions on consumption intentions.

Due to the irregular and illness-driven nature of the use of elephant skin as medicine, increasingly strict regulations, and the shift to underground markets in China, direct observation or tracking of actual behavior was not feasible (Harrison et al., 2016; Zhang et al., 2008). Therefore, consistent with prior research, we adopted self-reported consumption intention as a proxy for behavioral outcomes (Frommeyer et al., 2022; Moorhouse et al., 2020). Four specific intentions related to the use of elephant skin medicine for treating stomach illness were selected to represent individual behavioral outcomes. The perceived medicinal value of elephant skin and two types of perceived risks were mapped onto the constructs of perceived benefits and perceived barriers.

Development of the survey instrument

To develop a baseline understanding of the drivers of the medicinal use of elephant skin and to develop intervention messages and a randomized control trial (RCT), we conducted extensive preliminary tests of interview questions and target baseline surveys from April 2021 to February 2022. First, we interviewed stakeholders, including eight traditional Chinese medicine (TCM) doctors, 19 TCM traders with knowledge of the elephant skin market, 19 TCM consumers who knew about elephant skin (including eight elephant skin consumers), and 88 randomly approached residents of Yunnan province, China (Dehong prefecture, Xishuangbanna prefecture, and Kunming city). We also interviewed six international IWT or behavior change experts from six different countries worldwide. We tested the baseline survey on a target audience of 446 drawn from randomly approached people in Yingjiang, Dehong prefecture, Yunnan province.

From the test surveys, we identified ways to gather demographic information in Dehong prefecture, our study site. The Han and Dai ethnic groups made up the majority of the population, and the Jingpo ethnic group ranked third (Appendix S4). About 64% of the population in Yingjiang and half the population in Mangshi were rural residents who made their living mainly by agriculture (personal observation). For urban residents, trade and tourism were the most important income sources. Inhabiting the border area, residents, especially the middle-aged and elderly, had limited access to formal education. The majority of rural residents were over 40 years old and had finished second grade of primary school. Hence, many residents relied on traditional medicinal knowledge, which is spread mostly through word of mouth.

Based on our test surveys, we devised intervention messages and determined the message format. Test surveys showed that legal risks (e.g., caught and sanctioned for purchasing elephant skin) and health risks (e.g., unsanitary skin of unknown composition) were the two main barriers when considering whether to purchase elephant skin. We also found that because elephant skin as a TM, usually purchased at street stalls from Myanmar traders, dates back two decades, elephant skin's efficacy and ger-

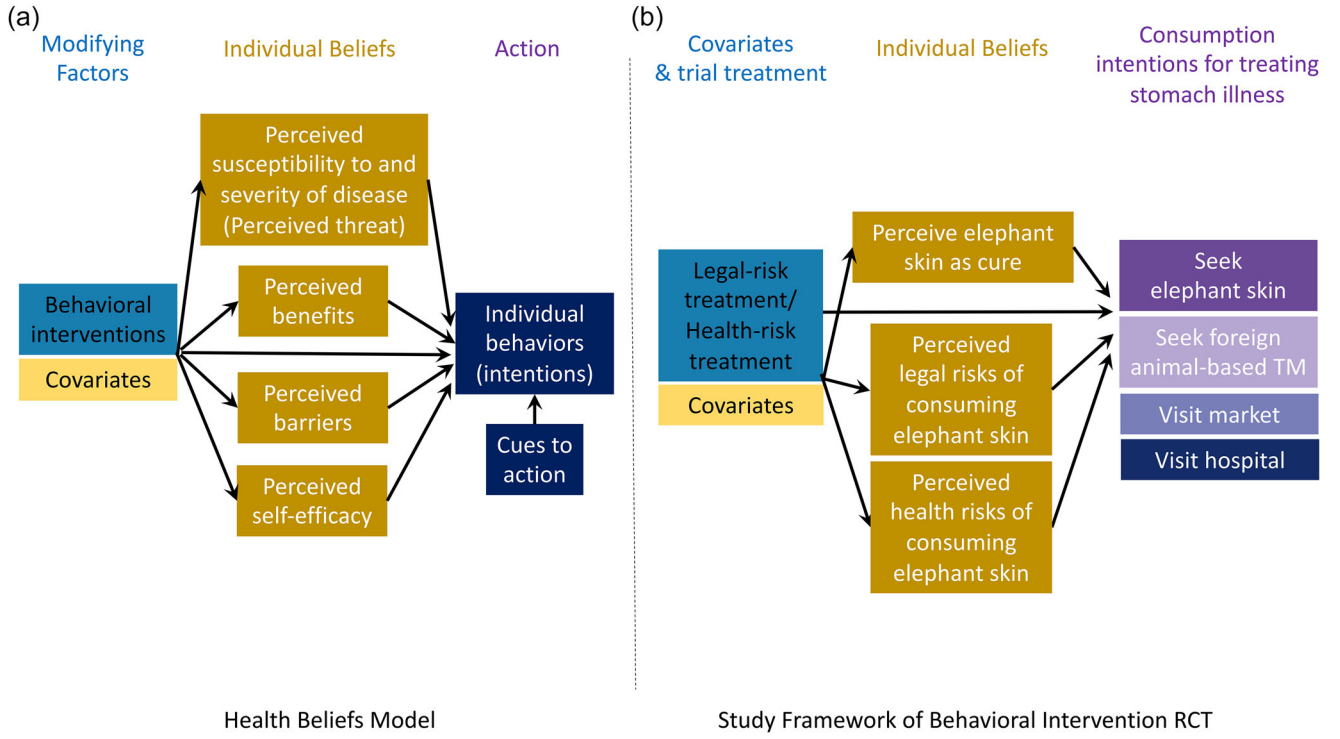

FIGURE 1 (a) Health beliefs model (Champion & Skinner, 2008) and (b) the framework of a behavioral intervention randomized control trial (RCT) of legal-risk and health-risk messaging on the consumption of elephant skin to treat stomach illness among the public at the China–Myanmar border (arrows, causal relationships between variables). Perceived benefits are measured based on respondents' perception of elephant skin as a cure. Perceived barriers are measured based on respondents' perceptions of the legal or health risks of consuming elephant skin. Individual behaviors are measured based on four consumption intentions for treating stomach illness.

mane stomach symptoms remain controversial across consumer groups and TCM practitioners. To increase accessibility, ensure authenticity, and reduce legal risk, people usually ask an acquaintance to buy raw elephant skin pieces from Myanmar. However, this means of purchase brought concerns about owing others' favors.

