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RESEARCH ARTICLE

Advanced Modelling

Socio-demographic and behavioural factors associated with prominent misconceptions of HIV/AIDS transmission among ever married women in Sri Lanka: An application of modelling correlated binary outcomes using a bridge distribution function

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Abstract: Human Immunodeficiency Virus (HIV) case reporting usually represents only the trending pattern of HIV infected people in Sri Lanka. Having a decent level of knowledge about HIV largely contributes to preventing HIV prevalence in the country. People with HIV are not hazardous to the public who live together with them and with whom they have ordinary, non-sexual contact. However, suffering from HIV in a culture like Sri Lanka generates an extreme level of stigmatizing by people living with HIV and many psychological and social effects. This study aims to identify the factors that are associated with possessing knowledge, among ever married women in the reproductive age in Sri Lanka, regarding two prominent misbeliefs on HIV/AIDS transmission. This will be useful to identify various socio-economic, geographic subgroups who are lacking knowledge on HIV/AIDS spread. Secondary data from 2016 Sri Lanka Demographic and Health Survey was used in the analysis. Joint modelling was considered since it was found that two outcome variables are highly associated and hence the ever-married woman who believes one misconception is more likely to believe the second misconception too. To capture the association between two outcomes, we incorporated a shared random effect and assumed the bridge distribution for the random effect. Respondent's province, highest level of education, access to mass media, religion, age and wealth index were found to have a significant effect on prominent misconceptions on HIV/AIDS transmission.

Keywords: Bridge distribution, correlated binary responses, HIV/AIDS transmission, logistic regression, misconceptions on disease transmission.

INTRODUCTION

Human immunodeficiency virus (HIV) gives rise to acquired immune deficiency syndrome (AIDS), which is known as an incurable disease of human beings ultimately leading to death. According to UNAIDS in 2022 there were 37.7 million (30.2 million–45.1 million) people globally living with HIV. Among them, 36.0 million (28.9 million–43.2 million) were adults and 1.7 million (1.2 million–2.2 million) were children (<15 years old). Approximately 84% [67–>98%] of people with HIV globally knew their HIV status in 2020. The remaining people about 6.1 million (4.9 million–7.3 million) still need access to HIV testing services to test their HIV status. HIV testing is an essential gateway to HIV prevention, treatment, care and support services. Most people with HIV are living in low- and middle-income countries. By 2021, new HIV infections have been reduced by 54% since the peak in 1996. In 2021, around 1.5 million (1.1 million–2.0 million) people

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were newly infected with HIV, compared to 3.2 million (2.4 million–4.3 million) people in 1996. According to UNAIDS, women and girls accounted for 49% of all new infections in 2021 (UNAIDS Fact Sheet, 2022).

Consistent with the final report of the Sri Lanka Demographic and Health Survey (SLDHS) in 2016, since the identification of the first HIV infected Sri Lankan in 1987, a cumulative total of 4,245 HIV positive cases has been reported up to the end of 2022. In 2021, 410 HIV cases have been reported to the National STD/AIDS control programme (NSACP) which is responsible for coordinating, planning, and implementing the HIV National Strategic Plan and the AIDS Policy in the country. However, the reported numbers represent only a fraction of HIV infected people in the country, as many infected people may perhaps not be aware of their HIV status and in addition, stigma and discrimination towards HIV infected people adversely affect voluntary testing for HIV (Annual Report NSACP, 2021). An estimated 3638 (3250 – 4000) people were living with HIV in Sri Lanka at the end of 2021. During 2021, 411 people living with HIV were newly diagnosed. This is a 13% increase from the previous year. Further, an increase in the incidence rate of HIV cases has also been observed in the Island during the recent past (Figure 1).

