

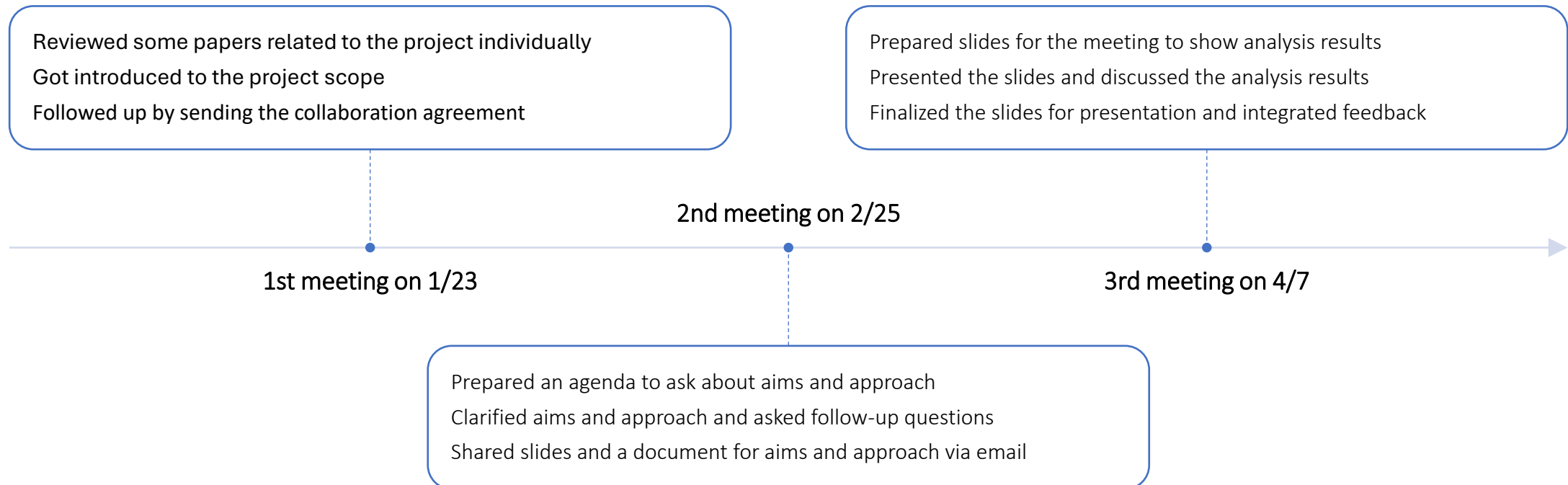


## Immunization Uptake in Bugoye, Uganda and Its Association with Vaccine Beliefs and Caregiver Experiences

Consulting Experience

# Consulting Process

- De-identified dataset, data dictionary, and study protocol were shared via Sharepoint.
- We had a meeting with them via Zoom three times in total and sent regular emails.



# Consulting Process (pt. 2)

- We did not encounter any obstacles in the consulting process.
  - Our collaborators were receptive to our work and were always responsive.
  - They answered our questions during meetings and were always available via email.
  - As a group, we were provided enough information from our collaborators to tackle the project independently.
  - We were open to their feedback as we shared our progress.
- Statistical obstacles that we discussed with our collaborators:
  - How to deal with imbalanced data
  - How to deal with the missing values in the dataset
- Things we would have done differently:
  - More regular Zoom meetings
  - More sharing of analyses

# Aims and Approach

# Background

- **Phenomenon:** In 2016, a national health survey reported that only **55%** of young children (12–23 months) in Uganda received all basic vaccinations.
- **Hypothesis:** Areas with limited access to immunization services predict lower childhood vaccine uptake compared to areas with full access.
- **Study Information:**
  - Location: Bugoye sub-county, Uganda
  - Study Type: Cross-sectional (from 2021-01-20 to 2021-04-30)
  - Target Population: Children ages 12–23 months
  - **Objective:** Explore social determinants (e.g., caregiver attitudes and beliefs) linked to vaccination coverage in a rural, under-resourced area.

# Data Structure

	Variables	Definitions	Descriptive Statistics	
<b>Outcome,</b> No. (%)	<b>Fully vaccinated</b> (vacc_full)	If child received all eight vaccines (tuberculosis, polio, pentadose1, pentadose2, pentadose3, rotavirus1, rotavirus2, and measles) or not according to vaccine card and/or self-report	Yes	1381 (81.8)
			No	230 (13.6)
			Missing	78 (4.6)
<b>Exposures,</b> Median (sd) [range]	<b>Beliefs score</b> (beliefs1)	Aggregation of caregiver responses to 10 vaccine belief questions (higher score indicates more positive beliefs)	8 (1.25)	[2.5, 10]
	<b>Experience score</b> (exp1)	Aggregation of caregiver responses to 14 vaccine experience questions (higher score indicates more positive experience)	11 (1.21)	[7.0, 14]
<b>Covariates</b>	<b>Possible confounders</b>	7 caregiver demographics (e.g. educational attainment, marital status), 3 biological measures (e.g. child age, mid-upper arm circumference), 5 childbirth measures (e.g. bednet use, inpatient status), and 1 variable on where most vaccines were received		

# Specific Aims

To explore associations between **caregiver beliefs and experiences** and **fully vaccinated children** (ages 12-23 months) in Bugoye, Uganda, after adjusting for confounders.

