Depression Prevalence Estimation Using An Imperfect Diagnostic Depression Screening Tool in NHANES (The National Health and Nutrition Examination Survey)

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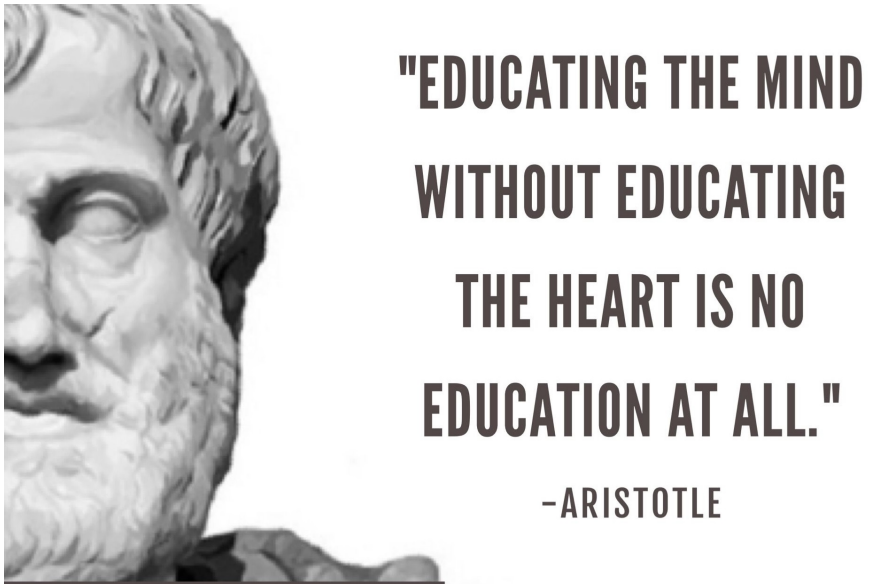
Outline



Motivation and Overview

Depression is a common and disabling mental disorder. In order to develop targeted public health interventions, accurate data about depression prevalence is important.

Establishing a diagnosis of major depressive disorder for a single respondent is time consuming and costly, as experienced psychiatrists are needed to conduct the diagnostic gold standard of an semi-structured clinical interview.

Motivation and Overview

Population based surveys such as the National Health and Nutrition Examination Survey (NHANES) in the US, do not employ semi-structured clinical interviews, but rely on depression screening tools such as the PHQ-9.

Motivation and Overview

Aims:

1. The study is to apply Bayesian Latent Class Models to the NHANES Depression Screening data in order to obtain prevalence estimates for major depressive disorder in the US general population corrected for imperfect diagnostic accuracy of the PHQ-9
2. Investigate time trends of major depressive disorder prevalence in the US between the NHANES Waves 2005/06 and 2017/20.
3. Provide reproducible code for the analysis in order to allow other researchers to conduct similar analysis more easily.

Materials and Methodology

The Health and Nutrition Examination Survey (NHANES) is unique among nationwide health surveys in the United States, combining in-person interviews with standardized physical examination and laboratory tests. Since 1999, NHANES has operated as continuous survey, and nationally representative data have been released in 2 year cycles.

Materials and Methodology

Patient Health Questionnaire-9 (PHQ-9) is a well-known and often used measure of depressive symptoms and can be used to assess (significant) depressed mood.

Each item was scored on a 0-3 scale The total score of PHQ-9 ranged from 0 to 27,with scores $\geq$ 10 representing clinically significant depressive symptom and were categorized as “none or minimum” (0-4), “mild” (5-9), “moderately several” (10-14), and “severe” (20-27) for depression severity.

Materials and Methodology

PHQ-9 for each Cut-Off in NHANES (2005-2020)

PHQ-9 Cut Off	Population(N)	Cases (Major Depression) (n)
PHQ-9 $\geq$ 5	8301	2192
PHQ-9 $\geq$ 6	8301	1783
PHQ-9 $\geq$ 7	8301	1457
PHQ-9 $\geq$ 8	8301	1205
PHQ-9 $\geq$ 9	8301	972
PHQ-9 $\geq$ 10	8301	788
PHQ-9 $\geq$ 11	8301	631
PHQ-9 $\geq$ 12	8301	507
PHQ-9 $\geq$ 13	8301	413
PHQ-9 $\geq$ 14	8301	349
PHQ-9 $\geq$ 15	8301	279

Materials and Methodology

The observed number of the test positive y, out of the n tested individuals is assumed to follow a binomial distribution.