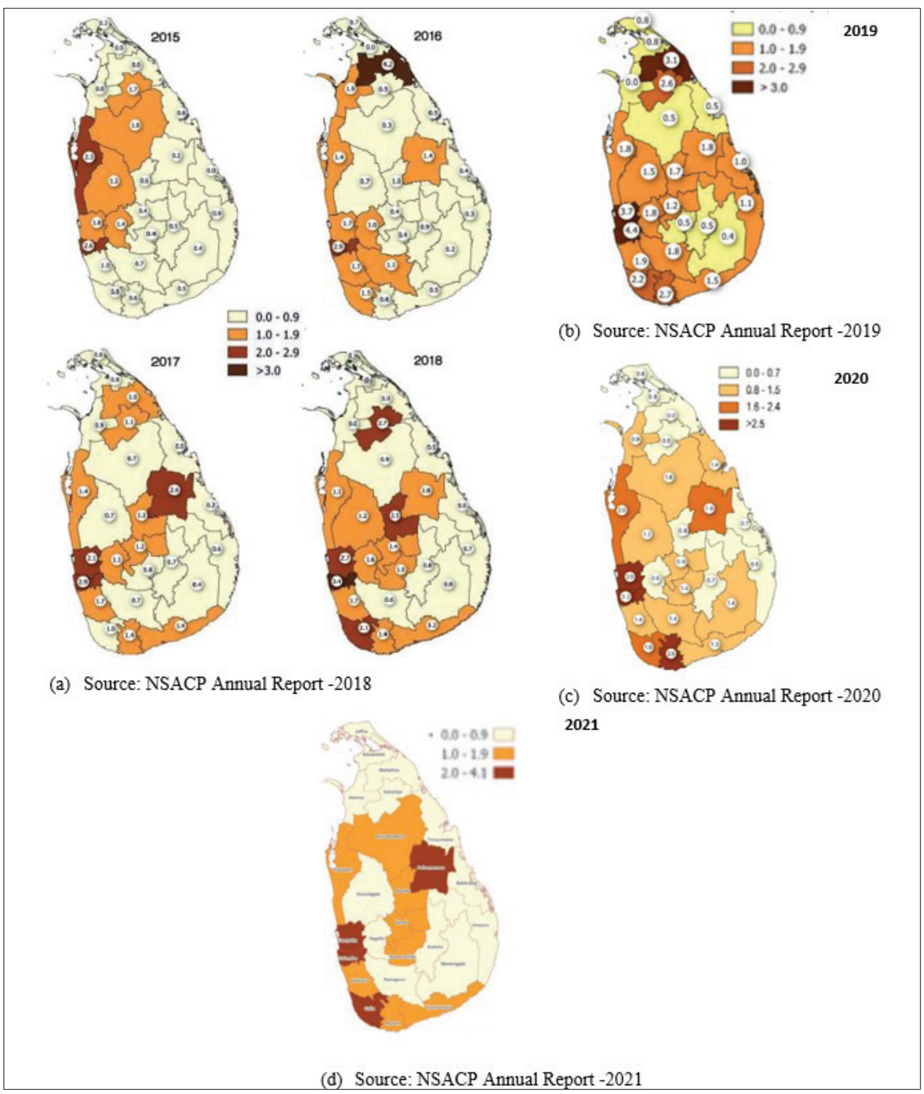

Figure 1: Rate of newly reported HIV cases per 100,000 population as reported in NSACP Annual reports 2018 – 2021.

People living with HIV are not a public hazard to those who coexist with them in the community and engage in ordinary, non-sexual contact. However, in the cultural context of Sri Lankan society, individuals living with HIV experience a significant degree of stigmatization, resulting in various psychological and social consequences. An HIV infected individual also loses his/her social recognition, respect and acceptance (Samarakoon *et al*., 2020). In conservative societies that still exist in most countries in the South Asian region, including Sri Lanka, the treatment that Society accords an HIV infected person seems to depend on the social status of that individual. As Thakuri and Thapa (2018) claim regarding the case of India, 'those whose characters are unblemished enjoy a high position in the society and the extreme opposite creates serious issues like social marginalization.' Saki *et al.* (2015) point out how the AIDS patients suffer from different dimensions of stigma, rejection, and insult that affect the individual him- or herself, family, others, and finally the society. The majority of people who live with HIV are in the African Continent, more than any other region of the world, and numerous misconceptions are prevalent about HIV and AIDS (Niehaus & Jonsson, 2005). Most of these false ideas prevail when the people are unable to comprehend the scientific basis behind them. Hence, they tend to formulate different ideas based on norms, values, public opinion, and speculation. Such beliefs are prominent in third world countries such as Ethiopia, Bangladesh, Iran, and India, which tend to possess similar cultural characteristics (Niehaus & Jonsson *et al*., 2005; Saki *et al.*, 2015; Thakuri & Thapa, 2018; Agegnehu & Tesema, 2020). Even at present, many rural communities with less educated people and even the educated, urban younger generation who do not have access to the latest knowledge of the sciences tend to live in their own traditional, gloomy spheres. Current misconceptions include genocidal beliefs such as 'HIV/AIDS was developed by White people in the West to control Black African population' and superstitious beliefs such as 'AIDS is caused by supernatural forces or witchcraft' (Niehaus & Jonsson, 2005). Some African men believe that condoms were infected with 'AIDS worms' and that HIV was created by racist Whites and that HIV is put into the lubricant in condoms exported and distributed in Africa. Hence, these HIV/AIDS misconceptions are also obstructing HIV prevention efforts since they were associated with decreased condom use among African men (Bogart & Thorburn, 2005).

There also exist several misconceptions about HIV transmission that are common in most communities: HIV infection can be acquired by swimming, sharing meals, shaking hands, casual touch, speaking face-to-face with an infected person, and transmission through mosquito bites (Choudhary *et al*., 2015; Thakuri & Thapa, 2018). Qian *et al.* (2007) have identified that the gender of the respondent is not significantly associated with the misconceptions of HIV transmission in rural Chinese communities, while Bogart *et al.* (2011) observed that some misconceptions are gender specific among African Americans aged 15 to 44 years and living in the contiguous United States. As aforesaid, these beliefs prevail when people are unable to comprehend the scientific basis behind them. For example, there is a biological reason why HIV cannot be transmitted through a mosquito bite; this is because HIV cannot replicate inside the mosquito due to the lack of a T4 antigen on the cell surface (Iqbal, 1999). It has also been found that among young Sri Lankan adults the knowledge of HIV prevention and misconceptions of HIV transmission is not at a sufficient level (Bogart *et al.*, 2011; Karthijekan, 2017).

Asaduzzaman *et al.* (2016) found that awareness and knowledge of HIV/AIDS among married women in rural Bangladesh are associated with exposure to mass media. Extracted data of 11,570 rural married women aged 15–49 years old from the sixth Bangladesh Demographic Health Survey in 2011 was utilized and through logistic regression analysis it was found that exposure to each type of media (listening to the radio, reading newspapers/magazines, watching television) was significantly associated with awareness of HIV/AIDS. Authors suggested that television can be utilized to increase awareness and comprehensive knowledge of HIV/AIDS through effective TV programmes. Furthermore, Haque *et al.* (2018) found that apart from exposure to mass media access, respondents' education status, place of living, and working status played a significant role on the attention of HIV/AIDS among married women in Bangladesh by performing a logistic regression analysis.

Many authors have addressed the knowledge of HIV prevention among adults in Sri Lanka (Kanda *et al.*, 2010; de Silva *et al.*, 2014; Karthijekan, 2017; Madurapperuma *et al.*, 2018) but have not sufficiently addressed knowledge about the misconceptions of HIV/AIDS. Samarakoon *et al.* (2020) through a generalized linear mixed model approach found that among tertiary and vocational education trainees in Sri Lanka, possessing knowledge on these prominent misconceptions is associated with their level of education, having a sound knowledge on sexual and reproductive health, and having attended workshops on sexually transmitted diseases.