We found that comics and paintings were commonly used in local knowledge campaigns to deliver messages, including painting comics on village walls, posting them on billboards, and disseminating printed comics on brochures. Local social workers endorsed the effectiveness of the comic format based on their experiences with using comics in brochures on health-related topics.

In response to our preliminary targeted baseline surveys, many people over 40 years old with limited education did not understand messages in only text format, possibly due to limited education and the unfamiliarity of this as a communication tool and a way to obtain information. Survey techniques that required a respondent to imagine unfamiliar scenarios or identify or interpret abstract concepts (e.g., 5-point Likert questions for a construct latent variable) did not work for respondents with education below middle school. Respondents often had difficulty accurately differentiating between subtle variations in Likert-type response options, such as distinguishing between *somewhat agree* and *strongly agree*. Very often, we could only get yes or no answers and no description of the probabilities for how likely an action would be, even when we asked for the degree of probability. It was also challenging for most respondents to identify likelihood-based perceptions regarding an illness that is uncommon. For example, "I do not have such a disease" was a common response when the respondent was asked to estimate the threat of the illness. When we asked people about their subjective cognition of the effect of other people's attitudes or social norms on their possible purchase of elephant skin, it was hard for them to answer; most said they did not know. This may have been because the close connections among community members made it difficult for respondents to discuss the thoughts of their neighbors with outsiders.

Randomized controlled trial

In our RCT study and survey instrument, we prioritized the inclusion of those who had more experience and exposure to the medicinal use of elephant skin (up to 50 years) but a limited understanding of the associated complex questions. We made the questions relatively simple and straightforward to ensure clarity and ease of understanding during data collection. We were especially careful to minimize challenges related to discussing the consumption of illegal wildlife products, which is a sensitive topic. We avoided asking 5-point Likert questions and instead described daily or concrete scenarios and asked

about behavior intention or preference with dichotomous questions. For perception of risks questions, we used a 4-point scale, but first asked whether this possibility was more likely or less likely, and followed up by asking whether the possibility was extremely likely or likely but not absolutely certain. We integrated intervention messages in comics to enhance respondents' understanding of the issue. We also changed our original plan for self-administered surveys to one-on-one structured interviews. To reduce associated sensitivity brought about by the interview, we had three volunteers who were local residents introduce the interviewers to the respondent before the interview began. For sensitive questions on consumption, we used indirect questions. For example, we asked about respondents' intentions based on scenarios regarding the family (Davis et al., 2022; Fisher, 1993). Survey questions are in Appendix S14.

To cover both urban and rural areas along the China–Myanmar border, we chose Mangshi city and Yingjiang county (both in Dehong prefecture) as our two study sites. Dehong prefecture has the largest China–Myanmar land port in Ruili, and Yingjiang county has one of the longest China–Myanmar rural borderlines. We chose Dehong Dai and Jingpo prefectures as our study area because these prefectures have the highest rate of convictions for illegal trade in elephant skin in China (Appendix S1). Our study was conducted during the pandemic when the port of Ruili was closed and villages nearest the China–Myanmar border were quarantined; thus, access to the study area was limited. Residents of all age groups who had lived in the study area for >1 year were qualified to participate.

We framed two interventions on the legal risk and health risk of the purchase and use of elephant skin in comics based on our own tests and similar previous studies (Figure 2). We did not consider the efficacy of TM (Thomas-Walters et al., 2020). The legal-risk treatment depicted the consequences of the illegal purchase of skin under strict enforcement of the law. The health-risk treatment depicted a hospital visit scene with a doctor warning the patient about the health–safety problems with elephant skin. We selected two highly regarded professions as messengers in the comic: a police officer and a doctor. We chose these messengers because, as trusted authorities, they influence subjective norms. The risk-related comics were followed by a comic depicting a visit to the hospital for stomach problems as an alternative to the use of elephant skin. According to the COM-B model, the alternative behavior fits with the underlying behavioral motivation of the original behavior and may stress the capacity and opportunity for behavior change (Michie et al., 2011). Testing of the effectiveness of redirecting TM consumption to alternatives has been called for (Moorhouse et al., 2020). We used a hospital visit message as a substitute instead of recommending a substitute medicinal product.

To measure intentions relative to the use of elephant skin, we measured the likelihood of purchasing elephant skin for treating a hypothetical stomach illness based on four behavioral intentions: intention to seek elephant skin, intention to seek foreign, animal-based TM (i.e., seeking animal-based medicines from Myanmar or Laos), intention to visit a market (i.e., visiting informal markets and stalls on the street to buy medicine), and intention to visit a hospital (i.e., visiting hospitals or pharmacies to buy prescribed medicines or licensed over-the-counter medication) (Figure 1). To determine possible mechanisms of treatment effects with our HBM theory model, we also measured and evaluated the influence of the public's beliefs about the benefits of the use of elephant skin and the barriers to its use. We measured perceived benefits based on the perception of whether elephant skin is a cure for stomach illness (hereafter, *perception of cure*). Perceived barriers were represented by perceived legal (i.e., perceived legal risk) and health (i.e., perceived health risk) consequences of consuming elephant skin. Due to the limited ability of respondents to understand complex questions and the IWT context for IWT of elephant skin, we did not consider the perception of self-efficacy or perception of threat (i.e., perceived susceptibility and perceived severity).

We developed the survey for the RCT intervention experiment and then revised the trial surveys and comic interventions by consulting and getting feedback from local volunteers and conducting pilot surveys at our study sites, Yingjiang and Mangshi (Appendix S14). The trial consisted of one blank control (i.e., no message) and two treatment groups, one with the legal-risk message (i.e., legal-risk treatment group) and another with the health-risk message (i.e., health-risk treatment group). Based on a power calculation and the assumption that 80% of respondents are unlikely to seek out elephant skin, 500 respondents per trial group would result in a minimum detectable effect size of 6.58%. This rate is acceptable when balancing the efforts of data collection in practice. All respondents in the three trial groups received the same baseline survey questions about their demographic information, TCM consumption, and experience with elephant skin (Appendix S14). With the exception of the blank message control group, we asked all respondents follow-up feedback questions that were pertinent to their treatment group (Figure 2; Appendix S2). Then we quantified all groups' consumption likelihood of elephant skin for treating hypothetical stomach illness based on the four behavioral intentions and respondents' perceptions of cure and legal risk or health risk.