**Primary Hypothesis:** Positive caregiver beliefs and experiences are associated with fully vaccinated children, after adjusting for household demographic factors and clinic center.

**Secondary Hypothesis:** Positive caregiver beliefs and experiences are associated with increased uptake of specific vaccines (e.g., Measles) and vaccine card availability, after adjusting for household demographic factors and clinic center.



# Methods

- Exploratory Data Analysis
  - Descriptive statistics for variables related to the main outcome and exposures
  - Correlation analysis between the main outcome and exposures
  - Complete case analysis to handle missing data
- Final Analysis
  - Weighted logistic regression to handle the imbalanced outcome
- Two strategies for measuring main exposures
  - Use an aggregated "score" for beliefs and experiences
  - Use multiple disaggregated belief and experience indicator variables

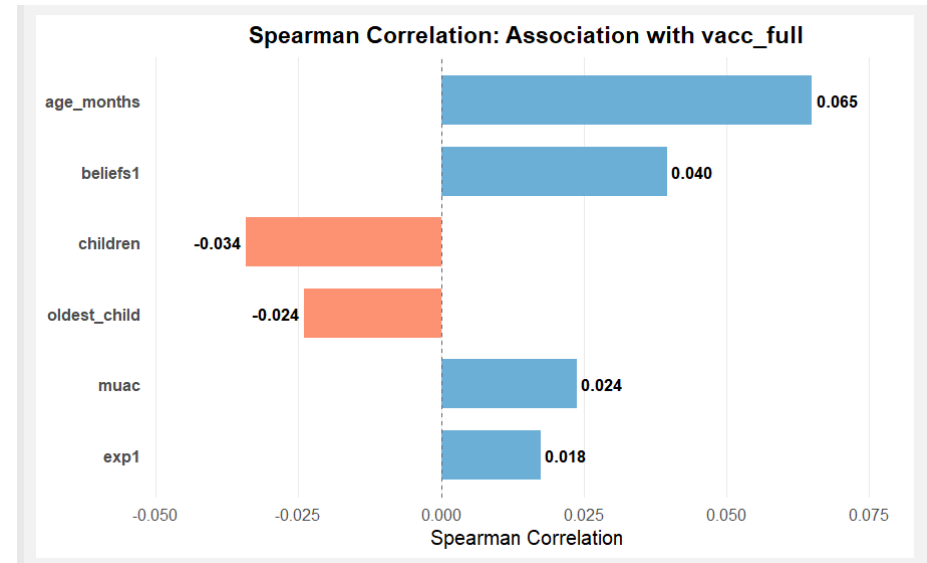
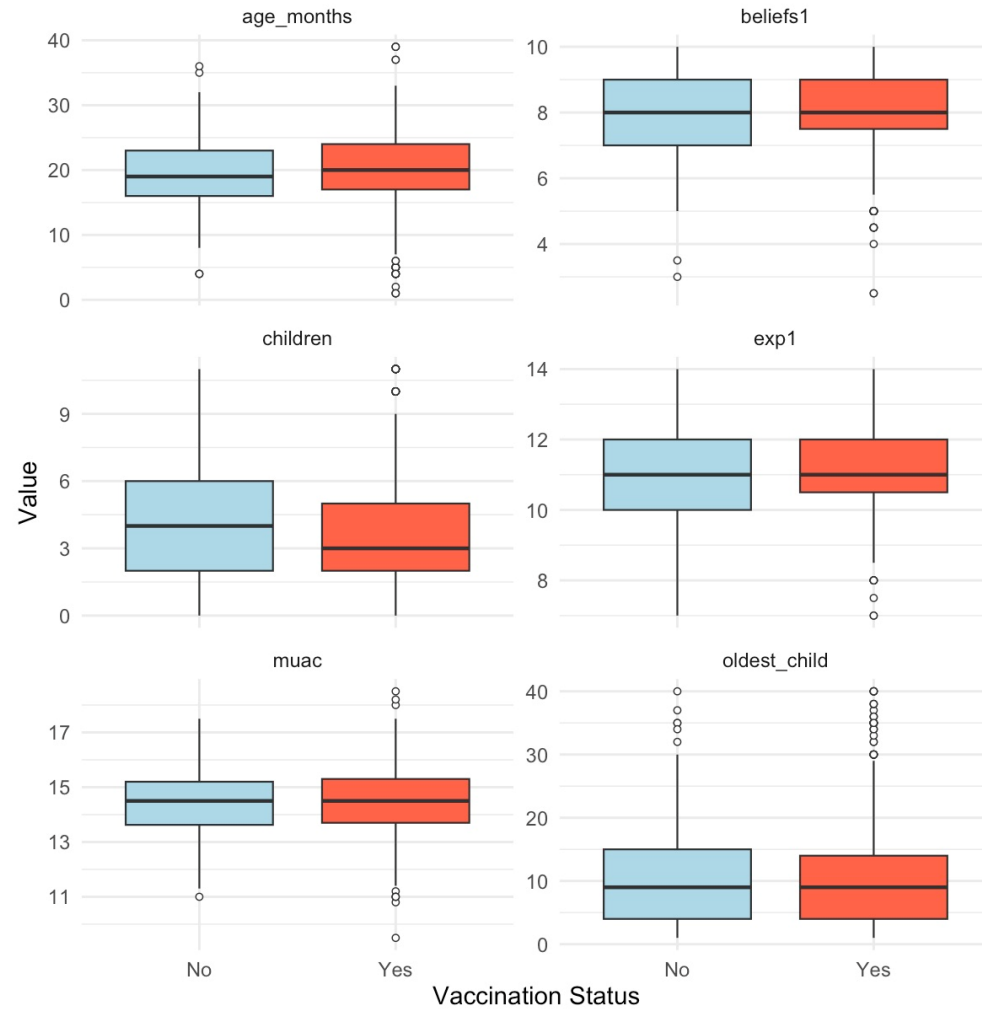
Belief Question Examples	Experience Question Examples
Children get more vaccinations than are good for them. (vacc_more)	Do you know of someone in your family or community who had either polio, pneumonia, measles or whooping cough? (exp_seen)
Many of the illness which vaccinations prevent are severe. (vacc_severe)	Have you ever delayed having your child get a vaccination for reasons other than illness or allergy? (exp_delay)
When a parent refuses to vaccinate a child, it harms the entire community through risk of disease. (vacc_refuse)	Are you able to discuss any concerns you have about vaccinations with your child's healthcare provider? (exp_concern)