According to the 2016 Sri Lanka Demographic and Health Survey, comprehensive knowledge of HIV/AIDS among 18,302 ever-married women is defined as understanding the following:

1) Consistent use of condoms during sexual relationships can reduce the chance of contracting HIV.
2) Having just one uninfected faithful partner can reduce the chance of contracting HIV.
3) It is possible for a healthy-looking person to have HIV.
4) It is a misconception that people can get the HIV virus from mosquito bites.
5) It is a misconception that someone can contract the HIV virus by sharing food with an HIV-infected person.

The most common fallacies about HIV transmission in Sri Lanka are that 'people can get the HIV virus from mosquito bites' and 'someone can get the HIV virus by sharing food with an HIV-infected person,' as stated in the final report of the 2016 SLDHS.

In this paper we made an in-depth investigation on these two common misconceptions on HIV transmission using the data gathered through the most recent SLDHS conducted by the Department of Census and Statistics (DCS) in 2016. The main objective of the current study was to identify the awareness of ever-married women about these two misconceptions about HIV transmission and to investigate how their awareness varies with their socio-demographic and behavioural factors. This was achieved by jointly modelling the outcome variables considering the correlation between outcomes.

It is obvious that two responses regarding the misconceptions of spreading HIV observed from the same respondent are likely to be correlated since a single person who believes one misconception is more likely to believe the second misconception too and awareness of two delusions are related to individual characteristics. Failure to account for such correlations by treating responses from the same respondents as independent may consequently yield incorrect inferences. Standard errors calculated by incorrectly assuming correlated observations to be independent tend to underestimate the true sampling variability, consequently yielding a type I error of significance tests (Withanage *et al*., 2014). Hence, joint modelling of two outcomes provides better control over type I error rates in multiple tests and gains efficiency in the parameter estimates.

MATERIALS AND METHODS

The survey and data source

The data used for this study were obtained from the Sri Lanka Demographic and Health Survey (SLDHS) 2016 conducted by the Department of Census and Statistics (DCS) of Sri Lanka. Demographic and health surveys, also known as DHS programmes, are national representative population-based household surveys, which provide accurate and internationally comparable data on health indicators in developing countries. They collect and disseminate data on areas such as fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria, and nutrition. DHS surveys are part of the world-wide DHS project, intending to observe and improve population health (The DHS programme, 2016).

Computer-Assisted Personal Interviewing (CAPI), coupled with the use of mobile and wireless technology, was the method of data collection used in the SLDHS 2016. In CAPI, the data entry and validation of DHS 2016 was also done on-site using the digital questionnaire on tablet computers for the first time in DCS history. A total of 28,720 housing units were selected as the sample, from which 27,455 were occupied at the time of the survey and out of those existing households 27,210 were successfully interviewed. Moreover, there were 18,302 ever married women who were interviewed during the research. However, for the current study, all respondents who satisfy the criteria given below were selected: (1) ever married women in the age group 15 – 49 years in Sri Lanka, (2) who have ever heard about HIV/AIDS, and (3) have given 'Right' or 'Wrong' as answers for the two response variables which were identified as the two most prominent local misconceptions about HIV transmission, in the SLDHS in 2016. This resulted in a sample of size 11,808 women. Note that the whole population of ever married women in the reproductive age group (15 – 49) who have heard about HIV/AIDS was the target population of the study.

Response variables and predictors

In the SLDHS 2016, respondents were asked a couple of questions regarding misconceptions about HIV/AIDS. Among these questions, two prominent misconceptions were analysed: the belief that 'people can get the HIV virus from mosquito bites (Y1)' and the belief that 'someone can get the HIV virus by sharing food with an HIV-infected person (Y2)' (Table 1). Both questions were close-ended, allowing for responses of 'Right,' 'Wrong,' or 'Don't know.' However, for the analysis, we focused on individuals who answered either 'Right' or 'Wrong' as these options provide clear information about the respondents' awareness regarding these misconceptions. It is important to note that both statements, Y1 and Y2, are false.

Table 1: Response variable statements considered

Response variables	Percentage of responses	
	Wrong (%)	Right (%)
People can get HIV virus from mosquito bites (Y1)	76.2	23.8
Someone can get the HIV virus by sharing food with a HIV infected person (Y2)	79.1	20.9

Since the SLDHS 2016 aimed to measure various aspects of households and their members, the questionnaire comprised a substantial number of questions and variables. Through a meticulous review and consideration of existing literature, relevant predictors related to misconceptions about the spread of HIV/AIDS were carefully filtered and selected for examination. The association between these predictors and response variables was determined using a Chi-squared test. Predictors that exhibited a significant association with responses at a 10 % level of significance were chosen to model the responses in conjunction with the predictions.

Statistical analysis

As the first step, a descriptive analysis followed by a Chi-squared analysis was conducted to understand the composition of the sample and investigate for the possible existence of associations between various categorical variables and each response variable. Binary logistic regression models were fitted for each response variable separately as the next step to identify the factors influencing the awareness of Y1 and Y2 among ever married women in the reproductive age range (15–49 years) in Sri Lanka. The final logistic regression models were selected based on forward conditional procedure. Predictors that showed significance (at 10% level of significance) for at least one of the response variables were included in the joint model. A higher level of significance (10%) was chosen for individual logistic models to ensure that all important predictors would be included in the joint model.