In March 2022, we conducted the on-site RCT. Our research protocol was approved by the Research Ethics Committee of the Wildlife Conservation Society (REF 20-58, 21-64). We used a stratified random sampling plan to conduct an RCT to increase the representation of diverse respondents and avoid sampling bias. We set 500 sample quotas for each of the three trial groups. Quotas for gender, age group, and rural (or urban) characteristics for each site were based roughly on data from China's Seventh Population Census. We then selected diverse sampling locations to visit, which consisted of different public venues where different groups of people may occur in an urban area (i.e., farmers' markets, business districts, public parks, hospitals, government offices), and different types of villages, including concentrated resettlement villages, communities of different ethnic groups, and communities growing different cash crops. In rural areas, sampling sites were randomly chosen along the road for every second person encountered. At each sampling location, we conducted an RCT by having each trained interviewer approach a member of the public to invite that person to participate. If the person agreed to participate, the person was assigned randomly to one of three surveys (legal-risk, health-risk

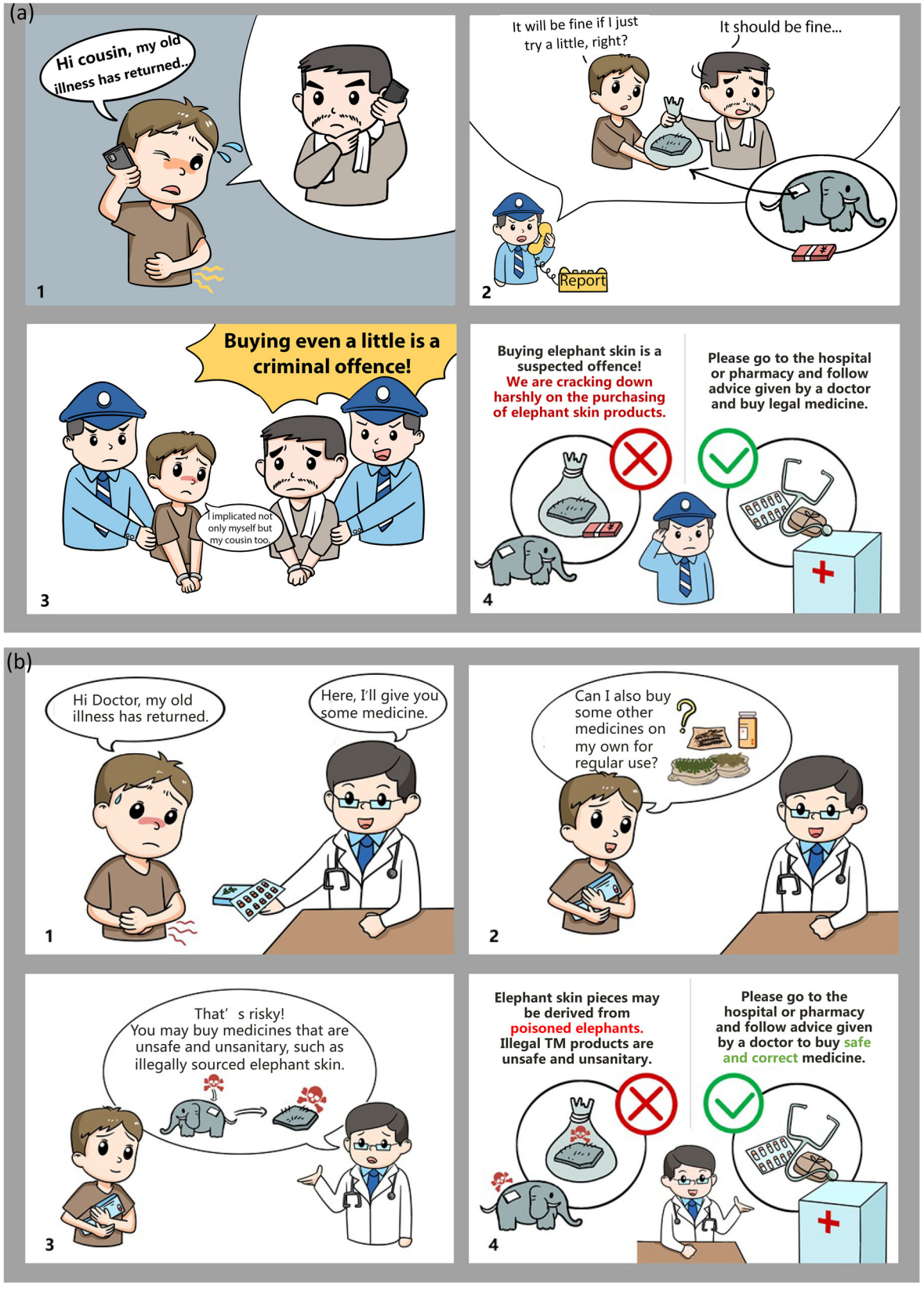

FIGURE 2 Trial treatment intervention comics for (a) the legal-risk treatment group and (b) the health-risk treatment group (TM, traditional medicine).

TABLE 1 Measures to control and test internal validity and external validity of a randomized control trial of legal-risk and health-risk message interventions.

Validity	Potential problem	Measures to control
External		
Sampling bias	Respondents not representative of the local population	Approached people randomly in public places, including squares, parks, central business district, farmers' markets, and farms Set a rough quota for the samples from city and rural areas based on local population distribution
Background	Ban on ivory trade in China	Set blank control group as reference level in treatment variable to detect and isolate the potential additive treatment effect from the baseline level framed by the historical background and contexts
Internal		
Confounding variables	For example, demographic characteristics	Approached respondents at all sorts of public places and randomly assigned them to one of three trial groups
Extraneous variables		
Social desirability	Respondents may answer questions based not on true preference but on what is socially acceptable, for example, did not purchase elephant skin	Told participants they would be anonymous asked indirect questions on preference, for example, asked respondents' intention to purchase elephant skin based on scenarios about their family Set blank control group (receiving no intervention) as reference level in treatment variable to detect the potential additive effect of treatment from possible social desirability
Effect of demand characteristics	Once respondents guessed the purpose of the survey and comics, they may choose answers that are for or against the research, regardless of their true preferences	Introduced research as a study to learn public preferences and opinions on traditional medicine, and indicated that there were no right or wrong answers Performed relevant tests between outcome variables to identify possible influence of the effect of demand characteristics (Appendix S4), to be able to conclude that the treatment effect is not statistically significant due primarily to the effect of demand characteristics
Situational variables	Interview location may lead to random errors	Conducted trials and collected all data within 10 days Randomized data collection location and expanded sample size for all three trial groups to minimize situational influences on any single group
Interviewer effects	Differences among interviewers may affect respondents' responses	Conducted training on research ethics and standardized interview languages and responses for 14 interviewers Interviewers randomly conducted surveys for all three trial groups Monitored the interview process and terminated interviewers who did not follow the standardized protocol
Participants effects	Imbalance and variation of participants' demographic characteristics across trial groups may affect the outcome	Approached respondents and randomly assigned them to one of three trial groups Checked for balance of demographic variables across trial groups and then added the imbalanced variable into structural equation models as an independent variable to account for its possible influence on the treatment effect