# Exploratory Data Analysis

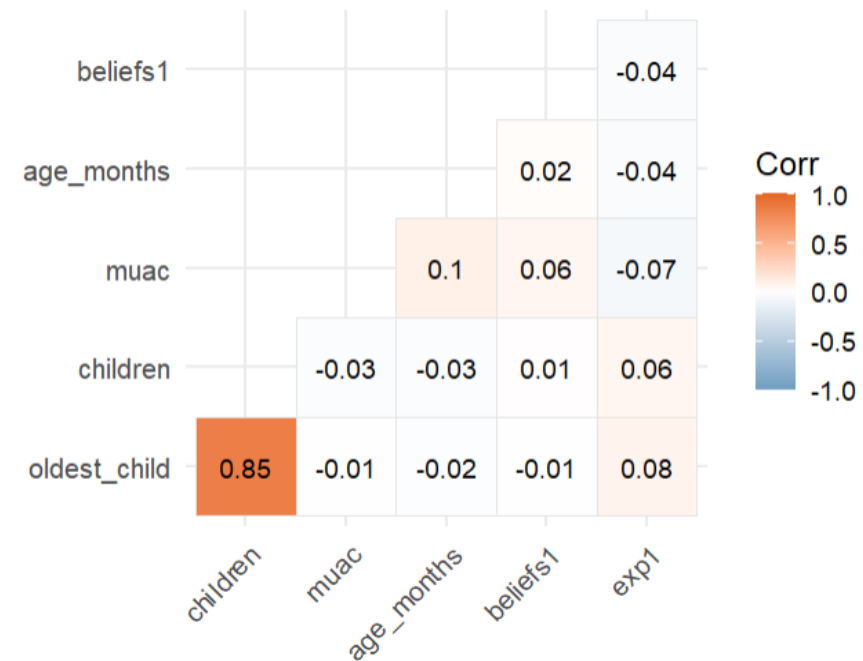
# EDA Results

- Continuous

Boxplots of Predictors by Vaccination Status



Correlation Matrix for Continuous Variables



- Binary:

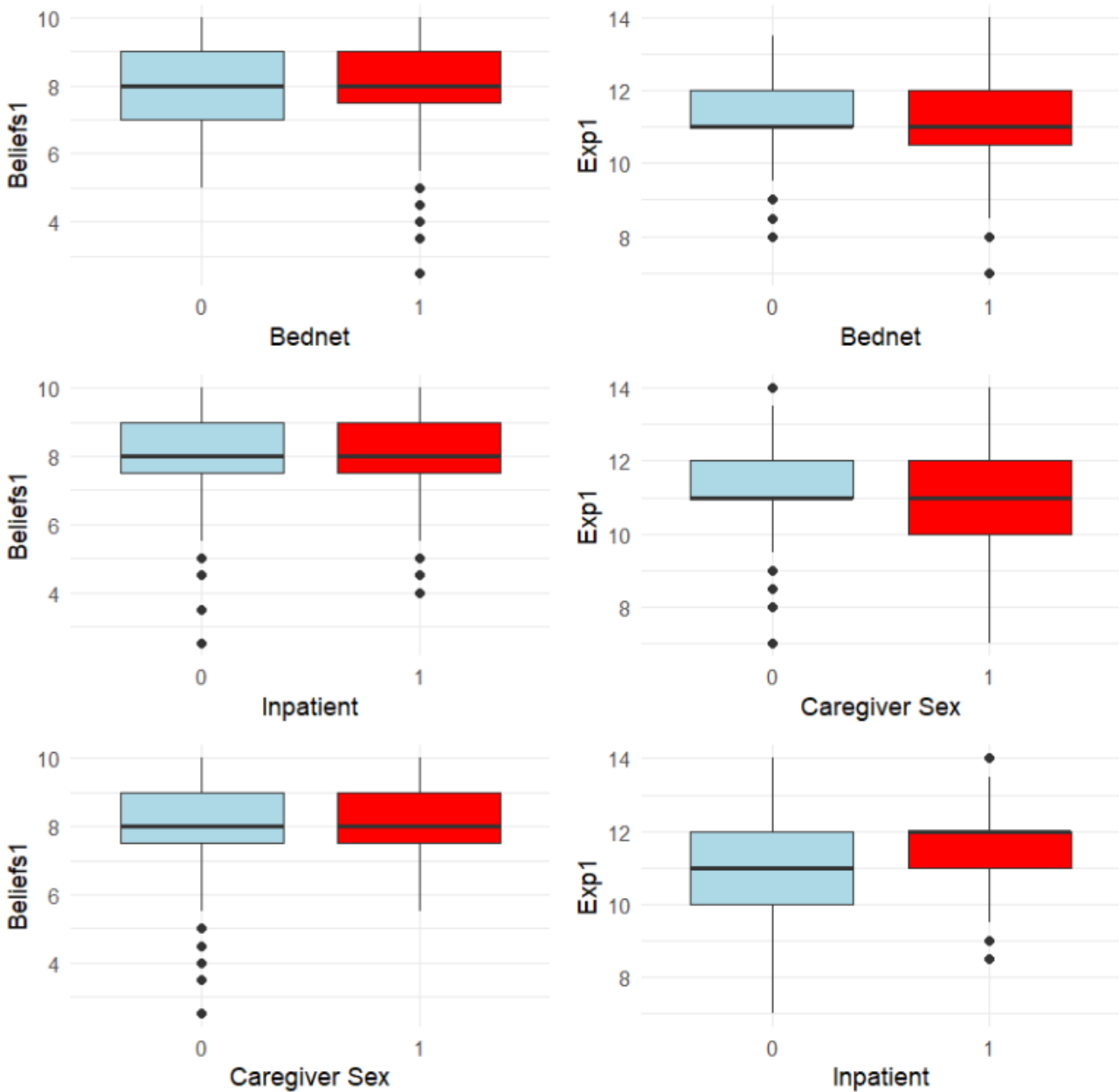
Phi Coefficient: Binary variables association with Vaccination Status	
bednet	0.150
caregiver_sex	-0.080
inpatient	0.055
child_sex	-0.028
hbv_res	0.023
hbv_test	0.020
dbv	-0.010

- Ordinal:

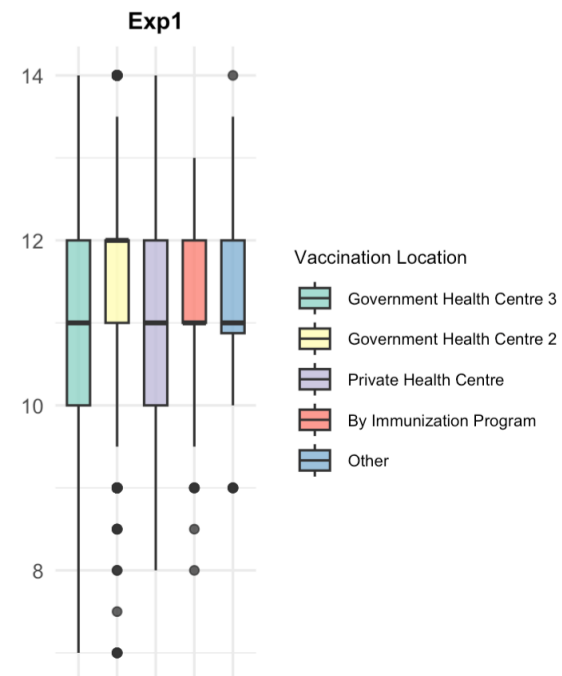
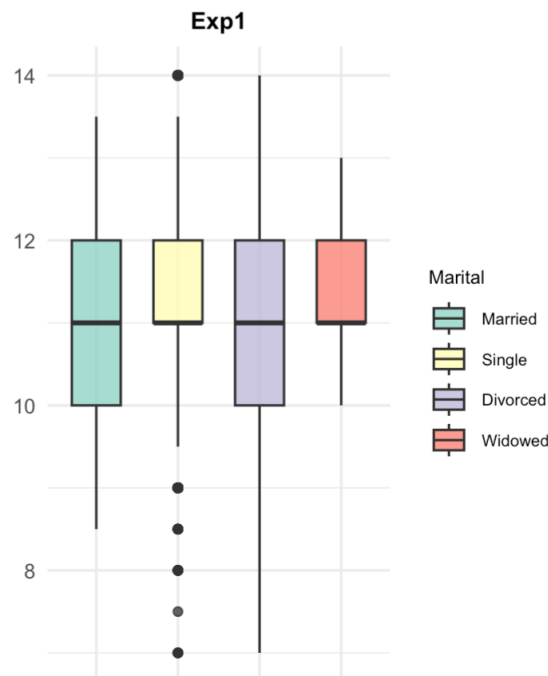
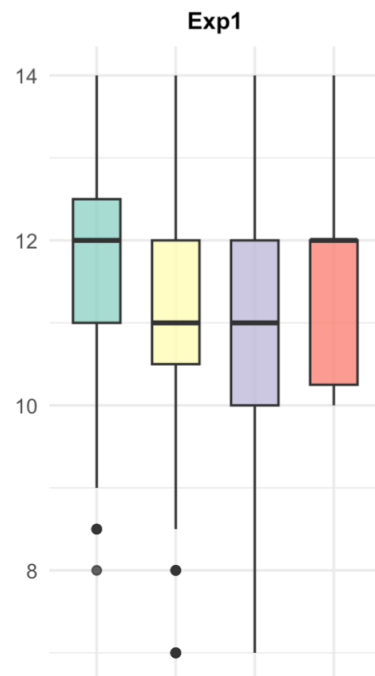
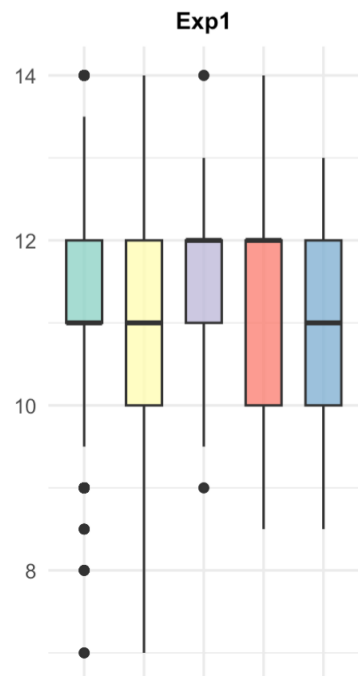
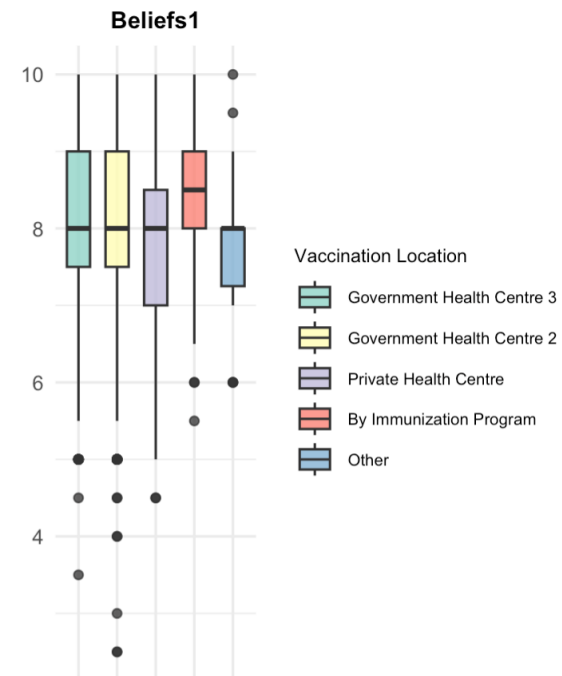
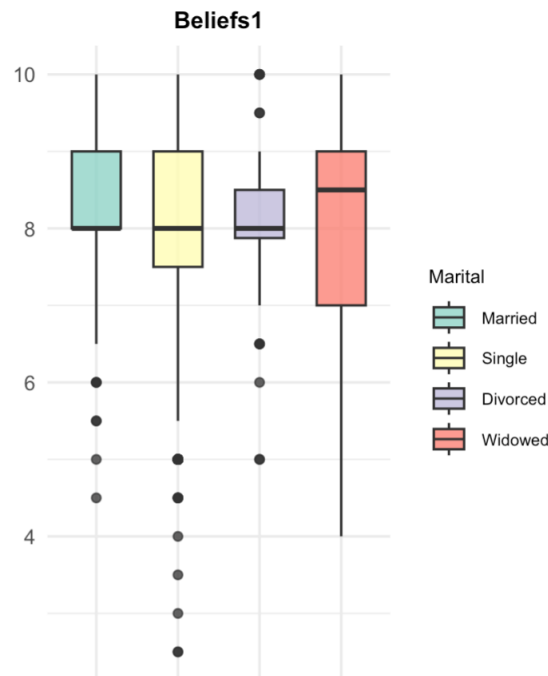
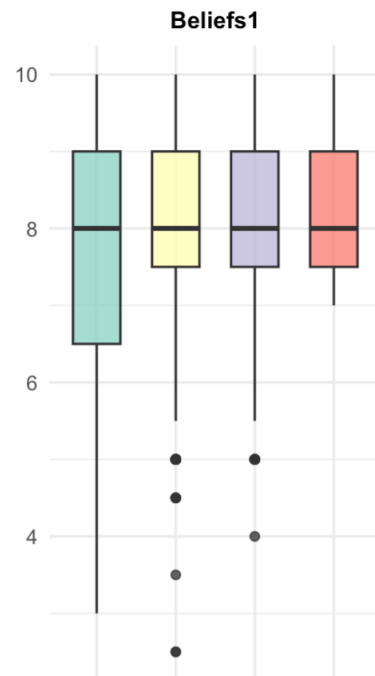
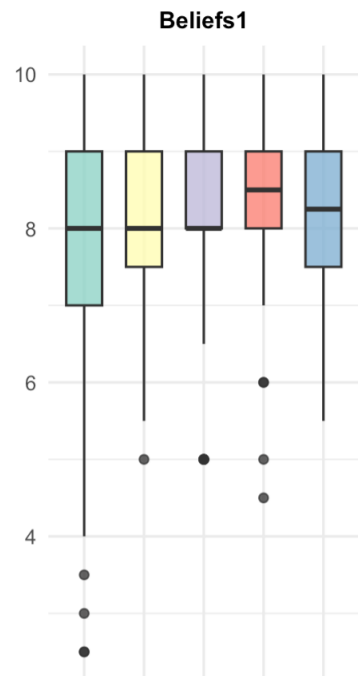
Kendall's Tau: Ordinal Variables Association with Vaccination Status (** $p < 0.001$ , ** $p < 0.01$ , * $p < 0.05$ )	
exp_delay1	0.165***
exp_seen	0.106***
exp_concern	0.097***
vacc_refuse	0.097***
vacc_more1	-0.071**
vacc_severe	0.067**
exp_access	0.066**
exp_defer	0.065**
.....	
birthplace	0.013

