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Patterns of paternal investment predict cross-cultural variation in jealous response

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Long-lasting, romantic partnerships are a universal feature of human societies; but almost as ubiquitous is the risk of instability when one partner strays. Jealous response to the threat of infidelity is well-studied, but most empirical work on the topic has focused on a proposed sex difference in the type of jealousy (sexual or emotional) men and women find most upsetting, rather than on how jealous response varies^{1,2}. This stems in part from the predominance of studies using student samples from industrialized populations, which represent a relatively homogenous group in terms of age, life history stage, and social norms^{3,4}. To better understand variation in jealous response, we conducted a two-part study in 11 populations (1,048 individuals). In line with previous work, we find a robust sex difference in the classic forced-choice jealousy task. However, we also show substantial variation in jealous response across populations. Using parental investment theory, we derived several predictions about what might trigger such variation. We find that greater paternal investment and lower frequency of extramarital sex are associated with more severe jealous response. Partner jealousy thus appears to be a facultative response, reflective of the variable risks and costs of men's investment across societies.

Main

One of the essential features of human mating is the prominence of stable, long-lasting partnerships, which in almost every society are socially enforced through the institution of marriage^{5,6}. A widespread feature of marriage is the custom of sexual exclusivity. Despite the near ubiquity of this expectation, marriages are at risk of disruption by extramarital partnerships. Adultery is the most commonly cited reason for divorce across cultures⁷, and concurrent partnerships are often common^{8,9}. In response to threats of infidelity, humans, like other species with stable partnerships, have evolved adaptations to protect against mate poaching and defection. Some of these behaviors, like partner concealment, vigilance and sexual coercion, are shared with other species¹⁰⁻¹², while others like foot binding and purdah are culturally constructed and unique to humans^{13,14}. Underlying these behaviors is a suite of psychological mechanisms, of which jealousy is one of the most important.

While jealousy itself is thought to be a universal human emotion, traditional evolutionary explanations predict that jealous response to cues of infidelity will differ in men and women, reflecting the unique adaptive problems they face^{1,13,14}. Men face a risk of paternity uncertainty, which results in the loss of a fitness opportunity, but also in the potential misallocation of investment. Women, on the other hand, risk the diversion of critical resources by their partner

toward other women and their children. These sex differences in the potential costs of infidelity have led researchers to hypothesize that, when given a choice, men should report being more upset than women by a partner's sexual infidelity, and that emotional infidelity will be more upsetting to women than men¹. This sex difference has been replicated in multiple studies of US student populations, several cross-cultural studies conducted with university students, and a limited number of non-student populations from industrialized nations^{3,4}.

Even with these robust findings, few replication attempts have been conducted outside of W.E.I.R.D. (western, educated, industrial, rich and democratic) societies¹⁵, with only one example from a small-scale society¹⁶. Conducted with Himba pastoralists in Namibia, this study found the predicted sex difference, but also found that Himba responses did not conform to W.E.I.R.D. standards. The majority of both men and women found sexual infidelity to be more upsetting in a forced choice scenario, but both sexes also emphasized that infidelity was normatively permitted and that they would not be very upset by either type of infidelity. These findings suggest that jealousy is a facultative response, potentially responsive to local norms and socioecological conditions.

While the suggestion that partner jealousy is facultatively expressed has long been part of evolutionary discussions^{1,17,18}, there is little empirical work attempting to explain cross-cultural variation. Where they exist, they almost always focus on individual-level differences, like age, relationship experience and sexual orientation⁴. This is surprising given that the same evolutionary logic that was used to derive the prediction of a sex difference can be employed to generate predictions about variation. One clear example of this is that the level of paternal investment in a given society is expected to influence both men's and women's feelings about infidelity. For men, the more they are expected to invest in their wives' children, the more concerned they should be with her having other partners. For women, a greater dependency on male resources increases the relative cost of diverted investment. Therefore, we expect greater levels of paternal investment will be associated with more severe ratings of infidelity for both men and women.

Levels of paternal investment are intimately linked to other aspects of social structure and behavior. Men tend to invest less in systems where the mating-parenting trade-off favors desertion, such as when the adult sex ratio (ASR) is female-biased¹⁹. More generally, permissive sexual behavior is more common when men's investment is less obligatory (e.g. in matrilineal systems) or when it is less critical for offspring survival²⁰. Therefore, we expect that a female-biased ASR and social norms that are more permissive of extramarital sex will be associated with less severe jealous response.