treatment, or control) (Table 1). In urban areas, we approached a person every 10 min (roughly equivalent to one person in every five).

At rural sampling locations, we surveyed all the individuals we encountered in the selected sampling villages due to low population density and all individuals (from different households) who gathered to conduct collective farm work. At the end of each survey day, we summarized sample sizes and ratios of gender and age groups within and across three trial groups. When substantially imbalanced gender and age groups were detected, we added respondents at the same sampling area over the next few days to meet the required sample quotas. In total, we collected 1673 samples; 580 valid samples in the control group, 529 valid samples in the legal-risk treatment, and 564 valid samples in the health-risk treatment (Appendix S4). Respondents who did not understand the survey at all or did not answer questions seriously were excluded.

To ensure the internal and external validity of treatments and to isolate the influence of confounding and extraneous variables, we applied measures in the trial and posttrial statistical methods (Table 1; Appendix S4). These measures included randomization, informing respondents of their guaranteed anonymity and the neutrality of the study, and hiding the main research purpose. We used an SEM with the observed variables to isolate the possible influence of participant effects caused by imbalanced demographic variables between groups and to detect the additive treatment effect from the baseline level of background and social desirability by comparing the results with those of the control group. We also ran the correlation test between outcome variables so as to

TABLE 2 Differences in perceptions and consumption intentions across the control group, legal-risk treatment group, and health-risk treatment group in a randomized control trial of consumption of elephant skin to treat stomach illness.

Outcome variable	Variable characteristic	Description	Control group ($n = 580$) n (%)	Legal-risk treatment group ($n = 529$) n (%)	Health-risk treatment group ($n = 564$) n (%)
Consumption intentions	Binomial (likely or unlikely)	Seek elephant skin	102 (17.59)	63 (11.9)	102 (18.1)
	Binomial (likely or unlikely)	Seek foreign animal-based traditional medicine	69 (11.9)	40 (7.6)	71 (12.6)
	Binomial (likely or unlikely)	Visit market	131 (22.59)	95 (18.0)	97 (17.2)
	Binomial (likely or unlikely)	Visit hospital	542 (93.45)	503 (95.1)	546 (96.8)*
Perception of cure	Binomial (yes or no)	Perceive elephant skin as a cure for stomach disease	242 (41.72)	179 (33.84)[a]	230 (40.78)
Perception of legal risk	Ordinal[a] (4-point scale)	Perceive legal risks of buying illegally sourced elephant skin			
		Very unlikely	7 (1)	15 (3)	9 (2)
		Somewhat unlikely	53 (9)	36 (7)	50 (9)
		Somewhat likely	219 (38)	175 (33)	178 (32)
		Very likely	301 (52)	303 (57)	327 (58)
Perception of health risk	Ordinal[a] (4-point scale)	Perceive health risks of consuming illegally sourced elephant skin			
		Very unlikely	17 (3)	17 (3)	21 (4)
		Somewhat unlikely	69 (12)	48 (9)	63 (11)
		Somewhat likely	258 (44)	221 (42)	247 (44)
		Very likely	236 (41)	243 (46)	233 (41)

Note: The response variables are tested for statistical differences between groups with a chi-square test (adjusted p value with Bonferroni method; *, significant difference between treatment group and control group at 0.05 level).
[a]Considering respondents' comprehension level, these 4-point ordinal scale questions are dichotomous: first, *likely or unlikely*; second, *extremely likely or likely but not absolute*.

tentatively exclude the possible effect of demand characteristics (Appendix S4).

Statistical analyses

For key demographic variables and to test the balance across the three treatment groups, we used across-group chi-square tests and calculated adjusted family-wise-error-rate p values with Bonferroni methods (Appendix S4). Except for the education level between the control group and health-risk treatment group, all other key demographic variables were balanced across the trial groups. We used the same procedure to detect possible differences between treatment groups and the control group (Table 2). Following this, we used an SEM, specifically the structural model or path analysis among observed variables, to explore the mechanisms of correlation between treatment and behavior intentions. Because we used multiple observed variables to construct latent variables, we used only an SEM to conduct the path analysis among the observed variables. We assumed that these categorical types of observed variables were measured without error and analyzed their relationships and path coefficients in the SEM framework by using the robust weighted least squares mean and variance adjusted (WLSMV) estimator in the software Mplus (Finney & Distefano, 2006; Muthén & Muthén, 2017). This estimator allows for analyses for categorial or nonordinal data in an SEM and provides more accurate results than maximum likelihood (Finney & Distefano, 2006). Hereafter, we use SEM to indicate the use of structural modeling and path analysis.