Only significant predictors identified for at least one response model were included in the joint model. Non-significant predictors were removed from the model using the Wald test statistic. However, the results of the separate logistic regression models for Y1 and Y2, assuming independence between the two outcomes, were not included in this manuscript. Only the joint model results, which account for the correlation between Y1 and Y2, are presented. PROC NLMIXED in SAS 9.2 University edition was used to fit the joint model. The SAS codes are in the appendix.

Joint modelling (random intercept logistic regression model)

Random effects logistic regression models are often used to model clustered binary response data assuming normal distribution for the random effects. Regression parameters in these models have a conditional, subject-specific interpretation in that they quantify regression effects for each cluster/unit. Hence, these parameter estimates are not directly comparable with the parameter estimates of the binary logistic regression models. In this study, joint modelling of two outcomes is appropriate since it was found that the two outcome variables are highly associated. In this joint modelling approach, following Wang and Louis (2003), a shared random effect was incorporated to capture the correlation between the two outcomes and a bridge distribution was assumed for the random effect. Under this assumption, the marginal functional shape is logistic and regression parameters have an explicit marginal interpretation. In addition, with a simple transformation, likelihood inference can be obtained for either marginal or conditional regression inference within a single model framework. A brief description of the joint model formulation is as follows:

The model conditional on random intercept has the following form:

$$logit\{Pr\left(Y_{ij}=1|b_i,\boldsymbol{X}_{ij}\right)\}=b_i+\boldsymbol{\alpha}_j^T\boldsymbol{X}_{ij} \quad ...(01)$$

where the Y_{ij} is the j^{th} outcome for the i^{th} individual (i = 1, 2, ..., n, j = 1 or 2), $\boldsymbol{X}_{ij}$ are the vectors of covariates associated with j^{th} outcome and $\boldsymbol{\alpha}_j$ are the corresponding vectors of regression coefficients. The marginal probability has the form,

$$Pr\left(Y_{ij}=1\right)=\int\frac{exp\left(b_i+\boldsymbol{\alpha}_j^T\boldsymbol{X}_{ij}\right)}{1+exp\left(b_i+\boldsymbol{\alpha}_j^T\boldsymbol{X}_{ij}\right)}dF(b_i) \quad ...(02)$$

where, $F(.)$ is the bridge distribution function. The bridge density function for the logit link is,

$$f(b_i)=\frac{1}{2\pi}\frac{sin\ (\phi\pi)}{cosh\ (\phi b_i)+cos\ (\phi\pi)}$$

$$(0<\ \phi<1,-\infty<\ b_i<\infty) \quad ...(03)$$

with $\phi=\left(1+\frac{3}{\pi^2}d\right)^{-1/2}$ and d the random-intercept variance (Wang & Louis, 2003).

With the above bridge distribution for the random effects, the marginal distribution can be modelled directly by,

$$logit\{Pr\left(Y_{ij}=1\right)\}=\boldsymbol{\alpha}_{mj}^T\boldsymbol{X}_{ij} \quad ...(04)$$

where $\boldsymbol{\alpha}_{mj}$ measures a marginal regression effect associated with the covariate X_{ij} for the j^{th} outcome. The relationships of regression parameters between conditional and marginal regression models are given by

$$\boldsymbol{\alpha}_{mj}=\frac{\boldsymbol{\alpha}_j}{\sqrt{(1+3d/\pi^2)}} \quad ...(05)$$

RESULTS AND DISCUSSION

Descriptive statistics

Around 76% of the respondents indicated that the Y1 statement is false, while approximately 79% of the respondents stated that the Y2 statement is false (Table 1). This indicates that the majority of ever married women were aware about two prominent HIV/AIDS transmission misconceptions. Table 2 presents a summary of the composition of the sample of women considered by the study with respect to residential sector, region

Table 2: Composition of the sample considering respondents' Residence, Region, Religion, Age, Current marital status, Highest educational qualification, Have given birth, Working status, and Wealth index.

Variable	Count	Percent (%)
Residence		
Estate	334	2.83
Rural	9467	80.17
Urban	2007	17.00
Region		
Central	1177	9.97
Eastern	1076	9.11
North Central	847	7.17
North Eastern	1363	11.54
Northern	1335	11.31
Sabaragamuwa	1276	10.81
Southern	1465	12.41
Uva	794	6.72
Western	2475	20.96
Religion		
Buddhist	8150	69.02
Hindu	1606	13.60
Islam	1001	8.48
Other	167	1.41
Roman Catholic	884	7.49
Age group (years)		
15-19	112	0.95
20-24	838	7.10
25-29	1761	14.91
30-34	2487	21.06
35-39	2619	22.18
40-44	2096	17.75
45-49	1895	16.05
Current marital state		
Currently married	10760	91.12
Living with a man	450	3.18
Other	598	5.06
Highest education qualification		
Degree and above	744	6.30
Passed G.C.E.(A/L) or equivalent	2910	24.64
Passed G.C.E.(O/L) or equivalent	2917	24.70
Passed Grade 6-10	4711	39.90
Passed Grade 1-5	460	3.90
No Schooling	66	0.56
Have you ever given birth		
No	1193	10.10
Yes	10615	89.90
Working status		
No	7885	66.78
Yes	3923	33.22
Wealth Index		
Lowest	2049	17.35
Second	2258	19.12
Middle	2428	20.56
Fourth	2532	21.44
Highest	2541	21.52

of the residence, current marital status, religion of the respondent, wealth index group, current working status, age, highest educational qualification and whether the respondent has given birth before. In the sample, of respondents, around 80% were from rural sector and 3% were from estate sector. In terms of the province where respondents resided, a majority were from Western province (21%) and the smallest number of respondents were from Uva province (7%). More than 91% of the ever-married women were currently married and around 5% of the ever-married women in the sample were not in the union, or were widowed, divorced, or separated. Around 90% of the respondents had given birth. Considering the religiosity of the respondents, the majority were Buddhist (69%), and among the others 14% and 9% of the respondents were Hindu and Islamic devotees, respectively. Out of the ever-married women in the sample, 33% were engaged in jobs. Considering the age of the respondents, 8% belonged to the age group of 15–24 years and 34% were 40 years or above. Regarding the highest educational level of the respondents, 25% have successfully passed G.C.E.(O/L) examination, 25% have successfully passed G.C.E.(A/L) examination and 6% have attained a degree or higher qualification. It is worth mentioning that approximately 4% of the respondents had received education only up to grade 5.