We designed a two-part survey, which was run in 11 populations (Figure 1). Of these, eight are small-scale societies, spanning five continents and multiple modes of production. The other three are urban settings: Los Angeles, urban India (an online sample) and Okinawa, Japan. In part one, all respondents rated both same-sex and opposite-sex scenarios for sexual and emotional infidelity (a total of four ratings per respondent). A five-point Likert scale ranging from “Very Bad” to “Very Good” was used to rate each statement. In part two, we present a replication of the forced-choice vignette originally designed by Buss and colleagues to assess differences in the type of jealousy (emotional and sexual) that is most distressing to men and women²¹. We test the prediction that, when asked to think about both a hypothetical sexual and emotional infidelity, men, more than women, will find the sexual infidelity more distressing.

To determine whether paternal investment and other related variables are important predictors of jealous response, each of the anthropologists in our study completed a survey about the population with whom they work. The anthropologists all conduct long-term projects, having worked at their sites for an average of 11.5 years (range 6-17 years), excluding the researchers native to their sites in Japan and the US. The survey included questions about the ASR, extramarital sex norms, and measures of paternal investment. Questions about paternal investment were divided into two categories: (1) direct care, which measured the amount of time men spend in contact with their children; and (2) provisioning, which measured male contribution to subsistence and resource transfers including marriage payments and inheritance.

The four severity ratings from part 1 provide a descriptive picture of how social norms about jealousy and infidelity differ cross-culturally (1037 of 1048 participants completed 4148 ratings). Overall, we find that sexual infidelity, regardless of the sex of the unfaithful agent, is viewed more harshly than emotional infidelity (Figure 2, Supplementary Figure 11). Another robust trend is that female infidelity is judged more harshly than male infidelity, regardless of type.

A multilevel ordered logit model allows us to evaluate the effects of both the sex of the respondent and the population to which they belong on their responses to the severity scales. Various iterations of the model highlight the explanatory power of culture (as a varying intercept) and sex (with fixed and varying effects by culture) in contributing to model fit (Table 1). The final model, including varying intercepts for culture, and varying slopes by sex, age, and marital status by culture (Model 5), shows substantially lower out-of-sample deviance than any other model and 100% of the model weight. However, the model that includes only culture (Model 3) results in substantially lower WAIC scores than do the models including sex as a fixed (Model 2) or varying effect (Model 4), indicating that perceptions of infidelity are influenced more by what population a

respondent belongs to than by the sex of respondent. Variance estimates of severity responses indicate higher variance in ratings of sexual severity (male = 0.92; female = 1.01) relative to emotional severity (male = 0.35; female = 0.24) in the best fit model (Supplementary Figure 8).

Population level differences could result from many factors, including sampling variation; random and systematic measurement variation, and ecological or social processes not measured in our study. Here we focus on three population-level variables: paternal investment, ASR and extramarital sex norms, which evolutionary theory predicts could contribute to the variation we see here. We found that levels of paternal investment were strongly associated with jealous response to sexual infidelity, but had a smaller and more uncertain effect on respondent's views of emotional infidelity (Figure 3, Supplementary Figures 3 - 5). Both male and female sexual infidelity were viewed more harshly as direct care paternal investment scores increased ($\beta=-0.62$, 89% PI = -1.15, -0.11, $\beta(\text{pr}<0)=97.2\%$; $\beta=-0.46$, 89% PI = -1.11, 0.20, $\beta(\text{pr}<0)=87.4\%$ respectively), although the distribution of the predictor on female sexual infidelity overlaps with zero. Increased levels of paternal provisioning were associated with harsher views of male sexual infidelity ($\beta=-0.69$, 89% PI = -1.24, -0.16, $\beta(\text{pr}<0)=97.9\%$), but not female infidelity ($\beta=-0.30$, 89% PI = -0.94, 0.34, $\beta(\text{pr}<0)=78.7\%$) where again the distribution of the predictor overlaps substantially with zero. Male, but not female, emotional infidelity was also viewed more harshly when direct paternal investment and provisioning was high ($\beta=-0.25$, 89% PI = -0.56, 0.05, $\beta(\text{pr}<0)=91.5\%$; $\beta=-0.40$, 89% PI = -0.74, -0.05, $\beta(\text{pr}<0)=96.3\%$ respectively).