Trial intervention studies commonly use across-group difference tests and logistic regression to measure the effect of treatment (Moorhouse et al., 2017; Wiik et al., 2020). We used an SEM to detect the treatment effect for demand reduction for IWT. Both logistic regression and SEM allow more accurate detection of treatment effects than the use of only across-group difference tests because they control for and isolate the impact of imbalanced cross-group variables and social desirability. Use of an SEM also allowed us to measure the treatment effect on multiple outcome variables in one single model with internalized

covariances (Gefen et al., 2000). This is particularly useful when direct measurement of behavior is not reliable and intentions are used instead. Measuring the consumption likelihood of elephant skin by considering the possible innate patterns and correlations of self-reported intentions helped us develop more robust and accurate conclusions than conducting multiple regressions individually would have. For example, groups with less recognition of elephant skin as a medicine, such as the younger people or people who have never heard of medicinal elephant skin, may only respond to consumption intentions of elephant skin based on their perceptions of and intentions toward general wildlife or animal medicines. By capturing the correlation of intentions of buying foreign animal-based TM and elephant skin in one SEM, we sought to more accurately estimate the treatment effect on the intention to purchase elephant skin than separate regressions for the two outcome variables could. Moreover, we used SEM to explore how the treatment worked and its effect on intention through individual beliefs or perceptions via mediation analysis (Janz & Becker, 1984; Ullman & Bentler, 2012). That is, we tested whether these variables were directly correlated or possibly correlated through cascading indirect effect via perceptions (Ullman & Bentler, 2012).

We built a full SEM framework and two SEMs to evaluate the effects of legal-risk and health-risk treatments, respectively, on four consumption intentions via mediation analysis of three public perceptions (Appendix S3). We constructed a binary treatment variable and used the blank control message as a reference for comparison of the two treatments so as to detect the additive effect of treatment from this baseline of background and social desirability. We added education level (the only imbalanced variable) and the perception-influencing variable TCM-use experience to this framework as covariates to measure the treatment effect. Based on the results of two full SEMs, we removed the two insignificant mediators, perception of legal risk and perception of health risk, and developed two final SEMs of treatments with good model fits (Figure 3). To test whether the treatment effects were consistent across sociodemographic groups, we conducted a multigroup analysis of the two treatment SEMs across groups with different residency, gender, age, and exposure to elephant skin.

All the SEMs were developed and analyzed in Mplus 8.10 with the WLSMV estimator (Muthén & Muthén, 2017). Our mediation analyses were bootstrapped 5000 times. Forest plots were created using the R package ggplot2 (Wickham, 2016).

RESULTS

Of the respondents recruited in the control, legal-risk treatment, and health-risk treatment groups, 91%, 87%, and 91% of respondents fully or mostly understood the survey, respectively (Appendix S3). Sixty-eight percent of the respondents had heard of elephant skin use for medicinal purposes, and there was no significant difference in awareness between urban and rural residents (Appendices S5 & S7).

Chi-square difference tests across RCT trial groups showed that compared with the control group, the legal-risk treatment group significantly reduced respondents' intentions to seek elephant skin ($\chi^2 = 6.60$, $p = 0.03$) and their perception of skin affecting a cure ($\chi^2 = 6.98$, $p = 0.02$) (Table 2). The health-risk treatment intervention significantly increased respondents' intentions to visit a hospital ($\chi^2 = 6.23$, $p = 0.04$).

The results from the SEM showed that in the legal-risk treatment, respondents' intentions to seek elephant skin were 24% (total effect = −0.24 [95% CI −0.42 to −0.06]) lower and intentions to seek foreign animal-based TM were 27% lower than the control group (total effect = −0.27 [−0.48 to −0.06]) (Figure 3). Both consumption intentions were significantly mediated by the reduced perception of elephant skin as a cure (indirect effect = −0.10 [−0.18 to −0.03] and indirect effect = −0.07 [−0.14 to −0.02], respectively). In contrast, the health-risk treatment showed that respondents' intentions to visit a market were 9% (direct effect = −0.09 [−0.17 to 0.00]), total effect = −0.09 [−0.17 to −0.00]) lower than the control group, and their intentions to visit a hospital were 17% higher (direct effect = 0.17 [0.03 to 0.30], total effect = 0.17 [0.04 to 0.31]) than those in the control group.

Results of the multigroup SEM analyses suggested that the two treatment effects might vary across respondents who have different levels of exposure to elephant skin and different demographic traits (Figure 4; Appendices S7–S13). Testing each grouping variable separately, we found that the health-risk treatment unintentionally increased the intention to seek elephant skin for urban residents who had previously not heard of elephant skin by 41% compared with the control group (direct effect = 0.45 [0.07 to 0.83], total effect = 0.41 [0.08 to 0.75]). This effect did not occur in any other groups (Figure 4). Based on the SEM, we found that the backfiring of health-risk treatment occurred directly and not via the mediating effect of perception of elephant skin as a cure. In contrast, the legal-risk treatment decreased intent to seek elephant skin among rural residents who had heard of elephant skin by reducing their perception of it as being a cure (indirect effect = −0.21 [−0.37 to −0.09], total effect = −0.41 [−0.71 to −0.13]). The corresponding treatment effects showed significantly different effect weights between urban and rural residents (indirect effect of legal-risk message, total and direct effect of health-risk message), indicating significant invariance between the two groups in response to the two different types of risk messages (Appendix S8).

Previous use of TCM also increased the intention to seek foreign animal-based TM and elephant skin and to visit a market across all trial groups (Table 3). However, the effect of TCM use on the increase in all three consumption intentions was neutralized by the effect of legal-risk treatment.

DISCUSSION

Previous studies show mixed results on the effectiveness of legality and health-related intervention messages on changing