It has been observed in previous studies, *e.g.*, by Agegnehu and Tesema (2020), that exposure to mass media is significantly associated with awareness of misconceptions of HIV/AIDS and also the comprehensive knowledge of HIV/AIDS. The reason for this observation is obvious since mass media (radio, television, and newspaper) is the main source of information, and the most powerful way of addressing a large group of people to change the community awareness, attitude, and practice towards HIV/AIDS. In the SLDHS 2016, exposure to mass media of ever married women was measured by three questions: (1) Frequency of reading newspapers (at least once a week, less than once a week, and not at all) (2) Frequency of watching television (at least once a week, less than once a week, and not at all) and (3) Frequency of listening to radio (at least once a week, less than once a week, and not at all). Table 3 illustrates the cross tabulation of exposure to mass media and two misconceptions Y1 and Y2. The awareness of two misconceptions of transmission of HIV/AIDS were higher among the ever-married women who read newspapers, who watched television and who listened radio, than among the ones who did not perform those activities at all.

Analysis based on two independent binary logistic regression models

The significant predictors for Y1 or Y2, identified using Chi squared test, included the following categorical variables: age group (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49), place of residence (estate, rural, and urban), province (Central, Eastern, Northern, North Central, North Eastern, Sabaragamuwa, Southern, Uva, and Western), respondent's education (never schooled, passed grade 1–5, passed grade 6–10, passed G.C.E. (O/L), passed G.C.E. (A/L), degree and above), wealth index (lowest, second, middle, fourth, and highest),

Table 3: Distribution of frequency of reading newspapers, watching television and listening to radio for the two response variables (Y1 and Y2).

Variable	Total (column %)	Y1 (row %)		Y2 (row %)	
		Right	Wrong	Right	Wrong
Frequency of reading newspapers					
At least once a week	5553 (47.00%)	1185 (21.3%)	4368 (78.7%)	920 (16.6%)	4633 (83.4%)
Less than once a week	3807 (32.30%)	881 (23.1%)	2926 (76.8%)	820 (21.5%)	2987 (78.5%)
Not at all	2448 (20.70%)	746 (30.5%)	1702 (69.5%)	732 (29.9%)	1716 (70.1%)
Frequency of watching television					
At least once a week	9691 (82.00%)	2270 (23.4%)	7421 (76.6%)	1857 (19.2%)	7834 (80.8%)
Less than once a week	1291 (11.00%)	290 (22.5%)	1001 (77.5%)	337 (26.1%)	954 (73.9%)
Not at all	826 (7.00%)	252 (30.5%)	574 (69.5%)	278 (33.7%)	548 (66.3%)
Frequency of listening to radio					
At least once a week	6092 (51.60%)	1475 (24.2%)	4617 (75.8%)	1200 (19.7%)	4892 (80.3%)
Less than once a week	2686 (22.70%)	559 (20.8%)	2127 (79.2%)	538 (20.0%)	2148 (80.0%)
Not at all	3030 (25.70%)	778 (25.7%)	2252 (74.3%)	734 (24.7%)	2296 (75.8%)

religion (Buddhist, Hindu, Islam, Roman Catholic, and other), working status (yes, no), exposure to mass media and current marital status (currently married, living with man, not in union) and ever given birth (yes, no).

The correct answer for each statement, Y1 and Y2, was considered a 'success' outcome, while giving the wrong answer was considered a 'failure' outcome. Logistic models were utilized to estimate the probability of success for each statement, Y1 and Y2, separately. Table 4 provides a summary of the significant explanatory variables (at a 10% level of significance) for each response variable, indicating their significant impact on the knowledge of HIV spread among ever-married women in the reproductive age group in Sri Lanka.

Results of the joint model

All predictors mentioned in Table 4 were included into the joint model as discussed. However, it was noted that the three predictors related to the exposure to mass media of ever married women were highly associated with each other, and hence the joint model including these three predictors (after adjusting for other predictors stated in Table 4) led to unrealistic conclusions due to problem of multicollinearity. To avoid high collinearity among these three predictors, the predictor variable of frequency of listening to radio was dropped from the model.

Table 4: Significant explanatory variables in the fitted binary logistic models.

Response variables	Significant explanatory variables (under 10% level of significance)
People can get HIV virus from mosquito bites (Y1)	Province Highest education qualification Frequency of reading newspaper Frequency of listening to radio Religion Wealth index
Someone can get the HIV virus by sharing food with a HIV infected person (Y2)	Residence Province Current marital state Highest education qualification Frequency of watching television Frequency of reading newspaper Religion Age group Wealth index

Interestingly, in the joint model, the predictors 'age' and 'residence' became significant for the response variable Y1 which was not significant individually (Table 4). It was stimulating to find out that when the two responses (Y1 and Y2) were jointly modelled, still current marital status no longer appeared as significant for Y1 at the 5% level of significance, but it is momentous at the 10% level of significance (p value = 0.068); therefore, we decided to keep it in the model. According to the fitted joint model, ever married woman's residence area, province, age group, level of education, religion, current marital status, wealth index, frequency of reading newspapers and frequency of watching television were statistically associated with the knowledge of two prominent misconceptions of HIV/ AIDS. The regression coefficients (standard errors) of the joint model for two outcomes alone with odds ratios are presented in Table 5.