Next, we modeled the effects of social norms we expected would be linked to both the level of paternal investment and infidelity, in order to understand the broader social milieu affecting jealous response. Populations where extramarital sex was more common tended to rate male and female sexual infidelity less severely, as predicted ($\beta=0.78$, 89% PI = 0.23, 1.35, $\beta(\text{pr}>0)=98.3\%$; $\beta=0.49$, 89% PI = -0.13, 1.10, $\beta(\text{pr}>0)=90.1\%$ respectively, Supplementary Figure 7). The effect of extramarital sex on perceptions of emotional infidelity had similar results (Men: $\beta=0.47$, 89% PI = 0.16, 0.79, $\beta(\text{pr}>0)=99.1\%$; Women: $\beta=0.18$, 89% PI = -0.12, 0.48, $\beta(\text{pr}>0)=83.6\%$). In line with our predictions, and existing literature, we found that ASR was negatively correlated with the level of extramarital sex across populations (Pearson's: $r=-0.59$). Populations with more female-biased sex ratios had greater frequencies of extramarital sex. However, we did not find any meaningful effect of ASR on the severity ratings, though they trended in the expected direction (Supplementary Figure 6).

When the three predictor variables were analyzed together, we found the effects of paternal investment were most robust (Supplementary Figure 3), varying little across the models. The effect of extramarital sex appears to be mediated by the level of paternal investment. Similarly, ASR is a

meaningful predictor only when all predictors are included. Model comparisons assessing model fit on combinations of these predictors further highlight the importance of paternal investment and frequency of extramarital sex in predicting severity (Supplementary Table 6).

In part two of our study, the forced choice vignette, we found strong and consistent support for the prediction that men are more upset by sexual infidelity than are women (Figure 2). Nine of the eleven populations showed a sex difference in the expected direction. In Yasawa, the effect was reversed, with slightly more women than men stating that sexual infidelity was more upsetting. All of the Tsimane respondents stated that the sexual infidelity was more upsetting than emotional infidelity. In addition, we find that when differences in sample composition are accounted for via multilevel logistic regression, variation in the magnitude of the sex difference (which appears quite variable in the raw data, Figure 2) is negligible (Supplementary Figure 12).

When sex and culture are considered together in the forced choice scenario, we see a more nuanced picture of jealous response. Posterior predictions from the best-fit model (in this case one that includes both sex and culture, Table 1) illustrate the effects of both sex and sex-by-culture interactions on the probability of being more upset by sexual versus emotional infidelity. While in the majority of populations both men and women were more likely to report sexual infidelity as more upsetting, in others both men and women were more upset by emotional infidelity (e.g. LA and Mosuo) (Figure 2).

These results make three important contributions to discussions of jealousy: (1) The sex difference in jealous response is robust and consistent across populations. (2) Sexual infidelity was of much greater concern and had more explanatory power than emotional infidelity in our study. (3) Sociocultural factors like the level of paternal investment and norms for extramarital sex are important contributors to cross-cultural variation in jealous response.

In both the forced choice and the severity questions, we see important sex differences. Respondents generally view infidelity committed by women more harshly than the same acts committed by men. In the forced choice we find robust support for the notion of a universal sex difference, with men being more upset than women by sexual infidelity. Furthermore, the magnitude of the sex difference is relatively invariable (Supplementary Figure 12). The inclusion in our sample of a broad range of populations, including many small-scale societies, leads us to conclude that this finding is not the result of a western bias about mating preferences, but rather reflects important sex-specific influences on partnership dynamics, most notably the male risk of paternity uncertainty.

We also found variation in the relative importance of sexual and emotional infidelity across cultures. Whereas western conceptions of jealousy focus on the importance of “romantic love,” respondents of both sexes in our sample place more emphasis on sexual infidelity. In the forced choice, seven out of 11 groups had both men and women reporting sexual infidelity as more upsetting, and sexual infidelity was uniformly viewed more harshly than emotional infidelity in the severity ratings (Figure 2). This trend has been seen in other work, which shows that outside of the forced choice paradigm, both sexes find sexual infidelity more distressing²². It is important to note that these findings should not be seen as dismissive of the cultural importance of romantic love in our sample. Even in the populations in our sample where concurrent partnerships are common, there are strong notions of limerence, “love match” marriages, and great value placed on long-lasting emotional bonds^{23–25}.