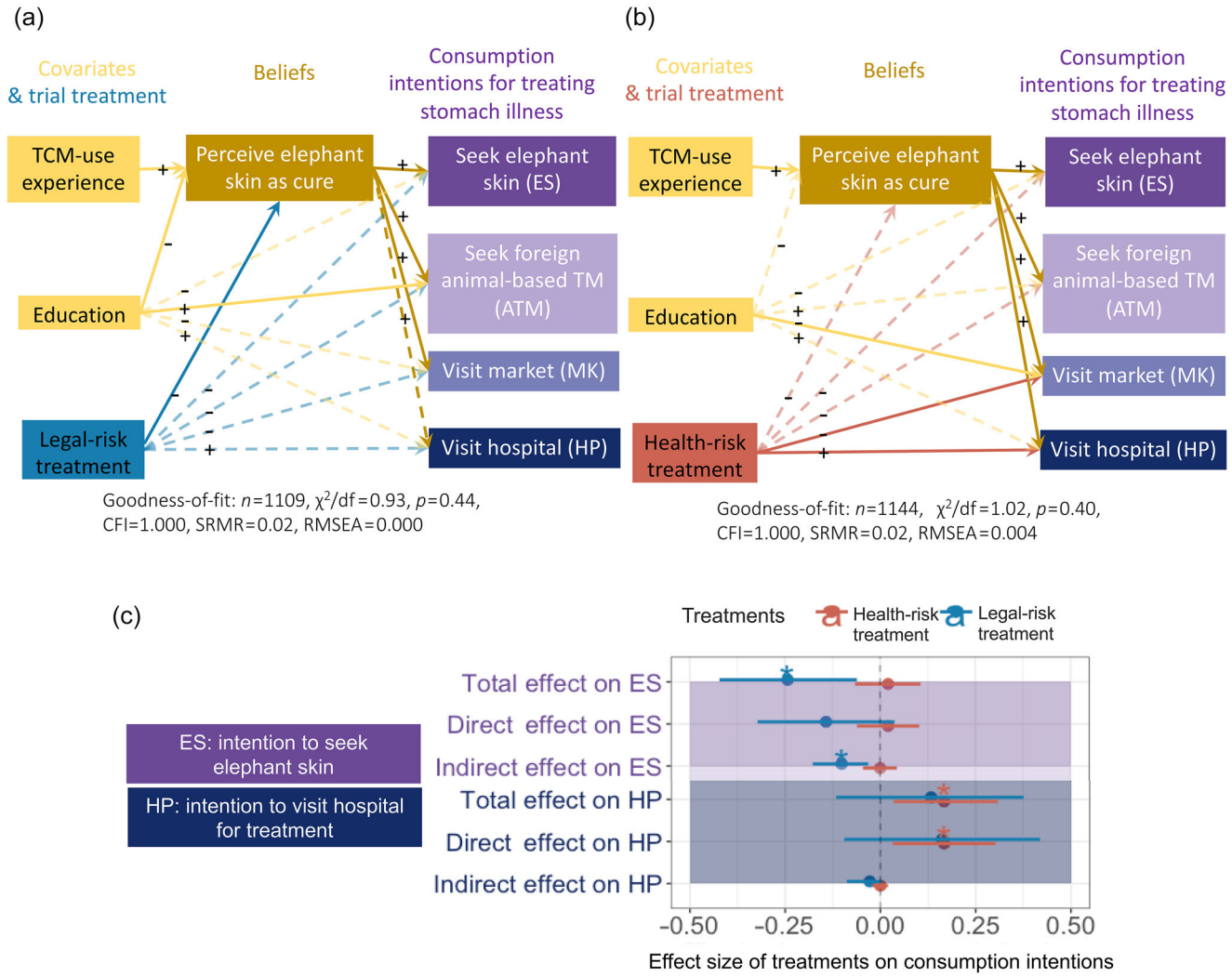

FIGURE 3 Structural equation model (SEM) pathways used to measure effects of experimental treatments (legal risk, health risk, control) in a trial of peoples' intentions to consume elephant skin to treat stomach illness: (a) legal risk and (b) health risk (TCM, traditional Chinese medicine; TM, traditional medicine; bold arrows, significant effect; dashed arrows, nonsignificant effects; plus, positive effect; minus, negative effect; blue arrows and red arrows, direct effects of treatments on perception or consumption intentions, respectively; yellow arrows, direct effects from covariates; brown arrows, direct effects from perception; SRMR, standardized root mean square residual; RMSEA, root mean square error of approximation) and (c) effects of legal-risk treatment (blue) and health-risk treatment (red) on two main consumption intentions for treating stomach illness (partial SEM) (ES, intention to seek elephant skin; HP, intention to visit hospital for treatment; indirect effects, treatment effect mediated by perception of cure; direct effects, direct treatment effect on consumption intentions not mediated by perception of cure; total effect, sum of indirect and direct treatment effects; *, significant effect at 0.05 level; whiskers, 95% CI).

TABLE 3 Total effect of use of traditional Chinese medicine (TCM) and treatment group on four intentions to treat stomach illness in a randomized control trial of consumption of elephant skin.

	Legal-risk treatment SEM		Health-risk treatment SEM	
	TCM use[a]	TCM use + legal-risk treatment	TCM use	TCM use + health-risk treatment
Effect on seeking elephant skin	0.14 (0.10, 0.19)*	−0.10 (−0.29, 0.09)	0.17 (0.12, 0.22)*	0.19 (0.09, 0.30)*
Effect on seeking foreign animal-based TM	0.10 (0.06, 0.16)*	−0.17 (−0.39, 0.05)	0.12 (0.08, 0.16)*	0.14 (0.03, 0.25)*
Effect on visiting market	0.07 (0.04, 0.11)*	−0.09 (−0.27, 0.09)	0.07 (0.03, 0.11)*	−0.02 (−0.11, 0.08)
Effect on visiting hospital	0.04 (−0.01, 0.10)	−0.09 (−0.34, 0.15)	0.07 (0.03, 0.13)*	−0.10 (−0.25, 0.04)

Note: Effect sizes are presented as coefficients; in parentheses, 95% CIs; *, significant difference between treatment group and control group at 0.05 level.
[a]Respondents have previous experience with the use of TCM.

