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RESEARCH ARTICLE

Achieving Sustainable and Equitable Consumption of Wild Meat

Conserving wildlife through demand reduction and supply alternatives: Two experiments in restaurants in Kinshasa

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Abstract

1. High aggregate levels of wildlife consumption in cities in Central Africa highlight the need for solutions that balance wildlife protection, local livelihoods and the relational values between people and nature.
2. This study explores the impacts of demand- and supply-side interventions on wild meat consumption through two randomized control trials in restaurants in Kinshasa, Democratic Republic of the Congo: a demand-side experiment and a supply-side experiment.
3. In the demand-side experiment, 544 subjects were given a coupon to their restaurant of choice and randomly assigned to view either a treatment video discouraging wild meat consumption or a control video unrelated to wild meat. Treatment group subjects are 31% less likely to order wild meat than control group subjects, though this difference is not statistically significant and may be affected by social desirability bias.
4. In the supply-side experiment, we assessed the effect of randomly reducing the price of Moambe Chicken, a potential alternative to wild meat, on restaurants' total wild meat sales. We estimate that a 1% reduction in the price of Moambe Chicken reduces total wild meat sales by 0.91%. Although this relationship is not statistically significant, it suggests that interventions increasing the availability and affordability of alternatives to wild meat may reduce wild meat consumption.
5. Our experiments advance previous research by utilizing actual consumption data rather than self-reported data, assessing social desirability bias and pre-registering all statistical specifications to enhance research integrity.
6. *Policy implications*. We provide preliminary evidence suggesting that both wild meat demand reduction through social marketing campaigns and supply expansion via affordable alternatives could contribute to effective wildlife conservation in Central Africa.

KEYWORDS
Central Africa, randomized control trials, wild meat consumption

1 | INTRODUCTION

Millions of people in tropical regions of the world depend on wildlife as a source of food and means of acquiring income (Coad et al., 2019; Wells et al., 2024). Simultaneously, overexploitation, including from hunting that exceeds population growth rates, has emerged as the most significant threat to many species (IPBES, 2019), impacting wildlife populations and threatening ecosystem functioning. The consumption of the meat of wild animals, "wild meat", is prevalent in rural areas, and there is also substantial demand for wild meat among people living in some urban areas (Carignano Torres et al., 2022; Edderai & Dame, 2006; Ingram et al., 2021; Simo et al., 2024). Consumption of wild meat in towns and cities is driven by a variety of factors, including culture, taste preference, the perception that it is the most natural meat and the relative availability and price compared to domesticated meats (Chausson et al., 2019; van Vliet & Mbazza, 2011; Wilkie et al., 2016). Where wild meat is more expensive than domesticated meat alternatives, it can also be considered a luxury product that signifies status (Sandalj et al., 2016). When demand for wild meat in urban areas drives hunting to unsustainable levels, it poses a unique challenge and opportunity for conservation efforts. Addressing this challenge requires innovative and just solutions that respect local livelihoods and traditions, protect wildlife and cultivate the relational values between people and nature (Chan et al., 2018; Ingram, 2020).

There are two primary approaches to tackle the overexploitation of wild meat in urban areas: reducing the demand for wildlife products or limiting the supply of wildlife to the market. Recent years have seen a surge in wildlife product demand reduction campaigns (Veríssimo & Wan, 2019; Willis et al., 2022). For instance, WildAid, a non-governmental organization (NGO), invests heavily in social marketing campaigns to reduce demand for wildlife products (WildAid, 2020). The World Bank's Global Wildlife Program has advocated for increased investment in such interventions (Sobrevila, 2016). Alongside efforts to reduce demand, supply-side interventions seek to limit the quantity of wildlife supplied to the market. For example, the Sustainable Wildlife Management Programme aims to regulate hunting and expand poultry production in some of the 15 countries in which it operates (Food and Agriculture Organization et al., 2019).

Both approaches have strengths and limitations. Demand-side interventions can create awareness and shift societal norms, but attempts to change preferences in domains other than wild meat consumption often fail (MacFarlane et al., 2022). Careful design and years-long campaigns may be required to change deeply ingrained preferences. But if successful, demand-side interventions can provide a lasting benefit to wildlife populations: Even if wild meat were available, fewer people would choose to consume or purchase it, reducing the incentive to hunt wildlife. Supply-side interventions, on the other hand, can have more immediate impacts. By more directly reducing the quantity of wildlife killed for food, they can quickly benefit wildlife populations. However, supply-side interventions alone may not be sufficient to reduce wild meat consumption to sustainable levels, because persistent demand leaves the economic incentive for hunting unaddressed. Despite the numerous and extensive initiatives undertaken by governments and NGOs, the effectiveness of both demand-side and supply-side interventions in changing actual wildlife consumption habits, especially in urban settings, remains underexplored (Ingram et al., 2021; MacFarlane et al., 2022; Travers et al., 2021; Veríssimo & Wan, 2019).

In November 2023, we implemented two complementary randomized control trials in Kinshasa. Our research questions are: (1) Does a demand-side intervention reduce wild meat consumption in restaurants? (2) Does a supply-side intervention reduce wild meat consumption in restaurants? The study focused on restaurants in Kinshasa, the capital city of the Democratic Republic of the Congo (DRC) and one of the fastest-growing megacities in the world with a population of ~17 million people. The DRC is the largest country in Central Africa, comprises 61% of the region's forests and is highly biodiverse (Grantham et al., 2020). Kinshasa is located on the Congo River, south of the world's second-largest rainforest, and it has approximately 3000 wild meat ("bushmeat") restaurants (Fa et al., 2019). Wild meat enters the city by road, river and plane, and it is sold in markets and restaurants across the city (Lucas et al., 2022). A recent study estimated that 8592 wild meat dishes were sold in restaurants in Kinshasa each day, equating to 1254 tonnes (by live weight) of wild meat annually (Wright et al., 2022). Primates and ungulates were the most popular types of wild meat, whereas generally the most frequently sold dishes across the city contained either fish, beans or chicken. While there appears to be no single driver of wild meat consumption in Kinshasa, tradition and culture, social status, taste, freshness, cost and accessibility all play a role (Trefon, 2023; Yocum et al., 2022). Furthermore, wild meat can be more expensive than domesticated meat in restaurants, suggesting it could be consumed more by wealthier residents (LaCerva, 2016; Wright et al., 2022). Restauranteurs in Kinshasa state that they sell wild meat because of high demand, its profitability, to maintain Congolese culture, and menu diversification (Wright et al., 2022). Indeed, some traditional Congolese dishes are made predominantly with wild meat. In restaurants with menus, wild meat is often openly listed for sale. Laws pertaining to wild meat in the DRC refer to the act of hunting, requiring a permit and to the species that are protected. No specific laws regulate the consumption in urban settings or trade of meat obtained by hunting (Sustainable Wildlife Management Programme, 2024).