In particular, the finding that women repeatedly choose sexual infidelity to be more upsetting contrasts with standard interpretations of jealous response in the evolutionary literature. Only four of the eleven populations had a majority of women choosing emotional infidelity as more upsetting in the forced choice, and two of these were Los Angeles and Okinawa. This indicates that the link between emotional infidelity and the diversion of resources, which has been presented as a “cardinal cue” of resource loss,² could be an artifact of previous biases in studies concentrated on industrialized populations. Opportunistic free response data from two of our populations (Tsimane and Himba) provide examples of places where sexual rather than emotional infidelity is more tightly linked to resource diversion. Several Tsimane women reported that if a man has sex with another woman, his children with his wife would get sick because the man would no longer be caring for those children. They further noted that this would not happen if the husband only had an emotional connection to another woman. Himba women also noted that it was sex, more than love, that was likely to lead to diversion of resources and even divorce. Therefore, while sexual infidelity is likely to be a fairly ubiquitous cue of lost paternity, future researchers should pay more attention to the appropriate local cues of resource diversion when making predictions about jealous response.

Finally, we have identified the level of paternal investment as one critical component of the local socioecology that explains a significant proportion of the variance in jealous response that we see across cultures. We find that the more men invest in their children, the more severely people in that culture view infidelity. While men everywhere face the risk of losing biological paternity, the relative costs (to men and women) of extra-pair partnerships are greater when investment is higher. Our findings that higher frequencies of extramarital sex had a dampening effect on jealous response and that populations with female-biased sex ratios had higher levels of extramarital sex are similarly

related. Where men's investment is riskier, or the benefits of desertion are greater, paternal investment should be lower, and the need to enact strong jealous response reduced. Overall, we find that people's responses to the threat of infidelity appear to reflect locally relevant risks and benefits.

There are several important limitations to doing cross-cultural research, to which our study is not immune. First, there is always a trade-off between internal and external validity in the design of study materials for projects that span multiple sites. While standardization allows for easier and clearer analysis, it is difficult to design a survey that has questions that are equally understandable and relevant in all cultures. In this case, we opted for a short, standardized survey with questions that were as unambiguous as possible. Similarly, we had to use questions about paternal investment that were relevant across cultures. Future studies that focus on a smaller number of populations, or look at intra-community variation could utilize more fine-grained variables.

Likert scales and forced choice questions were more familiar to some of our participants than to others. Ethnographers reported any obstacles they faced in administering the survey (Supplementary Materials), and we perceived no systematic biases that would lead to the results shown here. However, we cannot entirely discount the possibility that some of the cultural variation we see is due to varying interpretations of the survey. Another potential problem with using Likert scales is the possibility that raters will be biased toward extreme responding. This would be problematic if some populations were more prone to this than others. Using Likert responses on other types of moral transgressions collected for another study in seven of the populations in our sample, we find no evidence that extreme responding systematically affected our results (Supplementary Figure 19).

Third, while we aimed to include cultures that represent a wide range of practices relevant to jealous response, there were some ways in which our populations were similar. For example, only the Himba practice extensive polygyny. In addition, the fact that our sample spanned a broad range of parenting practices and obligations precluded a deeper investigation into the importance of particular types of paternal investment (e.g. the amount of brideprice paid). These could be better studied by choosing a set of cultures that all share a particular system but vary in the amount of expected investment. Relatedly, our data are correlational and cannot determine the causal relationship between paternal investment and jealous response, nor do we believe the directionality of these relationships will necessarily be uniform across populations. Our study was also framed in a heteronormative way, and we want to acknowledge the important work looking at the effects of gender identity and sexual orientation on jealous response^{26,27}, which we did not address here.

Finally, while efforts were made to collect data on a broad swath of each population, we used convenience samples, and as such they are not necessarily representative of the populations at large. Measured differences between cultures may be the result of local norms at work, including the socioecological predictors used here. In addition, variation could be the result of sample variation in characteristics like age or marital status. Our statistical approach attempts to correct for variance in sample sizes as well as underlying demographic characteristics, but error as a result of convenience sampling remains a concern.