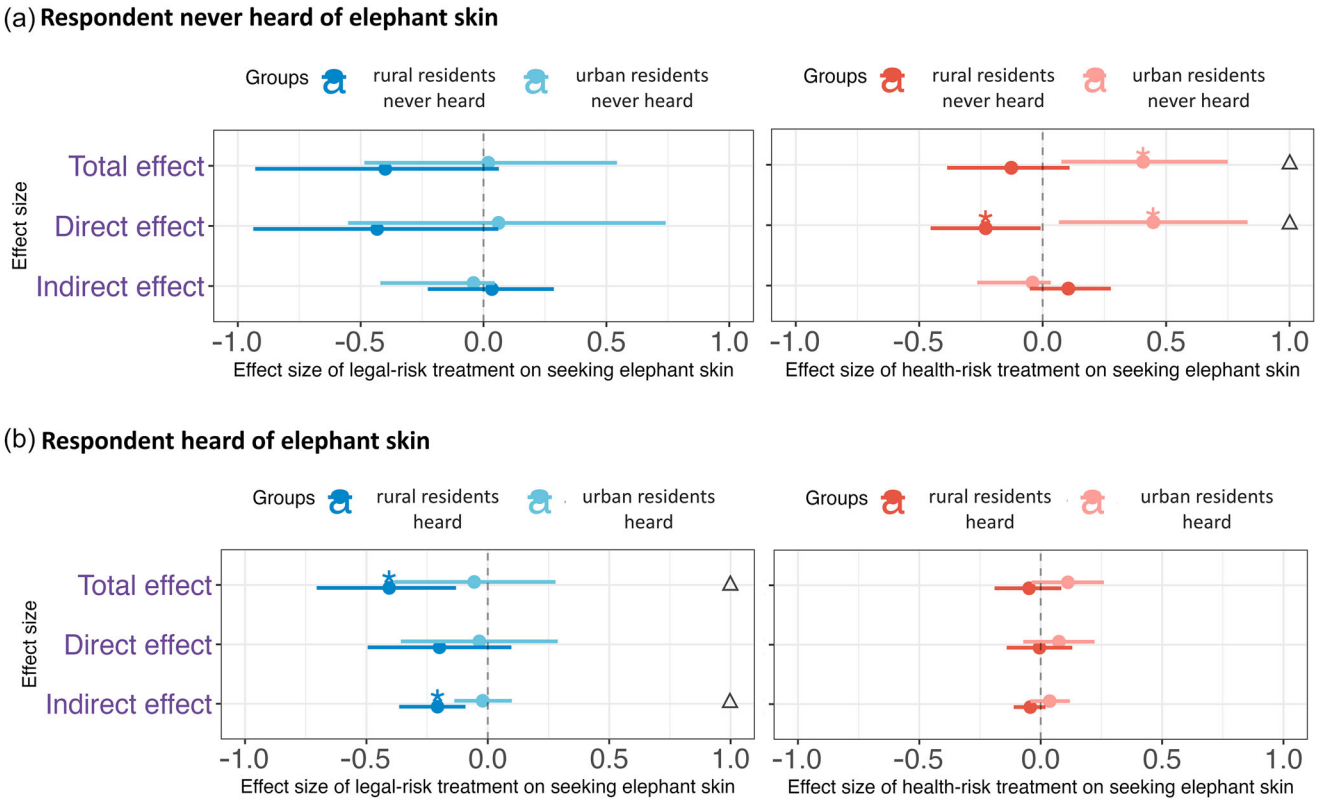

FIGURE 4 Effect of legal-risk and health-risk treatments in a randomized control trial of people on their intentions to seek elephant skin through mediation of their perception that elephant skin is a cure for stomach illness among respondents (a) who never heard of elephant skin and (b) who have heard of elephant skin by resident location (blue, legal-risk treatment; red, health-risk treatment; *, significant effect at 0.05 level; delta, path is significant between the rural and urban residents) (also see Appendix S8).

intentions toward the use of illegal wildlife products. One study indicates that presenting intervention messages on legality might be insufficient to change consumer intentions to purchase wildlife products, possibly because the intervention message clashed with respondents' beliefs on legality and the perception that the situation presented was not realistic. Other studies show a significant reduction in legality-related and health-related messages (Hu et al., 2024; Moorhouse et al., 2017, 2020). Our experimental study showed that legal-risk messaging reduced the intention to use illegal elephant skin based on a reduction in the belief that elephant skin has a curative effect (perception of cure). The relative 24% reduction in consumption intentions generated from the legal-risk message aligned with the range of 14–39% intention changes found in other IWT studies in which legality-related messages were used (Hu et al., 2024; Moorhouse et al., 2017). We found that health-risk messages increased the intention to visit professional medical facilities (i.e., hospitals) and that health-risk messaging could backfire on the intention of consuming elephant skin among urban residents who have never heard of it. We also found that legal-risk messaging neutralized the effect of prior TCM experience on consumption intentions. Consistent significant treatment effects on the intention to buy elephant skin and visit a hospital suggest that these effects are robust, whereas the treatment effect on the intention to seek foreign animal-based TM seemed sensitive to education and TCM use because it was significant only when demographic variables were balanced or taken into account.

Treatment effect was mediated via an indirect effect on perception of cure rather than risk perceptions, indicating possibly that the current perceived risk was already too high such that improved effectiveness was restricted (i.e., ceiling effect). Respondents' baseline perceptions of legal and health risks were already high, leaving little room for measurable change following the intervention (Table 2). Thus, even if participants internalized the intervention messages, changes in explicit risk perceptions would be difficult to detect through direct group comparisons, such as chi-square tests. However, the intervention could influence behavioral intentions by altering participants' perceptions about the curative effectiveness of the product (perception of cure) and possibly corresponding beliefs, rather than solely through changing perceived legal or health risks (Janz & Becker, 1984) (Figure 1). Such changes in perceived curative efficacy may operate as indirect pathways to intentions that are not easily detected by direct comparisons of perception scores across trial groups but may be detected with SEM.

Although intervention messages could be insufficient or counterproductive for behavioral change relative to beliefs and perception of the efficacy of TM (Cheung et al., 2021; Moorhouse et al., 2020), we found that the legal-risk message still

changed, through a mediation effect, the perception of the medicinal value of elephant skin and the intention to buy it. Thus, we speculate that emotions or feelings, in addition to risk perceptions, might be associated with legal-risk messages, as shown in other studies, which could then lead to a decrease in the perception of benefits and the intention of consumption (Alhakami & Slovic, 1994; Loewenstein et al., 2001; Sheeran et al., 2014). The additive treatment effect of the legal-risk message accounted for the impact of the baseline level of background and social desirability. This indirect effect of the legal-risk message on intention of consuming elephant skin could be an amplification of existing knowledge of the heightened enforcement of wildlife trade laws in China in recent years and the severity of the punishment (Hansen et al., 2018; Sheeran et al., 2014). Social norm narratives explicitly convey that buying even a little is a criminal offence. Legal-risk messages and similar messages from acquaintances may improve the likelihood of behavioral changes (Cialdini et al., 2006). Further study is needed to learn whether emotions might be short-lived or change if the enforcement level changes in the future.

We speculate that the lack of a health-risk message on buying elephant skin may be due to a diminishing dependency on elephant skin for disease treatment and hence may have led our respondents to perceive a lesser health risk from elephant skin. Nevertheless, the long-term effect of health-risk messaging on consumption through increased hospital visits and ceasing the use of TM requires further investigation. These results suggest that appraisals of legal risks have the potential to affect the perception of the medicinal efficacy of illegal wildlife TM and consumption intention without directly framing the message to clarify the plausible medicinal benefits of wildlife products (Cheung et al., 2021). Nonetheless, applying legal-risk messaging to IWT needs further scrutiny, particularly to understand and avoid possible spillover of legal-risk aversion to illegally traded wildlife (e.g., eating bats is illegal in China after COVID-19) that could negatively affect support for conservation efforts of some wildlife species (Lu et al., 2021).