1.1 | Conceptual framework and contributions

Relational values refer to the preferences, principles and virtues associated with relationships, both interpersonal and as articulated by policies and social norms, that contribute to a meaningful life (Chan et al., 2016). Unlike instrumental values (nature for human use) or intrinsic values (nature for its own sake), relational values emphasize the connections and responsibilities between people and nature (Klain et al., 2017). Our study is situated within the relational values'

framework, focusing on how human behaviours, cultural ties and economic incentives impact conservation outcomes. Relational values guide both the design and analysis of our experiments. The demand-side experiment employs a culturally resonant video that connects pride in Congolese wildlife to traditional culinary heritage without wild meat. This video aims to strengthen people's cultural bonds to wildlife in order to shift consumer behaviour through a renewed sense of stewardship and identity (West et al., 2018). Likewise, in the supply-side experiment, we tested how offering a culturally relevant alternative—Moambe Chicken—at a lower price could reduce wild meat consumption. This intervention respects existing food-related cultural practices while encouraging sustainable consumption, aligning with relational values that prioritize harmonious human–environment interactions (Schulz et al., 2017).

Our study offers practical insights for policymakers and conservation practitioners on designing culturally sensitive interventions that resonate with local values and traditions. By using actual consumption data and robust methodologies—including randomized control trials, pre-registration and response bias measurement—we adhere to best practices in conservation research (Cisse et al., 2023). Internationally, the demand- and supply-side interventions we evaluate could be tailored to urban areas beyond Kinshasa where wildlife consumption poses conservation challenges. Our study's theoretical contribution to the relational values framework is demonstrating how economic incentives can be integrated with cultural values to effect behavioural change. By addressing the sociocultural drivers of wild meat consumption, our work highlights the critical role of integrating relational values into conservation efforts to foster sustainable behaviours that are both ecologically beneficial and culturally acceptable.

2 | METHODS

2.1 | Design of demand-side experiment

A fundamental challenge in evaluating the effectiveness of demand reduction interventions is the difficulty in controlling exposure to specific messages. Mediums like billboards or television commercials offer limited insight into who views the message and, more critically, who constitutes the control group (e.g. those not exposed to the message). Establishing a credible control group is necessary as it acts as a comparison point or counterfactual, illustrating what the wild meat consumption level might have been in the absence of the intervention. Thus, our demand-side experiment was designed with a dual focus: first, to manage and document each participant's exposure to the intervention message; and second, to link this exposure to their subsequent consumption choices.

Restaurants in Kinshasa present an ideal setting for our experiment due to the real-world decision-making environment they provide. When patrons dine at a restaurant, they make real choices based on their preferences and budget, spending their own money on the dishes they choose. This setting facilitates the measurement of choices representative of actual, rather than hypothetical, consumption behaviour. We recruited four restaurants in Kinshasa to participate in our study (Figure 1), based on two criteria: They needed to offer both wild meat and non-wild meat options daily, ensuring a variety of choices for customers; and the restaurant owners agreed, via contract, to report each participant's order to us, allowing us to link their choices to the intervention message they received.

In the experiment, enumerators set up four tables, each representing one of the participating restaurants. These tables were positioned two or three blocks away from their respective restaurants, ensuring that the study and the restaurants were out of sight from each other. This configuration served a dual purpose: It prevented participants from being influenced by the direct visibility of the restaurants during the experiment and ensured that participants were not visible to enumerators when visiting the restaurants and ordering a dish. The placement also guaranteed that each subject had convenient access to at least one restaurant.

Over 8 days in November 2023, enumerators at each table encouraged passers-by to participate in a survey, offering a coupon to their restaurant of choice as an incentive. Participation was limited to adults (18 years or older) who are active wild meat consumers, defined as subjects who reported eating bushmeat at least once in the past month. Subjects were required to use their coupon within 2 weeks. Enumerators followed a strict protocol, attending to each participant individually to prevent interaction between participants that could bias their choices.

Subjects were randomly assigned to watch one of two videos on a tablet with headphones. The treatment group watched a publicly available 90-s clip from the 2019 multimedia campaign "Let's eat less bushmeat in the city" ("Mangeons moins de viande de brousse en ville"), led by the Government of neighbouring Republic of the Congo with the aim of reducing wild meat consumption in the city of Pointe Noire. In the video, two childhood friends reunite, and when one suggests cooking wild meat, they discuss the environmental consequences of urban wild meat consumption on the depletion of forest wildlife (Ministère de l'Economie Forestière—Congo, 2019). They decide to avoid such consumption in the future and instead embrace Congolese dishes that do not contain wild meat (Supporting Information, Appendix B). Rather than address all drivers of wild meat consumption simultaneously, the video we used focused on messages that target pride in Congolese forests and wildlife, while also supporting traditional Congolese cuisine. These could be considered as targeting drivers primarily linked to culture and tradition. The control group viewed a 90-s clip from a Congolese soap opera unrelated to wild meat or the environment.

After watching the video, subjects chose one of four restaurants for a $5 coupon (12500 Congolese Francs). We provided subjects with the name, location and a sample menu from each restaurant. We compensated restaurant owners for each redeemed coupon. Subjects were responsible for paying the difference between the price of their meal and the coupon value. For example, a subject would have to pay $4 for a $9 meal ($9 − $5 = $4). Each coupon had a unique identifier, linking subjects' orders to their treatment assignment status. Subjects were informed during the survey that they should order whatever dish they preferred, regardless of whether it was wild meat or not.