Our results point to the importance of studying universals and variation in conjunction with one another. While we find a nearly ubiquitous sex difference in the type of jealousy that men and women find most upsetting, the rest of our results emphasize the importance of culture in producing and maintaining variation in jealous response. As opposed to the predominant emphasis on sex differences in the existing literature, we highlight the similarity between men and women within the same culture and emphasize the importance of between culture differences in norms about jealousy and infidelity. Evolutionary theory can help us to go beyond the simple finding that culture produces variation to generate predictions about the particular socioecological conditions that contribute to variation²⁸. Here, we find strong support that the level of paternal investment (a reflection of differing mating-parenting trade-offs across societies) is one such variable.

Methods

All participants provided informed consent. In some cases participants received small forms of compensation (details in Supplementary Information). Ethical approval for this study was granted by the University of California, Los Angeles (#10-000238/#10-000253) covering work in Los Angeles, Namibia, China, Japan, and India; California State University Fullerton for work in Ecuador (#2003505); University of Cincinnati (#2016-2377) for work in Nicaragua; Arizona State University (#00002770) for work in Fiji; University of New Mexico (#10-034) for work in Bolivia; University of Washington (#46690) for work in Indonesia, and University of Nevada Las Vegas (#783950-1) and the Commission for Science and Technology (COSTECH-#2014-372-ER-2000-80) for work in Tanzania.

Sample

In total, 1,048 individuals across 11 populations were surveyed (1021 completed the forced choice question while 1037 completed the severity component). Efforts were made to include populations that varied in their level of paternal investment and in their permissiveness toward extramarital sex. We also aimed to only include cultures where the anthropologist had significant ethnographic

knowledge about their population, as we relied on that knowledge to create culture-level variables. The sample from India was collected through an online MTurk survey, the ethnographer who implemented this survey and answered the culture-level variables has studied marriage and parental investment in South Asia (including urban South India) for 18 years. All other interviews were conducted in person by an anthropologist, and/or where necessary, local translators who worked as part of the research team. Most samples were evenly split between men and women and included a large proportion of married individuals (Figure 1). Additional ethnographic and demographic details about each population can be found in the supplementary materials.

(b) Procedure

(i) Forced Choice Vignette

We used a standardized vignette with a single forced-choice response question to measure the relative importance of sexual versus emotional infidelity in men and women. In response to critiques that the original jealousy vignette developed by Buss and colleagues could exacerbate existing stereotypes and gendered beliefs about infidelity²², we used a variation of the original vignette, which posits both types of infidelity occurring and asks participants to choose which of the two is more upsetting. Previous studies have shown that this vignette produces results similar to the original, while minimizing chances of the so-called “double-shot” effect²¹. Familiarity with forced choice scenarios ranged across the populations, and in a few cases participants were reluctant to make a choice. In total, 22 out of 1,048 respondents refused to answer this part of the survey.

(ii) Severity Ratings

Participants were asked to rate the severity of two types of hypothetical infidelity (sexual and emotional) committed by a male and female member of their own culture, for a total of four ratings per respondent. A five-point Likert scale ranging from “Very Bad” to “Very Good” was used to rate each statement. For example, the male sexual infidelity statement presented to Himba participants read, “If a Himba man has sex with someone other than his wife, how good or bad is this?”

(iii) Ethnographer Culture Scores

In order to test predictions about the effects of norms of paternal investment and sociosexual behavior on jealous response, each ethnographer completed a survey about their fieldsite. Wherever possible, the survey utilized existing variables, mainly from the Standard Cross-Cultural Sample²⁹. Two measures of paternal investment were used: direct care, which measures everyday

care and interactions, and paternal provisioning, which included measures of male contribution to subsistence and other resource transfers. Details on the construction of these measures can be found in the supplementary materials. Measures of the frequency of male and female extramarital sex were adapted from Broude and Greene³⁰. ASR was measured using demographic data collected by the ethnographers, or in the cases of Yasawa and LA where this was not available, regional census data. The survey also included questions about mode of production, marriage and inheritance systems, religiosity, and market integration, which are presented in Supplementary Table 1, but were not included in our analyses. Complete survey responses can be found in Supplementary Table 3.