Women residing in urban areas had 1.3 times higher odds of possessing knowledge regarding the statement 'people can get HIV from mosquito bites,' and 1.4 times higher odds of knowledge regarding the statement 'HIV can be transmitted by sharing food with an infected person', compared to women residing in the estate sector. On the other hand, women in the Central province, which is relatively more ethnically diverse, had lower odds (0.811 and 0.801) of providing the correct answer for the statements regarding 'HIV transmission through mosquito bites' and 'sharing food with an infected person', respectively, compared to women in the Sabaragamuwa province, which is relatively less ethnically varied. When considering the age of the respondents, it was observed that women belonging to the 25–29 and 30–34 age groups exhibited decreased odds of giving the correct answer for the statement 'people can get HIV from mosquito bites' by 24% and 17%, respectively, compared to women in the 45–49 age group. However, for the second statement 'someone can get HIV by sharing food with an HIV-infected person,' it was observed that women belonging to the 35–39 and 40–44 age groups had an increased odds of giving the right answer by 23% and 18%, respectively, compared to women in the 45–49 age group. When considering the highest education level, women who had never been schooled had 77.6% lower odds of giving the correct answer for the statement 'people may get infected with HIV virus from mosquito bites' compared to women with a degree or above educational qualifications. Similarly, compared to the highest education level, women who had never been schooled had 59.5% lower odds of giving the correct answer for the statement 'HIV can be transmitted by sharing food with an HIV-

Table 5: Parameter estimates (standard errors) and odds ratios (95% confidence interval) with respect to the reference category for the joint model of Y1 and Y2.

Variable (Reference category)	Y1 (People can get HIV virus from mosquito bites)		Y2 (Someone can get HIV virus by sharing food with HIV infected person)	
	Regression coefficient (standard error)	Odds ratio (95% confidence interval)	Regression coefficient (standard error)	Odds ratio (95% confidence interval)
Residence (Estate)				
Urban	0.262 (0.121)*	1.300 (1.025, 1.647)	0.346 (0.156)*	1.413 (1.041, 1.919)
Rural	0.274 (0.139)*	1.315 (1.002, 1.727)	0.337 (0.143)*	1.401 (1.058, 1.854)
Province (Sabaragamuwa province)				
Western	0.012 (0.087)	1.012 (0.853, 1.200)	-0.034 (0.098)	0.967 (0.798, 1.171)
Central	-0.210 (0.094)*	0.811 (0.674, 0.975)	-0.222 (0.105)*	0.801 (0.652, 0.984)
Southern	0.150 (0.094)	1.162 (0.966, 1.397)	0.387 (0.112)*	1.473 (1.182, 1.834)
Northern	0.390 (0.119)*	1.477 (1.17, 1.865)	-0.299 (0.121)*	0.742 (0.585, 0.94)
Eastern	0.052 (0.108)	1.053 (0.852, 1.302)	-0.352 (0.113)*	0.703 (0.564, 0.878)
North Eastern	0.047 (0.094)	1.048 (0.872, 1.260)	0.016 (0.105)	1.016 (0.827, 1.248)
North Central	0.925 (0.125)*	2.522 (1.974, 3.222)	0.593 (0.132)*	1.809 (1.397, 2.344)
Uva	0.043 (0.107)	1.044 (0.846, 1.288)	-0.073 (0.117)	0.93 (0.739, 1.169)
Age group (45-49 years)				
15-19	-0.382 (0.219)	0.682 (0.444, 1.048)	-0.155 (0.128)	0.856 (0.666, 1.101)
20-24	-0.119 (0.102)	0.888 (0.727, 1.084)	-0.065 (0.103)	0.937 (0.766, 1.147)
25-29	-0.275 (0.082)*	0.76 (0.647, 0.892)	0.129 (0.088)	1.138 (0.958, 1.352)
30-34	-0.182 (0.076)*	0.834 (0.718, 0.968)	0.147 (0.081)	1.158 (0.988, 1.358)
35-39	-0.138 (0.075)	0.871 (0.752, 1.009)	0.204 (0.079)*	1.226 (1.050, 1.432)
40-44	-0.114 (0.077)	0.892 (0.767, 1.038)	0.164 (0.082)*	1.178 (1.003, 1.384)
Religion (Buddhist)				
Roman Catholic	0.029 (0.095)	1.029 (0.855, 1.240)	-0.272 (0.099)*	0.762 (0.628, 0.925)
Islam	-0.312 (0.085)*	0.732 (0.62, 0.865)	-0.719 (0.087)*	0.487 (0.411, 0.578)
Hindu	-0.325 (0.093)*	0.723 (0.602, 0.867)	-0.669 (0.093)*	0.512 (0.427, 0.615)
Other	-0.122 (0.188)	0.885 (0.612, 1.28)	-0.385 (0.191)*	0.684 (0.468, 0.989)
Highest education qualification (Degree and above)				
Never schooled	-1.494 (0.287)*	0.224 (0.128, 0.394)	-0.903 (0.307)*	0.405 (0.222, 0.74)
Passed Grade 1-5	-1.335 (0.154)*	0.263 (0.195, 0.356)	-1.455 (0.173)*	0.233 (0.166, 0.328)
Passed Grade 6-10	-0.608 (0.115)*	0.544 (0.435, 0.682)	-0.969 (0.137)*	0.379 (0.290, 0.496)
Passed G.C.E.(O/L)	-0.438 (0.115)*	0.645 (0.515, 0.809)	-0.552 (0.139)*	0.576 (0.439, 0.756)
Passed G.C.E.(A/L)	-0.152 (0.114)	0.859 (0.687, 1.074)	-0.203 (0.140)	0.816 (0.620, 1.074)
Current marital state (Not in union/Husband died/Divorced/Separated				
Currently married	0.031 (0.099)	1.031 (0.85, 1.252)	-0.113 (0.105)	0.893 (0.727, 1.097)
Living with a man	0.321 (0.155)	1.379 (1.017, 1.868)	0.317 (0.174)	1.373 (0.976, 1.931)
Wealth Index (Highest)				
Lowest	-0.290 (0.093)*	0.748 (0.624, 0.898)	-0.514 (0.101)*	0.598 (0.491, 0.729)
Second	-0.212 (0.081)*	0.809 (0.690, 0.948)	-0.481 (0.091)*	0.618 (0.517, 0.739)
Middle	-0.148 (0.078)	0.862 (0.740, 1.005)	-0.113 (0.098)	0.893 (0.737, 1.082)
Fourth	-0.160 (0.074)*	0.852 (0.737, 0.985)	-0.178 (0.087)*	0.837 (0.706, 0.993)
Frequency of reading newspaper (Not at all)				
At least once a week	0.189 (0.063)*	1.208 (1.068, 1.367)	0.261 (0.067)*	1.298 (1.139, 1.480)
Less than once a week	0.162 (0.064)*	1.176 (1.037, 1.333)	0.061 (0.067)	1.063 (0.9321, 1.212)
Frequency of watching TV (Not at all)				
At least once a week	0.342 (0.087)*	1.408 (1.187, 1.67)	0.371 (0.089)*	1.449 (1.217, 1.725)
Less than once a week	0.233 (0.108)*	1.262 (1.022, 1.56)	0.178 (0.109)	1.195 (0.965, 1.479)
Constant	1.341 (0.240)		1.751 (0.261	
Standard deviation of the random effect $\sqrt{d}$			1.377 (0.049)	