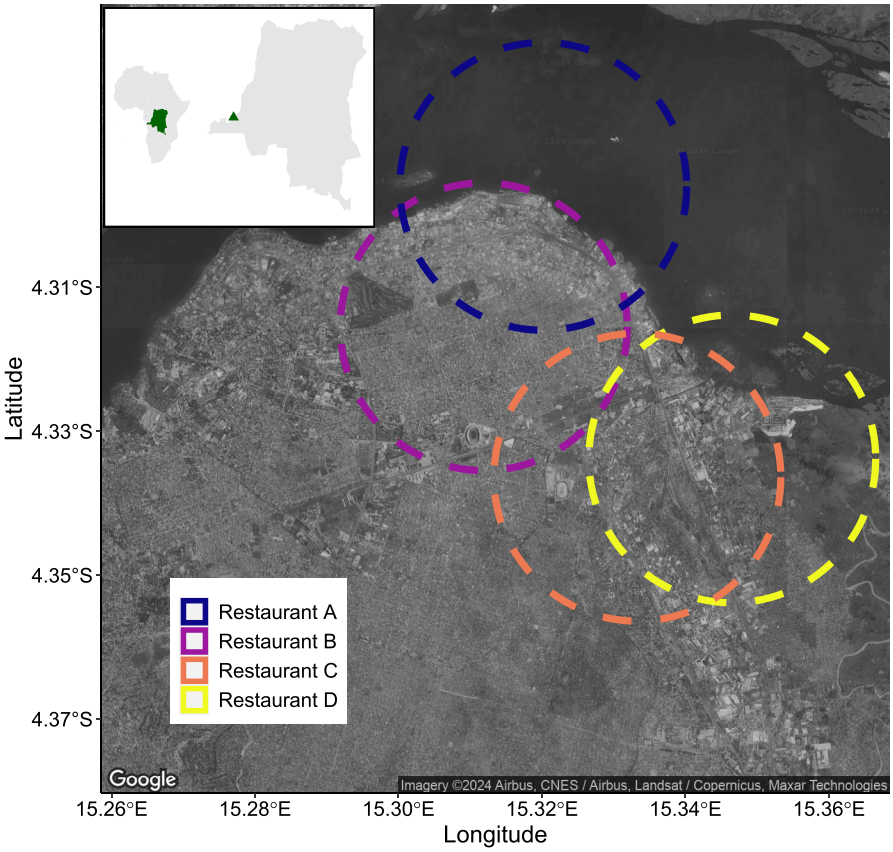

FIGURE 1 Approximate locations of participating restaurants. To ensure anonymity, the actual locations of the restaurants were randomly adjusted by up to approximately 3 km. The dashed circles, centred on these modified coordinates, indicate that the true locations of the restaurants are situated somewhere within the corresponding circles. The inset map on the left shows the Democratic Republic of the Congo (green polygon) within Africa (grey), while the inset on the right highlights Kinshasa (green triangle) within the Democratic Republic of the Congo (grey).

Immediately following the video viewing and restaurant selection, subjects completed a survey on their attitudes towards bushmeat and the frequency of consumption by people in their social network (Supporting Information, Appendix C). The attitude questions asked subjects to express their level of agreement with statements that wild meat is sustainable, fresh, tasty, cool, legal, healthy and connects them to their place of origin. These attitudes were selected based on other studies (Chausson et al., 2019; Wilkie et al., 2016), with the exception of legal and sustainable which we added out of interest. Additionally, enumerators asked subjects about their pride in the environment of the DRC. The purpose of the attitudinal questions was to provide insight into why any potential treatment effects occurred. Additionally, subjects answered 13 questions related to social desirability, enabling us to assess response bias (Dhar et al., 2022).

Five hundred and fifty-four subjects participated in the demand-side experiment, of whom 59% used their coupon within 2 weeks to order a meal at their restaurant of choice.

2.2 | Analysis of demand-side experiment

2.2.1 | Analysis of wild meat consumption and coupon usage

To understand the effects of the video aimed at discouraging wild meat consumption (treatment), our prespecified analyses employ ordinary least squares regression to estimate equations of the following form (Cisse et al., 2023):

$$Y_{ijt} = \beta T_i + \alpha X_i + \kappa_j + \zeta_t + \epsilon_{ijt}. \quad (1)$$

In this equation, Y_{ijt} is an outcome variable, such as whether a subject ordered wild meat. The subscript i denotes the subject, j represents the table where the subject participated in the experiment and t denotes the date of participation (not the date at which they ordered a dish in their restaurant of choice). T_i indicates whether the subject was in the treatment group that watched the wild meat demand reduction video ($T_i = 1$) or in the control group ($T_i = 0$). X_i is a matrix of eight individual subject characteristics, such as age, gender, education level, salary and business ownership status. κ_j and ζ_t are the "fixed effects", or individual dummy control variables for each table (κ_j) and individual dummy control variables for each date (ζ_t). Including these fixed effects obviates the need for an intercept term, as it would be collinear with either κ_j or ζ_t. The variable ϵ_{ijt} is the error term, which represents factors that affect the outcome variable but which are not otherwise accounted for in the equation. The coefficient of interest is β, which measures the effect of treatment assignment on the outcome variable.

The standard errors of all regression coefficients are clustered at the subject level to match the level at which treatment is assigned (Abadie et al., 2023). This method accounts for potential differences in the variability of responses across subjects. Our clustered standard errors are also "heteroscedasticity-robust". We do not solely rely on p-values in interpreting our results; we also assess the magnitudes of

the treatment effects, and we compare their consistency and interpretive validity across the different parts of our experiments (McShane et al., 2019; Wasserstein & Lazar, 2016). When we do assess statistical significance, we use the conventional p-value threshold of 0.05.

The inclusion of individual-level controls and fixed effects is aimed at increasing the precision of the estimated impact of the treatment, β. They are not necessary for estimating the magnitude of the treatment effect because random assignment ensures that any differences in outcomes between the treatment and control group can be attributed to the treatment video (Rubin, 1974). In Equation (1), X_i includes an indicator for whether the subject reports usually eating wild meat at formal or informal restaurants, the number of days the subject has eaten wild meat in the last 30 days, the age of the subject in years, an indicator variable for whether the subject is male, an indicator for whether the subject has attained university (post-secondary) education, the total number of years of education the subject has, an indicator variable for whether the subject was employed for pay in the previous 7 days and an indicator variable for whether the subject worked for pay as the owner of a business in the previous 7 days. For any missing values in these control variables (except for indicator variables), we impute the value with the mean among all non-missing values. For example, if age is missing for 44 subjects, we assume their age to be the mean age among the 500 subjects with recorded ages. We chose these eight control variables to capture key behavioural, demographic and economic factors that may influence wild meat consumption, while maintaining survey brevity (Chausson et al., 2019; WildAid, 2021). Other variables, such as ethnicity or duration of residency in Kinshasa, may also predict wild meat consumption.

The eight explanatory variables we chose can be grouped conceptually into three categories of wild meat consumption predictors. We expected the first two, whether subjects usually eat wild meat at restaurants and the number of days subjects have eaten wild meat in the previous 30 days, to positively correlate with subjects using their coupon to order wild meat. We chose the next four—age, sex, whether the subject attained university education and years of education—as capturing the most essential demographic information, including characteristics that predict wild meat consumption. For example, in Pointe Noire, Republic of the Congo, younger people eat less wild meat, and males eat more wild meat (Chausson et al., 2019). Finally, we expected the last two variables—in paid employment and business owner—to be positively correlated with subjects using their coupon because we thought richer subjects would be more able to pay the portion of the restaurant meal not covered by the coupon.

2.2.2 | Analysis of selection of wild meat-intensive restaurants

The decision of what dish to order at a restaurant focuses on the quantity of wild meat consumed, ignoring the preceding choice of which restaurant to visit. Our treatment video, and demand-side interventions more broadly, might influence not just the selections made within an eating environment but also the choice of the eating environment itself. With the four restaurants in our study offering varying numbers of wild meat dishes and these dishes constituting different proportions of their total menus, we have the opportunity to assess whether subjects exposed to the treatment are more likely to choose coupons to restaurants that feature less wild meat.