- Multi-level:

Cramér's V: Nominal Variables Association with Vaccination Status	
relationship	0.159
education	0.097
marital	0.09
vacc_where	0.09
birthplace2	0.033
mauc_color	0.027
birth_status	0.02

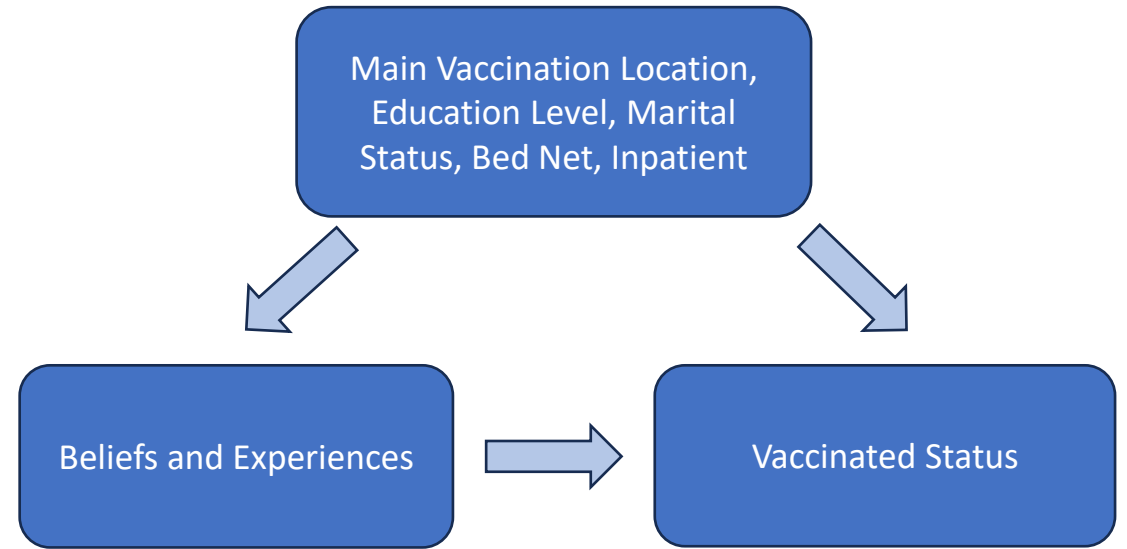


Distribution of Beliefs Score and Experience Score Across Nominal Variables



# Potential Confounding Variables

- Important Variables
  - Based on EDA:  
Relationship, main vaccination location, education Level, marital status, bed net, inpatient
  - In theory:  
Distance to health care
- Prior knowledge, Chi-squared tests, Wilcoxon rank-sum tests, and Kruskal-Wallis tests were used
  - To check associations between each variable and outcome/exposures



**Directed Acyclic Graph (DAG)**

Final Analysis

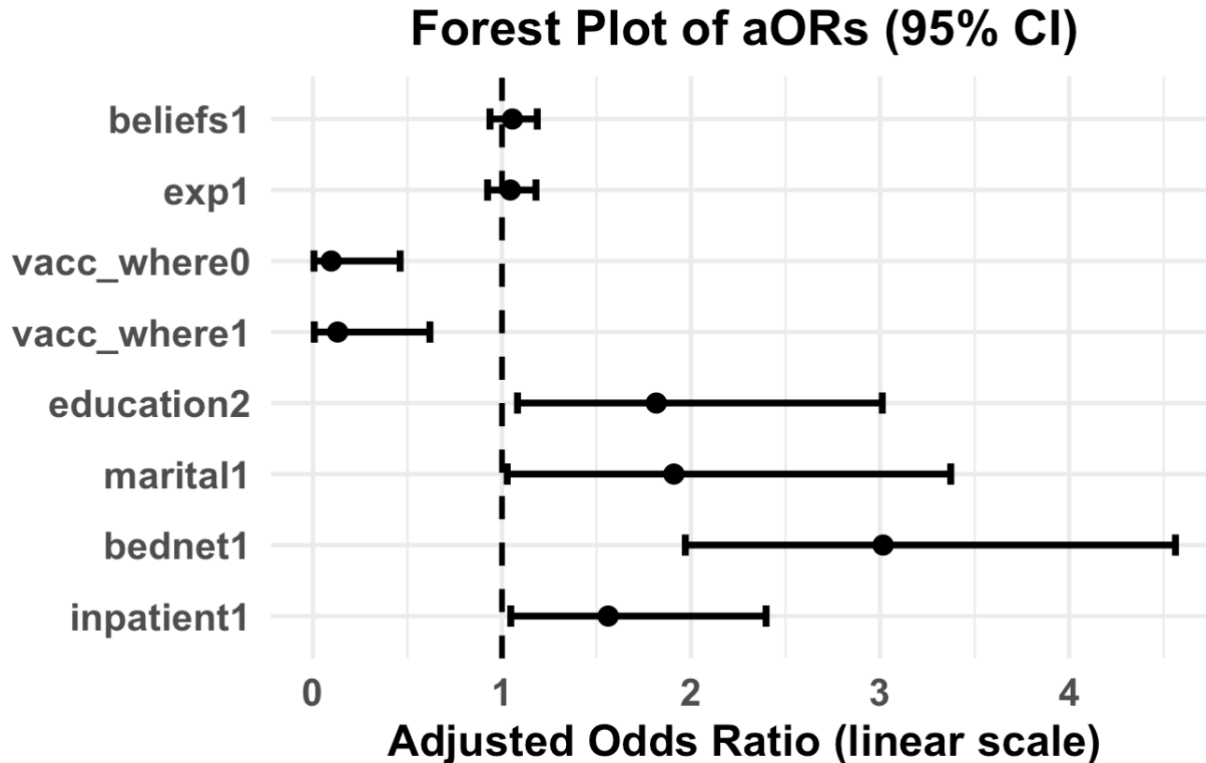
# Fully Vaccinated Status as the Outcome