* Refers to significance at 5% level of significance

infected person. It is interesting to note that the odds of providing a correct response for both misconceptions tends to decrease as the level of education decreases. When considering the frequency of reading newspapers, women who read newspapers at least once a week had increased odds of giving the correct answers for both statements, 'people can get HIV virus from mosquito bites' and 'HIV can be transmitted by sharing food,' by 21% and 30%, respectively, compared to women who never read newspapers or cannot read. Similarly, women who watched television at least once a week had increased odds of giving the correct answers for both statements, by 41% and 45%, respectively, compared to women who never read newspapers or are illiterate. The odds of giving correct answers for both misconceptions tended to increase with the wealth index of ever-married women. In terms of religion, Hindu and Islamic followers had lower odds of giving the right answers for both misconceptions compared to Buddhist followers. Ever-married women who were living with a partner were more likely to have knowledge about both misconceptions compared to women who were divorced, separated, or widowed.

Related literature also supports these findings. Asaduzzaman *et al.* (2016) found that exposure to different types of media (radio, newspapers/magazines, television) was significantly associated with awareness of HIV/AIDS. Similarly, Haque *et al.* (2018) found that education status, mass media access, place of residence, and working status played significant roles in the perception of HIV/AIDS among married women in Bangladesh. A study conducted by Kanda *et al.* (2010) among the general population in Kandy, Sri Lanka, revealed significant associations between knowledge of HIV/AIDS and gender, marital status, education, religion, and residence. The SLDHS 2016 report also indicated that urban and rural ever-married women had very high awareness about HIV/AIDS (94% for both groups), while only 60% of their counterparts living in estate areas were aware of HIV/AIDS. Furthermore, the report stated that knowledge of HIV prevention and transmission was higher among currently married women compared to those who were divorced, separated, or widowed.

In this study, we proposed a joint model to model two binary outcomes under the generalized linear mixed model (GLMM) framework. We incorporated the shared random effect to capture the correlation between two responses and assumed bridge distribution for the random effect, which in turn has the flexibility of marginal interpretation of regression coefficients. Modelling two misconceptions about HIV/AIDS jointly is more appropriate than separate fitting of models that ignore the dependence between two outcomes. The Pearson Chi-squared test of independence between two responses Y1 and Y2 was statistically significant, thereby indicating that the women who believe Y1 are more likely to believe Y2 as well (Chi-Squared value = 677.476, p-value < 0.0001). This was concluded by our model since the variance of the random intercept was different from zero ($\sqrt{d}$ = 1.377, p value < 0.0001).

The study has also several strengths compared to previous studies. First, the correlation between two misconceptions about HIV/AIDS was taken into consideration in our analytic approach. Second, following Wang and Louis (2003), our model parameters have marginal interpretations and hence, marginal odds ratios. A similar study has been conducted by Samarakoon *et al.* (2020) for the awareness of misconceptions of HIV/AIDS among trainees in vocational centres in Sri Lanka, but their model parameters originally do not have marginal interpretation. Third, our study covered a large population-based study, enhancing its generality to all married women in Sri Lanka.

CONCLUSIONS

In this study, we focused on investigating the factors associated with two prominent misconceptions about HIV/AIDS among ever-married women in the reproductive age (15–49) who have heard about HIV/AIDS. The data used for the analysis were collected through the SLDHS 2016 conducted by DCS. The two misconceptions under scrutiny were: 1) the belief that people can acquire the HIV virus from mosquito bites, and 2) the belief that someone can contract the HIV virus by sharing food with an HIV-infected person. The study aimed to explore the correlation between these two misconceptions while jointly modelling them by incorporating a shared random intercept into the logistic regression model. To interpret the parameter estimates, a bridge distribution was assumed for the random intercept, allowing for marginal interpretation. The joint model analysis revealed that a woman's residence area, province, age group, level of education, religion, current marital status, wealth index, frequency of reading newspapers, and frequency of watching television are significantly related to the awareness of the above two prominent misconceptions among ever-married women.