For this analysis, we categorize restaurants based on the proportion of wild meat dishes featured on their sample menus, as shown to subjects during the demand-side experiment. Our prespecified definition identifies "wild meat-intensive" restaurants as those with the highest proportion of wild meat dishes (23% and 21%, compared to 7% and 9%). Alongside the original control variables in Equation (1), we include as controls the distance from the subject's table to the chosen restaurant and the average price of dishes on the restaurant's sample menu. We included these variables to enhance the precision of our estimate of the treatment effect by controlling for factors like convenience and cost, which might affect a subject's choice of restaurant independently of treatment assignment.

2.2.3 | Analysis of attitudes towards wild meat

To understand the mechanisms behind the potential changes in wild meat consumption, we investigate how the treatment video affects subjects' views on various attributes of wild meat. We prespecified this analysis to discern whether changes in wild meat consumption are due to shifts in perception caused by the treatment video. After watching the video and choosing their restaurant, subjects answered eight questions measuring different aspects of their views of bushmeat (Supporting Information, Appendix C). To avoid priming the respondents or the enumerators into choosing the first response options, we randomly varied the order with which we displayed the response options (from completely agree to completely disagree vs. from completely disagree to completely agree).

We aggregate responses to these questions into a single index, coding responses to indicate a negative view of wild meat. This coding schema allows us to test whether the treatment video worsened attitudes towards wild meat. For the first seven attributes, we code a response showing disagreement as 1 (indicating a negative view), while coding agreement or neutrality as 0. For the statement about environmental pride, we code agreement as 1.

We sum the coded responses for each subject, creating a score ranging from 0 to 8. Then we standardize this score across all subjects by subtracting the mean and dividing by the standard deviation, resulting in a standardized response score. Finally, we re-estimate Equation (1) with this "Unfavourable" standardized score as the dependent variable.

2.2.4 | Analysis of social desirability bias

During our demand-side experiment, enumerators emphasized to subjects that they should order the dish they most desired at the

restaurant, regardless of whether it was wild meat or not. Despite these instructions, there remains a possibility that treated subjects might order less wild meat due to social desirability bias—subjects doing what they believe enumerators want them to do—rather than subjects being genuinely persuaded by the treatment video. To evaluate this potential bias, also known as experimenter demand effects, we replicate an established method to assess its impacts on our results (Dhar et al., 2022).

This method involves a 13-question module designed to measure social desirability (Supporting Information, Appendix C and References). Given each statement, subjects answered whether they completely agree, partially agree, neither agree nor disagree, partially disagree or completely disagree. To avoid priming the respondents or the enumerators into choosing the first response options, we randomly varied the order with which we displayed the response options. We code the response to each statement as 1 if the subject gives a socially desirable answer. For example, if a subject completely disagrees or partially disagrees with the statement "I sometimes feel resentful when I don't get my way", we code their response as 1 (and code the response as 0 if they neither disagree nor agree, partially agree or completely agree). We sum the coded responses over statements, so that subjects have a social desirability score of between 0 and 13. We standardize the score by subtracting the mean score across all subjects, and then dividing by the standard deviation of the score across all subjects.

To investigate social desirability bias's influence on our wild meat consumption results, we replace the eight individual characteristics' controls in Equation (1) with two variables: the standardized social desirability score (StdSoc_i) and its interaction with the treatment indicator $(T_i \times \text{StdSoc}_i)$. The dependent variable is an indicator of whether a subject ordered wild meat:

$$1\{\text{OrderedWildMeat}\}_{ijt} = \beta T_i + \sigma_1 \text{StdSoc}_i + \sigma_2 T_i \times \text{StdSoc}_i + \kappa_j + \zeta_t + \epsilon_{ijt}. \quad (2)$$

In this equation σ_2 is the coefficient of interest, indicating the potential interaction between treatment and social desirability. A negative σ_2 would imply that subjects in the treatment group less likely to order wild meat also exhibited higher social desirability.

2.3 | Design of supply-side experiment

In November 2023, alongside our demand-side experiment, we conducted a supply-side experiment at the same four restaurants to explore how changes in the price of Moambe Chicken affect wild meat consumption. Moambe Chicken, a dish specific to Congolese cuisine, is popular in the region and may fill a similar cultural role as wild meat. Our field team, primarily composed of Kinshasa residents, advised us that Moambe Chicken was the most likely substitute dish for wild meat at restaurants in Kinshasa. On randomly selected days, the price of Moambe Chicken was reduced by $2 (5000 Congolese Francs). On these days, we compensated restaurants $2 for every plate of Moambe Chicken they sold (to all customers, not only those participating in our demand-side experiment). The goal of this experiment was to determine whether making a non-wild meat option more affordable would reduce customers' decisions to order wild meat. This relationship between wild meat consumption and the price of alternatives is the rationale for supply-side alternative protein programmes, such as promoting poultry production, where the aim is to reduce wild meat consumption by increasing the availability and affordability of substitutes (Foerster et al., 2012; Moro et al., 2015).

The restaurants provided daily sales data, which included all customers, not only those participating in our demand-side experiment. These data encompassed the number of plates sold in three categories: wild meat, Moambe Chicken and all other dishes, along with the corresponding revenue for each category. For the purpose of our analysis, "wild meat dishes" referred to all types of wild meat combined into a single category. For instance, if a restaurant sold two dishes of antelope and two dishes of monkey on a day, it was recorded as four dishes of wild meat sold that day.

During the supply-side experiment, we gathered data across 68 restaurant-day observations, comprising 17 days for each of the four participating restaurants. Among these, 11 restaurant days were randomly chosen to lower the price of Moambe Chicken, creating the treatment group, while the other 57 served as the control group with regular pricing. This randomization enabled a comparison of dish sales between days with reduced prices (treatment group) and days when prices remained unchanged (control group). The smaller number of treatment observations compared to control observations reflects our budget constraints, as we only paid restaurants on days they were treated.

Importantly, the treatment assignment in the demand-side and supply-side experiments was independently randomized, ensuring that neither experiment would influence the results of the other on average. This independent randomization means that while subjects in the demand-side experiment may visit a restaurant during the supply-side experiment, these interactions would be randomly distributed and thus would not bias the results of either experiment.

2.4 | Analysis of supply-side experiment

The key assumption in our analysis is that the only way the experiment affected wild meat and Moambe Chicken sales was through the experimentally induced change in Moambe Chicken price. This assumption is likely valid given the randomization of the experiment and its singular focus on subsidizing treated restaurants to reduce Moambe Chicken price by $2 on randomly selected days.

Our analysis begins with estimating the effect of the treatment on Moambe Chicken's price by ordinary least squares regression:

$$\log(P_{it}) = \gamma_1 T_{it} + \delta_1 Q_{i0} + \delta_2 \text{Price}_{i0} + \epsilon_{it}. \quad (3)$$

Here, $log(P_{it})$ is the log price of Moambe Chicken in restaurant i on day t, with T_{it} indicating treatment status (T_{it} equals 1 if treated and equals 0 otherwise). The control variable Q_{i0} is the number of wild meat dishes sold in the week preceding the supply-side experiment, and Price_{i0} is the average price over all dishes on the

restaurant's sample menu, as used in Section 2.2.2. These control variables were prespecified to improve the precision of our treatment effect estimates (Cisse et al., 2023; McKenzie, 2012).