Presenting messages in interviews helped increase the understanding of messages because interviewers adopted local ways to gain information and because it was more engaging. However, it might have inflated the average treatment effect relative to other intervention studies in which surveys were self-administered (Moorhouse et al., 2020). Although comparing intervention formats and their effectiveness is not within our study's scope, other studies show that using comics may facilitate intention changes because they are more engaging than other formats, such as photos. However, the message delivery method may not have affected the treatment effect more than the message content, given that the results of legal-risk and health-risk treatments differed even though messages in both treatments were presented in comics and through interviews.

The backfiring of the health-risk message reinforces recent calls for framing IWT demand-reduction interventions specifically for different subgroups or audience types for more effective interventions (Thomas-Walters et al., 2020). Although some studies show that correcting misinformation would likely backfire by reinforcing familiar misinformation, we did not find that messages backfired among groups who had heard of medicinal elephant skin for either risk-appraisal message (Pluviano et al., 2019). Instead, legal-risk messages decreased consumption intention of rural residents who had heard of elephant skin. Only the health-risk treatment with urban residents with no knowledge of medicinal elephant skin backfired. These results could have been due to unintentional triggering of nonmedicinal motivation for consuming elephant skin (e.g., bushmeat, entertainment) (Veríssimo et al., 2020) (Appendix S7). We speculate that, in this case, motivated by a growing expansion of life-fulfillment needs that scaled with urbanization and accumulated affluence, urban residents who had not heard of elephant skin may have been inspired by the health-risk treatment to consume elephant skin out of curiosity (Thomas-Walters et al., 2021). In contrast, the rural respondents did not show such a pattern, probably because they were more likely to be influenced by traditional norms of mustering and consuming wildlife products as basic needs (e.g., medicine) (Jayawickramarathna et al., 2021; Veríssimo et al., 2020). Overall, the invariant treatment effects suggested that different IWT intervention approaches will be required for groups with different prior experiences with illegal wildlife products and for those with various motivations characterized by demographic variations (Burgess, 2016; Thomas-Walters et al., 2020, 2021). As such, interventions or pilot experiments exploring heterogeneous preferences and motivations of potential consumers could be more informative if they differentiated consumers, thereby avoiding unintended conservation consequences (Hinsley et al., 2015; Thomas-Walters et al., 2021).

When faced with the possible dilemma that promoting the sustainable use of wildlife products might also increase the volume of illegal wildlife trading, our study provides some evidence that risk appraisal might be a possible solution (Tittensor et al., 2020; Wang et al., 2022). Our results suggest that legal-risk messaging may counteract TCM users' demand for illegal wildlife products without increasing the consumption of legal TM via channels like hospitals. Legal-risk messages could be tailored to guide and promote the sustainable use of TM (Cheung et al., 2021; Thomas-Walters et al., 2020).

Our study has several limitations. The limited comprehension ability among our respondents limited the use of behavior change theory frameworks and the full measurement of constructs with latent or ordinal variables. We excluded the respondents' perceptions of stomach illness because so few of them actually had experience with stomach illness. Perceived barriers in the HBM theory could contain other physical and psychological costs beyond the perceived risks and cumulatively affect this belief. However, because we sought to appropriately match levels of understanding and to make the process easy for respondents, we measured constructs based on only one or two key factors and with a binary scale. Thus, our ability to capture respondents' nuanced variations in psychological characteristics related to behavior across multiple dimensions was constrained. Although the perception of threat may likely have a weak effect,

as shown in other studies applying HBM, the effect of changing the perception of legal risks over all perceived barriers for consumption behaviors is unknown based on our results (Carpenter, 2010). Future studies should focus on consumer groups with more IWT experience or use a fact-based proxy of measurements to increase understanding of the consumption of elephant skin.

We measured only behavioral intentions and cognitive perceptions because we could not directly observe participants' behavior in real life or quantify contextual influence, such as the social and opportunity environment for the consumption of elephant skin. These gaps limit the strength of our conclusions about the actual behavior and reduce the predictive validity of our results, even though these are common challenges for IWT studies due to the clandestine nature of IWT. We examined only the immediate effects of the intervention; therefore, knowledge of the long-term sustainability of behavioral changes was not fully examined. Well-developed scales for measuring behavioral intentions as proxies of behavior are currently also lacking (Frommeyer et al., 2022; Nguyen et al., 2019). When questions to construct intentions as latent variables become available, researchers may be able to better measure intentions and to close the intention–behavior gap for studies on illegal wildlife consumption (Chandon et al., 2005; Conner & Norman, 2022). Moreover, as is implied from the findings of mediation effects of legal-risk treatment, future researchers may also use risk-as-feelings models to measure feelings and unconscious responses and consider noncognitive drivers and indicators for behaviors (Loewenstein et al., 2001). This may supplement understanding of sensitive IWT studies by taking into account indicators of the contextual environment. Future researchers may also monitor the treatment effects and consequential behaviors of consumption and identify the longitudinal effects of cognitive and contextual influencers.

Our results suggest that appraisals of legal risks are most effective in reducing demand for elephant skin and that health-risk messaging could backfire among urban residents who have never heard of elephant skin. They provide scientific and rigorous intervention solutions for promoting conservation of Asian elephants and evidence-based insights for designing and implementing public campaigns that use risk-based messages to address IWT. They also suggest that understanding heterogeneous motivations and context across multiple groups and testing the impact of potential interventions are essential for conceiving rigorous and effective IWT intervention and conservation practices (Thomas-Walters et al., 2020). We found that legal-risk messaging targeting species-specific products may also affect the intention to use other animal-based TMs simultaneously.

AUTHOR CONTRIBUTIONS

Beilu Duan, Zac Posada-Baynham, Joceline Yong, Zhan Chen, Xiaoxi Zhang, Anita K. Y. Wan, Lishu Li, Alexander Clark, and Tien Ming Lee designed the research. Beilu Duan, Wuji Zheng, and Xiaoxi Zhang collected survey data. Beilu Duan, Tien Ming Lee, and Jingjing Zhao contributed to data analysis. Beilu Duan wrote the initial draft, and all coauthors revised the paper.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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