- Imbalance in fully vaccinated status
  - 86% were fully vaccinated → normalized weight: 0.583
  - 14% were not fully vaccinated → normalized weight: 3.502
- Final model:
  - $\text{logit}(\text{Pr}(\text{Vaccination Status}_i = 1)) = \beta_0 + \beta_1 \text{Beliefs Score}_i + \beta_2 \text{Experiences Score}_i + \sum_{j=0}^4 \beta_{3j} 1(\text{Main Vaccination Location}_i = j) + \sum_{j=0}^3 \beta_{4j} 1(\text{Education}_i = j) + \sum_{j=0}^3 \beta_{5j} 1(\text{Marital Status}_i = j) + \sum_{j=0}^1 \beta_{6j} 1(\text{Bed Net}_i = j) + \sum_{j=0}^1 \beta_{7j} 1(\text{Inpatient}_i = j)$
- Model Performance
  - Small VIFs ( < 2 ) → no concerning multi collinearity
  - Hosmer and Lemeshow goodness of fit (GOF) test: p-value= 0.5978  
→ model fits the data well



# Adjusted Odds Ratios and 95% Confidence Intervals

Note: only significant confounding variables were included.



Variable Name	Variable Level	Adjusted Odds Ratio (aOR)	95% Confidence Interval	P-value
Beliefs Score	.	1.055	[0.937, 1.186]	0.374
Experiences Score	.	1.044	[0.923, 1.180]	0.488
Main Vaccination Location	Government Health Centre 3	0.097	[0.005, 0.461]	0.023
Main Vaccination Location	Government Health Centre 2	0.130	[0.007, 0.619]	0.047
Education Level	Secondary School	1.816	[1.082, 3.012]	0.022
Marital Status	Married	1.909	[1.027, 3.374]	0.032
Bed Net	Yes	3.016	[1.970, 4.562]	<0.001
Inpatient	Yes	1.562	[1.046, 2.396]	0.035

There were **no significant associations** between immunization status and beliefs or experiences related to vaccines, after adjusting for the confounding variables.

# Impact of Individual Beliefs and Experiences

- Model for Individual Beliefs
  - $\text{vacc\_full} \sim \text{belief\_1} + \text{belief\_2} + \dots + \text{belief\_10} + \text{experience\_score} + \text{vacc\_where} + \text{education} + \text{marital} + \text{bednet} + \text{inpatient}$
- Model for Individual Experiences
  - $\text{vacc\_full} \sim \text{experience\_1} + \text{experience\_2} + \dots + \text{experience\_14} + \text{belief\_score} + \text{vacc\_where} + \text{education} + \text{marital} + \text{bednet} + \text{inpatient}$
- Significant beliefs/experiences:

Variable Name	aOR	95% CI
vacc_more	0.520	(0.367, 0.737)
vacc_severe	2.534	(1.479, 4.342)
vacc_refuse	1.984	(1.289, 3.052)
exp_seen	2.121	(1.449, 3.105)
exp_delay	0.337	(0.237, 0.478)
exp_concern	2.436	(1.293, 4.589)