(d) Statistical analysis

Multilevel logistic regression was used to model the results of the forced choice vignette (where more upset by sexual infidelity = 1, emotional infidelity = 0). All severity results (4148 observations from 1037 participants) were assessed in an ordered logit model, with varying intercepts by participant, and dummy variables and interaction expressions to allow estimation of effects by severity type. To assess effects of sex and culture on model fit, model comparisons were run using a null, intercept only model, and then adding fixed or varying effects to assess model fit (see Table 1 for description of each model). Culture was added as a varying intercept, and sex was added as both a fixed effect, and as a varying slope by culture, to allow sex to have different effects on jealous outcomes in each culture. Finally, marital status and standardized age were added as varying slopes by culture. Widely applicable information criteria (WAIC) was calculated to compare models, which measures out of sample deviance, where the lowest WAIC values indicate the best fit, and therefore the most accurate model. Based on these values, Akaike weights were also calculated, estimating the relative probability that a given model, out of a specified set, will be make the best predictions of future data. Additional models were used to assess the effects of paternal investment, extramarital sex and ASR. Predictors were run individually as fixed effects, and then paternal investment variables, sexual infidelity and ASR were run in combination. Here we report the results of predictors run individually, but results using a combination of predictors are shown in Supplementary Figure 3. All models utilized regularizing priors and allowed for partial-pooling to improve estimates by group, particularly in groups with smaller sample sizes. In addition, because the Indian sample was the only one conducted online, and for reason might be expected to be somewhat aberrant, all models were run excluding India. However, doing this did not cause any major changes to our results so only the models with India included are presented in the main text. Models were fit to RStan³¹ using the *rethinking* package version 1.72³². Results presented here show 89% prediction intervals (89% PI) to

avoid confusion with significance tests, which is standard with the statistical package. Full model details are available in the supplementary materials.

Data Availability: The variables used in this study is available at Open Science Framework:

https://osf.io/tgc95/?view_only=fb78b2eaae344efe95a6fd8b0d80739d

Code Availability: The R code used in our analyses is available at Open Science Framework:

https://osf.io/tgc95/?view_only=fb78b2eaae344efe95a6fd8b0d80739d

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Author contributions

B.A.S. conceived and designed the experiment. T.B., A.N.C., M.G., M.K., J.K., G.K., S.M.M., S.P.P., E.P., B.A.S., M.K.S., K.S., J.S., C.S., and K.P. contributed to data collection. S.P.P., B.A.S., and R.M. analyzed the data. B.A.S. and S.P.P. wrote the paper. All authors provided comments and approved the final draft.

Competing interests

The authors declare no competing interests.

Figure Legends

Figure 1. Location of study populations. Sample size for each population is presented in the boxes, broken out by gender (n=1048).

Figure 2. Severity ratings and forced choice responses by respondent sex and culture. Rows 1-4 show the percent severity ratings according to Likert scale responses (Very Bad to Very Good) for each of type of infidelity (n=1038). The final row shows the percent of respondents who were more upset by sexual than emotional infidelity when given a forced choice (n=1021).

Figure 3. Influence of predictor variables on severity ratings. Posterior distributions (posterior mean and 89% PI) for individually run models for key predictors of participant ratings on the severity scales. Where the majority of the distribution falls either below or above zero, the predictor is believed to have a meaningful impact. Negative scores indicate greater severity judgements. Both paternal investment and the frequency of extra-marital sex are predictive of severity scores for sexual infidelity only (in opposite directions). Full model results are shown in the supplementary materials.

Tables

Table 1. Model comparison to predict severity ratings and forced choice outcome.

Mode	Parameters ^a	Severity	Forced Choice
1	Intercept only	6806.3 (0)	1307.0 (0)
2	Fixed: Sex	6798.2 (0)	1294.5 (0)
3	Varying intercept: Culture	6613.8 (0)	1183.7 (0)
4	Varying intercept: Culture Varying slope: Sex	6618.0 (0)	1155.7 (0.85)
5	Varying intercept: Culture, Varying slope: Sex, Age, Marital Status	6591.1 (1)	1159.1 (0.15)

^aValues indicate WAIC (and weight). Sex, age and marital status vary by culture when listed. Severity models include varying intercept by participant ID in all models to correct for repeated observations.