Limitations

The main limitation of this study is restraining measurement of women's awareness on HIV/AIDS into selected variables of which most are relevant to only the woman's residence area, province, age group, level of education, religion, current marital status, wealth index, frequency of reading newspapers and frequency of watching television. However, the education level and work experience of the husband too may be vital regarding awareness of disease or infection. The kinship, friendship, and neighbourhood relationships have been identified as crucial regarding determinants of disease spread in Sri Lanka. This research also could have been more successful if there were data provisions to comprehend women's knowledge on HIV/AIDS with regard to other aspects such as all supplementary types of STDs and maternity healthcare. Therefore, future researchers can consider these aspects too when designing the study, which will consequently allow them to arrive at more valid and applicable conclusions.

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Data availability

Demographic and Health Survey, 2016 dataset is not in the public domain and is the property of the Department of Census and Statistics, Sri Lanka. However, data can be obtained through a written request to the Department of Census and Statistics, Sri Lanka.

Ethical approval

The Sri Lanka Demographic and Health Survey obtained written informed consent from all the participants during the data collection. The survey secured ethical clearance from the Sri Lanka Medical Association - Ethics review committee. All methods were performed in accordance with the relevant guidelines and regulations (Declaration of Helsinki). Permission was obtained to analyse this data from the Department of Census and Statistics in Sri Lanka.

Conflict of interest

No potential conflict of interest was reported by the author(s).

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Appendix

SAS Code used for the analysis of data:

```
proc nlmixed data=sample3;
pi=3.1415926535897931;
parms beta10=1.348 beta11=0.256 beta12=0.278 beta13=-0.009 beta14=-0.219 beta15=0.140 beta16=0.373
beta17=0.022 beta18=0.034 beta19=0.889 beta110=0.028 beta111=-0.115 beta112=0.018 beta113=-0.324 beta114=-
0.319 beta115=-0.389 beta116=-0.107 beta117=-0.278 beta118=-0.171 beta119=-0.135 beta120=-0.124 beta121=0.035
beta122=0.341 beta123=-1.482 beta124=-1.337 beta125=-0.616 beta126=-0.436 beta127=-0.151 beta128=0.191
beta129=0.166 beta130=0.141 beta131=0.250 beta132=-0.079 beta133=0.145 beta134=-0.219 beta135=-0.295
beta136=-0.153 beta137=-0.163 beta20=1.754 beta21=0.366 beta22=0.343 beta23=-0.051 beta24=-0.229 beta25=0.385
beta26=-0.310 beta27=-0.375 beta28=0.008 beta29=0.552 beta210=-0.087 beta211=-0.387 beta212=-0.294 beta213=-
0.733 beta214=-0.668 beta215=-0.155 beta216=-0.054 beta217=0.126 beta218=0.157 beta219=0.206 beta220=0.151
beta221=-0.105 beta222=0.355 beta223=-0.885 beta224=-1.443 beta225=-0.964 beta226=-0.535 beta227=-0.189
beta228=0.260 beta229=0.063 beta230=0.371 beta231=0.193 beta232=-0.053 beta233=0.059 beta234=-0.529
beta235=-0.495 beta236=-0.124 beta237=-0.184 s1=2;
uni = probnorm(b/s1);
phi = 1.0/sqrt(1+3/pi/pi*s1*s1);
B1 = 1/phi*log(sin(pi*uni*phi)/sin(phi*pi*(1-uni)));


if Y=”Y1” then do;
tmp1 = beta10 + beta11*resurb + beta12*resrur + beta13*prov1 + beta14*prov2 + beta15*prov3 + beta16*prov4
+ beta17*prov5 + beta18*prov6 + beta19*prov7 + beta110*prov8 + beta111*reli1 + beta112*reli2 + beta113*reli3
+ beta114*reli4 + beta115*age1 + beta116*age2 + beta117*age3 + beta118*age4 + beta119*age5 + beta120*age6
+ beta121*currmari1 + beta122*currmari2 + beta123*highedu1 + beta124*highedu2 + beta125*highedu3
+ beta126*highedu4 + beta127*highedu5 + beta128*rednews1 + beta129*rednews2 + beta130*watchtel1 +
beta131*watchtel2 + beta132*lisradio1 + beta133*lisradio2 + beta134*wi1 + beta135*wi2 + beta136*wi3 +
beta137*wi4;
expeta1 = exp(B1+tmp1);
p1 = expeta1/(1+expeta1);
ll = response*log(p1) + (1-response)*log(1-p1);
end;

if Y=”Y2” then do;
tmp2 = beta20 + beta21*resurb + beta22*resrur + beta23*prov1 + beta24*prov2 + beta25*prov3 + beta26*prov4 +
beta27*prov5 + beta28*prov6 + beta29*prov7 + beta210*prov8 + beta211*reli1 + beta212*reli2 + beta213*reli3
+ beta214*reli4 + beta215*age1 + beta216*age2 + beta217*age3 + beta218*age4 + beta219*age5 + beta220*age6
+ beta221*currmari1 + beta222*currmari2 + beta223*highedu1 + beta224*highedu2 + beta225*highedu3
+ beta226*highedu4 + beta227*highedu5 + beta228*rednews1 + beta229*rednews2 + beta230*watchtel1 +
beta231*watchtel2 + beta232*lisradio1 + beta233*lisradio2 + beta234*wi1 + beta235*wi2 + beta236*wi3 +
beta237*wi4;
expeta2 = exp(B1+tmp2);
p2 = expeta2/(1+expeta2);
ll = response*log(p2) + (1-response)*log(1-p2);
end;

model zz ~ general(ll);
random b ~ normal(0,s1*s1) subject=woman_id;
run;
```