Second, we estimate the treatment's effect on sales volumes by ordinary least squares regression:

$$\log(Q_{it}) = \gamma_2 T_{it} + \delta_3 Q_{i0} + \delta_4 \text{Price}_{i0} + \epsilon_{it}, \quad (4)$$

where $\log(Q_{it})$ is the log number of Moambe Chicken dishes sold in restaurant i on day t or the log number of wild meat dishes sold. We cluster standard errors of all coefficients at the restaurant-day level to match the level of treatment assignment (Abadie et al., 2023).

Since the dependent variables in both equations are in the logarithmic form, the treatment coefficients γ_1 and γ_2 can be interpreted in percentage terms by applying the transformation $e^{\text{coefficient}} - 1$. Given the logarithmic dependent variables, restaurant-day observations with zero sales of a particular dish were necessarily omitted from that dish's regression.

The ratio of γ_2 to γ_1 represents the "elasticity" of Moambe Chicken or wild meat sales with respect to Moambe Chicken price. We estimate these elasticities using the feols() function in R, which provides accurate standard error estimates (Bergé, 2018). In the elasticity regressions, both the dependent and independent variables are in logarithmic form. Consequently, the coefficient on log Moambe Chicken price can be interpreted as the percentage change in the dependent variable (Moambe Chicken sales or wild meat sales) for a 1% change in the independent variable (price). Elasticities measure the sensitivity of Moambe Chicken sales or wild meat sales to the price of Moambe Chicken (Perloff, 2023). The interpretation of elasticities differs from that of γ_1 or γ_2 because the independent variable T_{it} is linear, rather than logarithmic.

2.5 | Ethics statement

Our study was reviewed and approved by the DRC's National Institute of Statistics (#0340/INS/DG/fau/2023) and the University of California, Berkeley's Institutional Review Board (Protocol ID: 2023-05-16343). The National Institute of Statistics validated the methodology and tools used to carry out our study and granted us the necessary statistical approval for our survey. Prior to initiating any part of the research, informed consent was obtained from all subjects as well as from the participating restaurants. While the restaurant owners provided written consent, subjects offered verbal consent recorded electronically in SurveyCTO in order to promote a digital record-keeping process. We anonymized all subject data.

We implemented distinct randomization procedures for our demand-side and supply-side experiments. In the demand-side experiment, we utilized SurveyCTO's programming features to assign subjects to treatment or control groups based on a randomly generated number. This process occurred automatically upon survey initiation, with the assignment concealed from enumerators, subjects and restaurants. For the supply-side experiment, we used R version 4.1.2 to randomly select one or two restaurants for treatment on specific days from a vector containing all four participating restaurants (R Core Team, 2024). Each evening, our field team informed restaurants of their next day's treatment status.

3 | RESULTS

3.1 | Demographic characteristics of subjects in the demand-side experiment

We begin by comparing the characteristics of treatment and control subjects in the demand-side experiment. Each row of Table 1 considers one of the eight individual subject characteristics that are included in the matrix X_i in Equation (1). The first three columns, respectively, display the mean value of a characteristic among subjects in the control group, the mean difference between the treatment and control groups and the standard error of this difference. All observed

TABLE 1 Individual subject characteristics in the demand-side experiment by treatment status.

Dependent variable	Control mean	Treatment difference	Standard error	*p*-Value	*N*
Restaurant habit	0.441	−0.034	(0.042)	0.429	544
Wild meat days	2.465	−0.008	(0.223)	0.973	544
Age	33.210	−1.000	(0.931)	0.283	544
Male	0.752	0.020	(0.037)	0.593	544
University graduate	0.325	−0.050	(0.039)	0.204	544
Years of education	11.598	0.135	(0.271)	0.620	544
Salary earner	0.441	−0.018	(0.043)	0.671	544
Business owner	0.241	−0.001	(0.037)	0.979	544

Note: Control mean is the mean value of each variable for the control group. Treatment difference is the mean value in the treatment group minus the control mean. Standard error is the standard error of the treatment difference. The standard error, clustered at the subject level, is derived from an ordinary least squares regression of each variable on an intercept and a treatment indicator. The *p*-value gives the Type 1 error rate for the treatment difference. Definitions of all variables are provided in Section 2.2.

differences are small and not statistically significant, indicating that our randomization procedure successfully created comparable groups. This balance is crucial as it ensures that observed differences in outcomes, such as whether a subject orders wild meat, can be attributed to the treatment rather than to pre-existing disparities between groups. In our sample of 544 subjects, 42% typically consume wild meat at formal or informal restaurants, the average number of days wild meat was consumed in the past 30 days is 2.5, the average age is 33, 76% are male, 30% are university graduates, the average number of years of education is 11.7, 43% earned a salary in the past week and 24% earned income as a business owner in the same period. These mean values differ slightly from the control means (Column 1 of Table 1) because they are average values among all subjects (across both the treatment and control groups).

3.2 | Results of demand-side experiment

3.2.1 | Effects on wild meat consumption and coupon usage

We now assess the results of the demand-side experiment. The first question we address is the impact of the treatment, the video aimed at discouraging wild meat consumption, on participants' dining choices. Specifically, we examine whether exposure to the video affected the likelihood of subjects ordering wild meat. The results from estimating Equation (1), with the dependent variable being whether or not the subject ordered wild meat (1 for yes, 0 for no), are presented in Column 2 of Table 2.

The main result of our demand-side experiment is a 31% decrease in the probability of subjects in the treatment group ordering wild meat compared to those in the control group (3.1% vs. 4.5%). We calculate this 31% reduction by dividing the Column 2 treatment coefficient (−0.014) by the mean of the dependent variable in the control group (0.045, as shown by the Intercept coefficient in Column 1). This result is not statistically significant according to the conventional *p*-value threshold of 0.05 (Figure S1a).

In addition to examining wild meat ordering behaviour, we also investigate whether the treatment influenced the overall likelihood of subjects using their coupon to order a dish (Column 4 of Table 2). Differential coupon usage between the treatment and control groups could imply a fundamental difference in the composition of the two groups, potentially challenging the validity of our comparison. However, this concern is alleviated by the finding that the difference in coupon usage is minimal, at only 0.6%, and not statistically significant. The similarity in coupon usage, with approximately 59% of subjects in both groups redeeming their coupons for a meal, supports our assumption that the only factor differentiating wild meat consumption between the treatment and control groups is the specific video each group watched.

Finally, including individual controls and fixed effects does not substantially change the estimated treatment effects (comparing results in Column 1 to Column 2 and in Column 3 to Column 4). The results are similar whether we use a simple regression model with only an intercept and a treatment indicator (Columns 1 and

TABLE 2 Effect of treatment on probability of ordering wild meat (Columns 1 and 2) and on probability of using coupon (Columns 3 and 4).