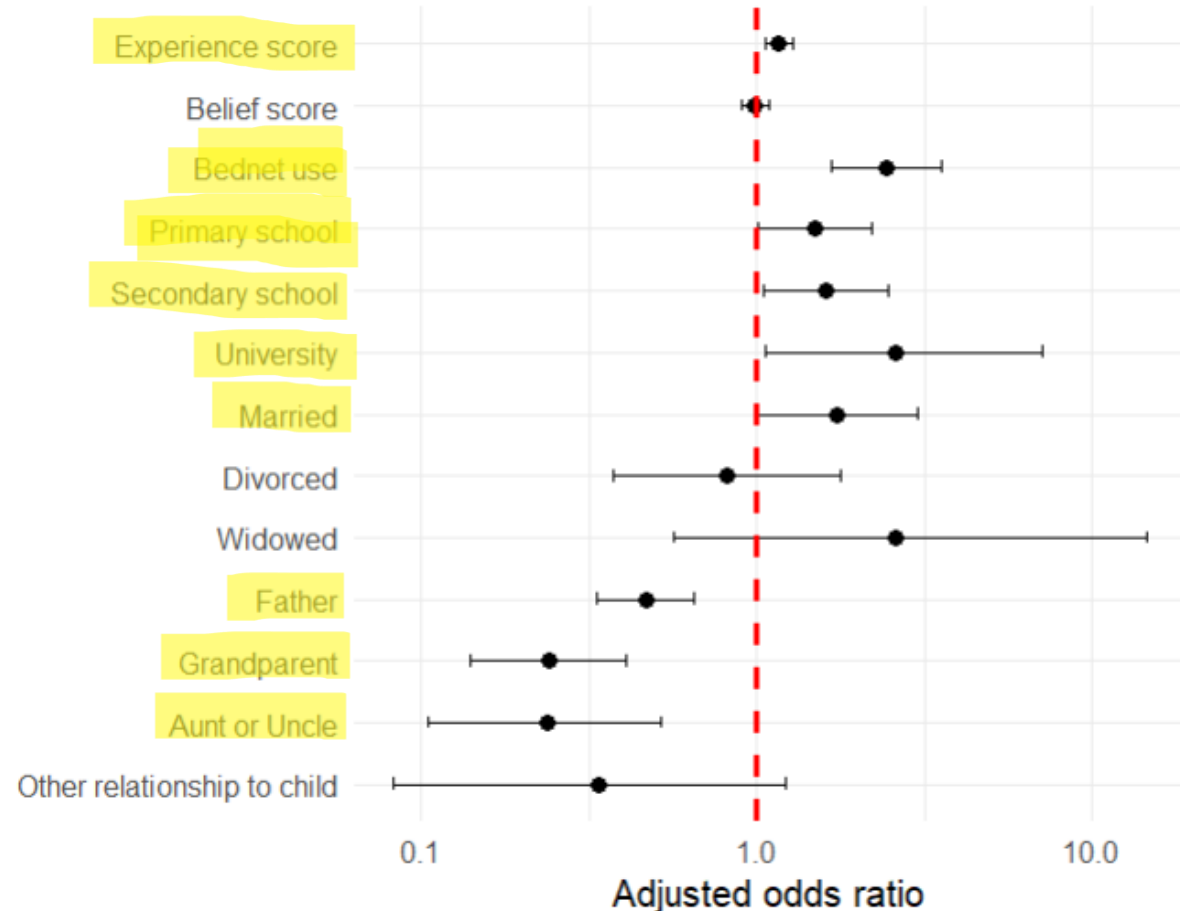
- VIF scores all below 2, so collinearity is not an issue

# Secondary Analysis: Measles Vaccine Model

- Firth logistic regression fitted due to extreme imbalance in data
  - 1414 vaccinated against measles (96.8%), 46 not vaccinated against measles(3.2%)
  - 14 parameters to be fitted in model (~3 unvaccinated per predictor)
- Model
  - measles ~ beliefs\_score + experience\_score + vacc\_where + education + marital+ bednet + inpatient
  - Exposures: beliefs\_score, experience\_score
  - Confounders: vacc\_where, education, marital, bednet, inpatient
- Estimates and adjusted odds ratios (aOR)
  - Beliefs score association found to be significant (aOR: 0.54, 95% CI: [0.39, 0.73]),but experiences score association found to be insignificant (aOR: 1.10, 95%CI:[0.82, 1.48])
- Extreme imbalance in data limits conclusions that can be made

# Secondary Analysis: Vaccine Card Outcome

- Logistic regression model fitted on factors associated with vaccine card availability
  - 67.5% had vaccine cards
  - 32.5% did not (self-reported vaccine status)
- Results:
  - Experience score was associated with vaccine card availability (aOR: 1.16, 95% CI: [1.06, 1.28]), but belief score was not.
  - Bednet use, primary, secondary, university education, married status, and mother caregiver (vs. father, grandparent, aunt or uncle) were positively associated with vaccine card availability.



# Conclusions

- No association found between fully vaccinated status and aggregated score for beliefs and experiences, after adjusting for confounders.
  - Bednet use, education level, and marital status, were related to both vaccinated status and card availability.
- However, some individual beliefs/experiences were associated with status
- About **82%** of children (ages 12-23 months) living in Bugoye, Uganda were fully vaccinated in 2021, a significant improvement to the **55%** national vaccination rate in 2016.
- Limitations: Recall and response bias (for those without a vaccine card), class imbalance

# References

- Boyce RM, Delamater P, Muhindo R et al. Accessible metrics of access: Novel tools to measure immunization coverage in rural sub-Saharan Africa [version 1; peer review: 1 approved, 1 approved with reservations]. Gates Open Res 2019, 3:1540 (<https://doi.org/10.12688/gatesopenres.13066.1>)
- Uganda Bureau of Statistics (UBOS) and ICF. (2018). Uganda Demographic and Health Survey 2016. Kampala, Uganda and Rockville, Maryland, USA: UBOS and ICF.