	Dependent variable			
	Ordered wild meat		Used coupon	
	(1)	(2)	(3)	(4)
Treatment	−0.011 (0.017)	−0.014 (0.017)	0.009 (0.042)	−0.006 (0.036)
Restaurant habit		0.023 (0.017)		0.059 (0.037)
Wild meat days		−0.003 (0.002)		−0.002 (0.006)
Age		0.000 (0.001)		0.004 (0.002)
Male		−0.015 (0.020)		0.020 (0.042)
University graduate		−0.036 (0.027)		−0.061 (0.058)
Years of education		0.003 (0.006)		0.008 (0.009)
Salary earner		−0.008 (0.018)		0.061 (0.037)
Business owner		−0.005 (0.029)		0.056 (0.051)
Intercept	0.045 (0.012)		0.584 (0.029)	
Date and table fixed effects	No	Yes	No	Yes
N	544	544	544	544
Percent change	−23.26	−31.29	1.56	−1.07

Note: The intercept equals 1 for all observations (Columns 1 and 3). Due to the inclusion of the treatment variable, which equals 1 only for subjects in the treatment group, the coefficient on the intercept is mathematically equivalent to the mean of the dependent variable in the control group. Standard errors are clustered at the subject level.

3) or a more complex model that controls for individual characteristics and fixed effects (Columns 2 and 4). This consistency across different model specifications provides further reassurance about the success of our randomization procedure. In our pre-analysis plan, we selected individual characteristics and fixed effects that we thought would increase the precision of our estimates. However, this approach did not yield the anticipated improvement; for example, the standard error of the treatment effect on wild meat consumption is 0.017 in both wild meat consumption specifications (Columns 1 and 2).

While individual characteristics also generally do not emerge as significant predictors of wild meat consumption or coupon usage, some variables predict these behaviours in ways that align with our initial expectations. For instance, subjects who typically eat wild meat at formal or informal restaurants are more likely to order wild meat (Column 2) and to use their coupon (Column 4). Likewise, subjects who earn a salary or business income are more likely to use their coupon, as they are likely to have a greater financial capacity to pay the difference between the price of their meal and the coupon value (Column 4).

3.2.2 | Treatment effect on selection of wild meat-intensive restaurants

We find little evidence that treatment reduced subjects' selection of wild meat-intensive restaurants. The treatment coefficient is small in magnitude and not statistically different from zero in our prespecified estimating equation (Column 2 of Table S1). The most likely explanation for this null result is that 74% of subjects chose the restaurant geographically nearest to them, limiting the scope for variation in restaurant selection along the dimension of wild meat intensity.

3.2.3 | Exploring mechanisms: Impact of treatment on attitudes towards wild meat

Most subjects strongly agree or somewhat agree that wild meat is tasty, sustainable, healthy, fresh, cool, legal and connects them to their place of origin (Figure 2a–g). About three-quarters of subjects also report being very proud or somewhat proud of the DRC's

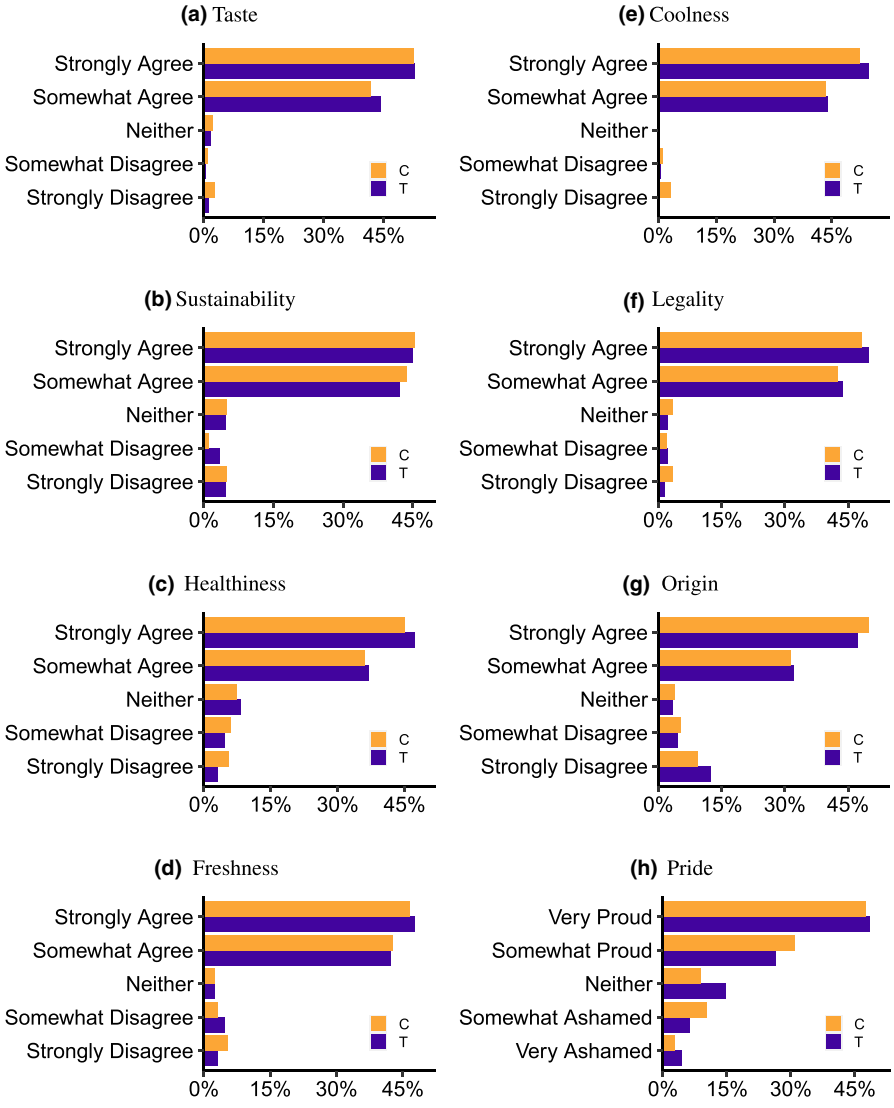

FIGURE 2 Extent to which subjects believe bushmeat is (a) tasty, (b) sustainable, (c) healthy, (d) fresh, (e) cool, (f) legal and (g) connects them to their place of origin. (h) Subjects' pride in the DRC's environment. Bars represent the percentage of control group (orange) and treatment group (purple) subjects who chose a response option. See Supporting Information, Appendix C for question wording.

environment (Figure 2h). Visually, the treatment video appears to slightly reduce perceived sustainability of wild meat, the extent to which wild meat connects subjects to their place of origin, and pride in the DRC's environment.

However, we do not find evidence supporting a shift in attitudes in our prespecified statistical analysis. The intervention did not significantly alter subjects' overall perceptions of wild meat (first row of Table S2). We also explore treatment effects on each of the eight separate attitudinal questions (second through ninth rows of Table S2). The intervention did not significantly shift perceptions on any specific dimension related to wild meat.

3.2.4 | Assessing social desirability bias

Subjects in the treatment group less likely to order wild meat also exhibit higher social desirability (third row of Table S3). However, this relationship is not statistically significant (*p*-value is 0.193).

3.3 | Results of supply-side experiment

Our supply-side experiment focused on the impact of food prices on consumer choices. Specifically, we examined how reducing the price of Moambe Chicken, a common alternative to wild meat, affected wild meat and non-wild meat sales.

We begin our analysis of the results by validating the supply-side experiment. While the price of Moambe Chicken may or may not directly affect wild meat demand, it should certainly affect Moambe Chicken demand. Indeed, the experiment significantly reduced Moambe Chicken's price by approximately 30% (Column 1 of Table 3) and correspondingly increased Moambe Chicken sales by about 35% (Column 2). Dividing the treatment effect on Moambe Chicken sales (Column 2) by the treatment effect on its price (Column 1) reveals the "elasticity" of Moambe Chicken sales with respect to its price (Section 2.4). The estimated elasticity of −0.837 indicates that a 1% decrease in price leads to approximately a 0.837% increase in Moambe Chicken sales (Column 3).

The central finding of our supply-side experiment is the result that reducing the price of Moambe Chicken reduces wild meat consumption. Column 4 shows the effect of the Moambe Chicken price reduction treatment on wild meat sales. The coefficient indicates that the treatment reduced restaurants' total wild meat sales by approximately 26%. In other words, our experiment likely caused some patrons who would have ordered wild meat to order Moambe Chicken instead, though the effect is not statistically significant.

We also obtain the elasticity of wild meat sales with respect to Moambe Chicken price (Column 5). This positive elasticity value, approximately 0.91, implies that a 1% decrease in Moambe Chicken price causes a 0.91% reduction in wild meat consumption. However, our estimate does not reach the conventional level of statistical significance (Figure S1b).

TABLE 3 Elasticities of Moambe Chicken and wild meat consumption with respect to Moambe Chicken price.

	Moambe chicken			Wild meat	
	Dependent variable			Dependent variable	
	Log price	Log dishes	Log dishes	Log dishes	Log dishes
	(1)	(2)	(3)	(4)	(5)
Price reduction treatment	−0.362 (0.041)	0.303 (0.119)		−0.302 (0.201)	
Log chicken price			−0.837 (0.341)		0.910 (0.573)
Baseline wild meat	0.011 (0.000)	0.028 (0.004)	0.037 (0.006)	0.019 (0.005)	0.008 (0.009)
Baseline average price	−0.002 (0.002)	−0.158 (0.017)	−0.159 (0.017)	−0.107 (0.021)	−0.104 (0.021)
Intercept	9.460 (0.028)	4.415 (0.207)	12.340 (3.297)	3.379 (0.268)	−5.264 (5.436)
N	67	65	65	54	53

Note: The unit of observation is a restaurant day. Effect of price reduction treatment on log(Moambe Chicken price) (Column 1), on log(Moambe Chicken dishes sold) (Column 2) and on log(wild meat dishes sold) (Column 4). Elasticity of Moambe Chicken dishes sold (Column 3) and wild meat dishes sold (Column 5) with respect to Moambe Chicken price. Due to the logarithmic nature of the dependent variables, observations with zero sales of a particular dish were omitted, resulting in slight variations in the numbers of observations across columns. Baseline wild meat is the number of plates of wild meat sold by the restaurant the week before the supply-side experiment began. Baseline average price is the mean price, in thousand Congolese Francs, of all dishes on the sample menu shown to participants in the demand-side experiment. Standard errors are clustered at the restaurant-day level.

4 | DISCUSSION

By conducting two randomized controlled trials in Kinshasa, DRC, our study provides the first experimental evidence regarding the effectiveness of interventions designed to reduce the consumption of wild meat in urban restaurants. One experiment targeted demand for wild meat by presenting a subset of participants with a specifically designed treatment video, while the other experiment targeted the supply side by reducing the price of an alternative domesticated animal protein dish (Moambe Chicken). Our findings represent encouraging results for the effectiveness of both demand- and supply-side interventions, such as social marketing and reducing the price of alternative meats, respectively.

4.1 | Wild meat consumption in Kinshasa

We found that study participants reported consuming wild meat on average 2.5 days in the past month, and across the treatment and control groups, 4% of subjects ordered wild meat in the experiment. Although per capita consumption of wild meat is relatively infrequent, the large and growing human population means urban demand for wild meat may be reducing wildlife populations in the DRC (Batumike et al., 2021; van Vliet et al., 2017). The relatively infrequent per capita consumption is likely driven by a number of factors including: (a) availability of wild and domesticated sources of animal protein; (b) fewer offerings of wild meat on menus in comparison to other meats and fish—in the four participating restaurants, wild meat-based dishes were 7%, 9%, 21% and 23% of all dishes; (c) the price of wild meat in comparison to other options—in two of our participating restaurants, wild meat dishes were 38% and 39% more expensive on average than other options. Together, these factors highlight the complex drivers of wild meat consumption in urban areas, which could be investigated simultaneously in future studies and intervention evaluations.

Separate from our experiments, the citywide Yoka Pimbo campaign between March 2021 and March 2024 aimed to reduce bushmeat demand in Kinshasa (Ministère de l'Environnement et Développement Durable, 2024). This campaign does not bias our treatment effects because we randomized treatment assignment in our experiments, which ensures that both treatment and control groups had similar average exposure to the Yoka Pimbo campaign.

4.2 | Demand-side experiment

While not statistically significant, our analysis shows that, compared to the control group, members of the treatment group had a 31% lower probability of ordering wild meat. This is a promising result for the potential of demand reduction interventions that involve video message dissemination. However, further evaluation is needed to have certainty in their effectiveness. Other wild meat demand reduction interventions had mixed success. A social marketing intervention involving an information campaign and community engagement in Brazil was found to reduce wild meat consumption by 62% (Chaves et al., 2018), while a radio entertainment-education intervention in Tanzania found no significant demand reduction (Veríssimo et al., 2018).

Despite the challenges with conducting an experiment on wild meat consumption in the DRC, we successfully recruited 544 wild meat consumers as participants. A larger sample size, which we recommend for future evaluations, would have yielded more statistical power to better interpret our results. For example, we found no statistically significant interaction between treatment and social desirability, although the direction and magnitude of the estimate suggest that participants in the treatment group who were less likely to order wild meat exhibited higher scores on our social desirability metric. These findings suggest that future evaluations of demand reduction programmes should measure and account for such potential biases.

Wild meat was positively viewed among study participants in terms of its taste, sustainability, healthiness, freshness, "coolness", legality, and to a slightly lesser extent, the ability to connect them to their place of origin. Most participants also expressed pride in the DRC's natural environment. While our survey measured attitudes rather than values, our results suggest that wild meat consumers may hold diverse values regarding wild meat, including instrumental (e.g. source of food) and relational values (e.g. cultural identity, sense of place) (Chan et al., 2018; Pascual et al., 2017). Values-centred approaches to achieving sustainability may be more ethical and effective (Pascual et al., 2023). The message used in the treatment video, highlighting the decline of wildlife in the forests of Congo and the desirability of cooking traditional recipes without wild meat, is likely to be appropriate in Kinshasa. The video speaks to relational values of wild meat consumption (culture, identity), and the strong levels of pride we observed in the participants towards the DRC's natural environment. These elements relate most closely to our questions regarding bushmeat's sustainability, the extent to which it connects subjects to their places of origin, and their pride in the DRC's environment. While the treatment video slightly shifts responses to these questions compared to responses in the control group, these changes are not statistically significant in our prespecified analyses. Repeated exposure to messages connecting existing norms (e.g. pride in wildlife) with reduced wild meat consumption could be effective in changing behaviour (MacFarlane et al., 2022; Wakefield et al., 2010).

4.3 | Supply-side experiment

Our supply-side intervention tested the theory that prices of alternative meats influence the consumption of wild meat. The results of our experiment showed that reducing the price of Moambe Chicken dishes by $2 (5000 Congolese francs) reduced the sales of wild meat by 26%. This suggests that Moambe Chicken is a substitute for wild meat in line with theoretical expectations. However, our estimates do not reach the conventional level of statistical significance, likely

due to our small sample size. Few such interventions have been experimentally tested for effectiveness (Ingram et al., 2021; Willis et al., 2022), highlighting the significant contribution of our study to the literature. One exception is an experiment that found that providing coupons for chicken in Brazil increased chicken consumption but did not decrease wild meat consumption (Chaves et al., 2018).

Our results therefore cautiously support the role of supply-side interventions in efforts to reduce wild meat consumption, particularly through interventions that increase the affordability of wild meat alternatives. Government agencies (such as environment and agriculture ministries), international aid organizations and conservation NGOs could implement and evaluate supply-side interventions. However, reducing urban demand for wild meat through supply-side interventions may have implications for the incomes of rural hunters and traders reliant on wild meat for their livelihoods, which should be considered during intervention implementation. An additional trade-off might also exist between the increased production of domestic livestock and subsequent land needs and intact habitats.

Whether wild meat is elastic to its own price or to the price of other potential substitutes is complex and depends on the site context (Rentsch & Damon, 2013; Walelign et al., 2019; Wilkie et al., 2005). For example, Walelign et al. (2019) found that wild meat demand in rural Tanzania was more elastic to its own price when the substitute option was beef but less so when the substitute option was fish or goat—although the latter depended on whether socio-economic covariates were controlled for in the analyses. Socio-economic household determinants (e.g. household income) and cultural factors (e.g. ethnic group) have been shown to be important factors in mediating wild meat demand and price responsiveness (Walelign et al., 2019). Importantly, none of the previous studies experimentally changed the price of alternatives in a restaurant setting to investigate the effect on wild meat consumption or sales. The setting is likely important because it influences the types of people attending so may include a different subset of society based on food consumption norms. For example, wild meat may hypothetically be consumed more frequently at home yet consumed outside the home on certain occasions or with certain groups of people. In our study in Kinshasa, the participating restaurants were all formal restaurants where patrons sit at tables inside permanent buildings and are served by waiters; results could differ in informal restaurants.

Foods and eating are often connected with identity, rituals, symbols and belief systems (Mintz & Du Bois, 2002), with wild meat in particular holding diverse roles and values in various cultures (Rodríguez-Ríos & García-Páez, 2018; Rose, 2001; van Vliet & Mbazza, 2011). While Moambe Chicken, a national dish of the DRC, shares some attributes with wild meat, it may not fill the identical social, cultural or relational function. Therefore, attempting to change potentially culturally important food consumption habits poses ethical questions. Further research is needed to better understand the prevalence and importance of social and cultural functions that wild meat may have, to inform the design of ethical strategies and interventions and to ensure sustainable levels of wild meat consumption.

4.4 | Limitations

As is the case for all studies, ours has some limitations. First, the statistical insignificance of our results means we cannot definitively ascertain whether our interventions reduced wild meat consumption. Second, our demand-side intervention considered the effect of a single exposure to the treatment video on a consumption decision temporally close to the exposure (within 2 weeks). Our results that a single exposure could result in behaviour change are promising, but it is not clear how long this change would last. Studies suggest that multiple message exposures might increase intervention effectiveness (Montoya et al., 2017), so we suggest future evaluations assess the influence of message frequency and effectiveness over time. In SMS-based behaviour change interventions, the frequency of message exposure matched the behaviour frequency (Fjeldsoe et al., 2009). For TV-based interventions, we suggest demand reduction messages be timed to coincide with typical wild meat consumption patterns. Third, the video was developed for a campaign in Pointe Noire, Republic of the Congo, yet we experimentally tested the video in restaurants in Kinshasa, DRC. While there may be sociocultural differences in how wild meat is consumed in these cities, the content of the video focused on the generic topics of wild meat consumption leading to empty forests in the Congo and cooking traditional Congolese dishes without wild meat. The video was also mostly in French, the official language of both countries. Therefore, we suspect the video to be relevant in Kinshasa.

5 | CONCLUSIONS

Our results suggest that both demand-side and supply-side interventions can reduce the consumption of wild meat dishes in formal restaurants in Kinshasa. While not statistically significant, the magnitude and direction of our estimates suggest that these interventions can succeed in reducing consumption. Approaches that include both intervention types may be most successful where wild meat consumption is unsustainable. We recommend further intervention testing with long-term monitoring and evaluation to definitively ascertain effectiveness. We encourage those involved in such interventions to (a) publish their results openly, whether successful or otherwise, so others can learn, (b) fully engage with any ethical concerns around intervention design and implementation and (c) randomly assign the intervention to some subjects (or units of study) but not to others. Random assignment allows estimation of the causal effects of the intervention, which are most useful for understanding intervention effectiveness and making recommendations for policy and action.

AUTHOR CONTRIBUTIONS

Abdoulaye Cisse, Gabriel Englander and Daniel J. Ingram conceived the ideas and designed the methodology; Gabriel Englander collected the data; Abdoulaye Cisse and Gabriel Englander analysed the data; Gabriel Englander led the writing of the manuscript, with

Daniel J. Ingram drafting the discussion. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

AC, GE and DJI declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

All anonymized data and replication codes are publicly available (Cisse et al., 2024).

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work (Introduction through Results), GE used ChatGPT (4, 4o, and o1 models) and Claude 3.5 Sonnet in order to draft and revise text. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication. AI and AI-Assisted Technologies were not used in the draft Discussion by DJI.

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SUPPORTING INFORMATION

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

Data S1. Supporting Information contains supplementary tables and figures, an English transcript of the treatment video, and a description of the survey instruments.

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