$y \sim \mathsf{Binom}(n, p)$

Materials and Methodology

Where p is the probability of observing positive test. Positive tests are either true od false positive. The positive test is modelled as function of prevalence of major depressive disorder(Prev), sensitivity (Sen) and specificity (Spe) of the diagnostic test:

p= TP+ FP = Sen * Prev + (1-Spe)*(1-Prev)

Materials and Methodology

Bayesian framework

We express such a prior information about model parameters in terms of prior distribution. We investigated prevalence, sensitivity, specificity in 2017-2020 for all cut off points (Cut off 5-6-7-8-9-10-11-12-13-14-15). We established multivariate normal models with prior information in semi structured, fully and general population meta-analysis results by Levis et al. (2020).

$$\begin{pmatrix} logit(Sen) \\ logit(Sen) \end{pmatrix} \sim N\left[\begin{pmatrix} \beta_1 \\ \beta_0 \end{pmatrix}, \begin{pmatrix} \tau_1^2 & \tau_1\tau_0\rho \\ \tau_1\tau_0\rho & \tau_0^2 \end{pmatrix}\right].$$

Materials and Methodology

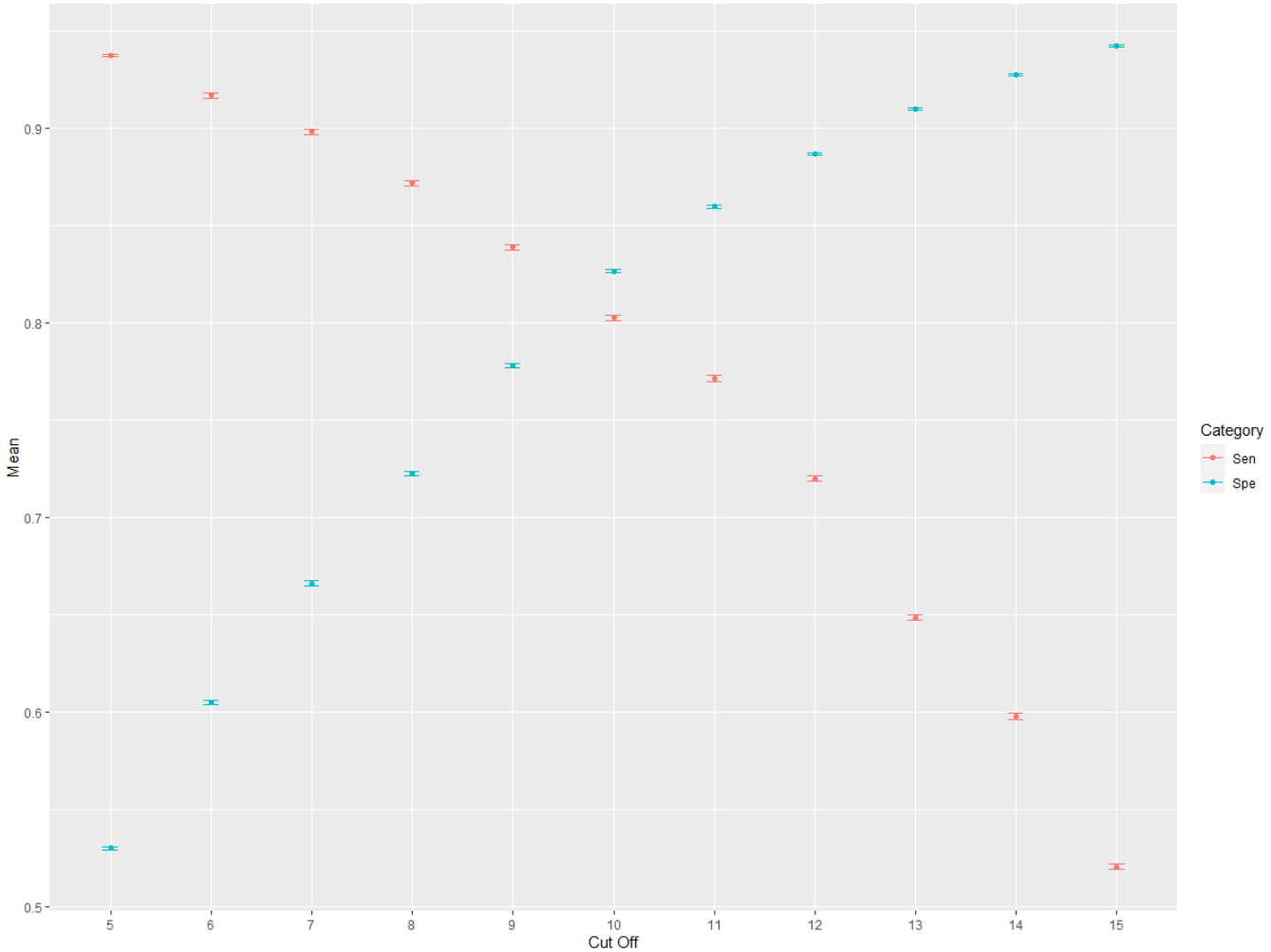


Figure 1: Sensitivity and Specificity Prior Distribution

Materials and Methodology

We used uninformative and informative prior for prevalence

- Uninformative
  $Prev \sim B(1,1)$

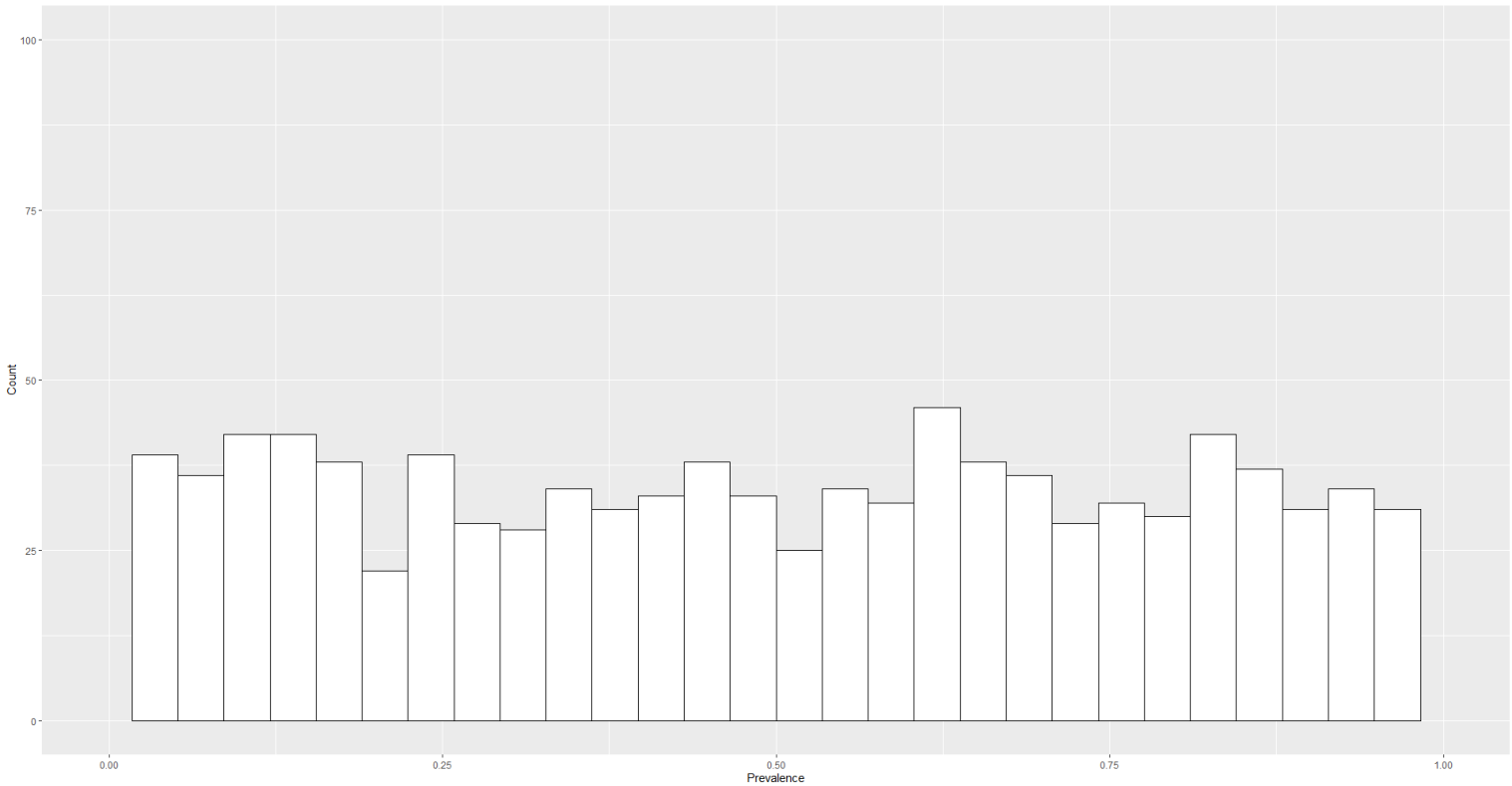


Figure 2: B(1,1)

Materials and Methodology

- Median = 0.025, Upper = 0.05 (very sure depression prevalence is very low)

$Prev \sim B(4.53, 163.96)$

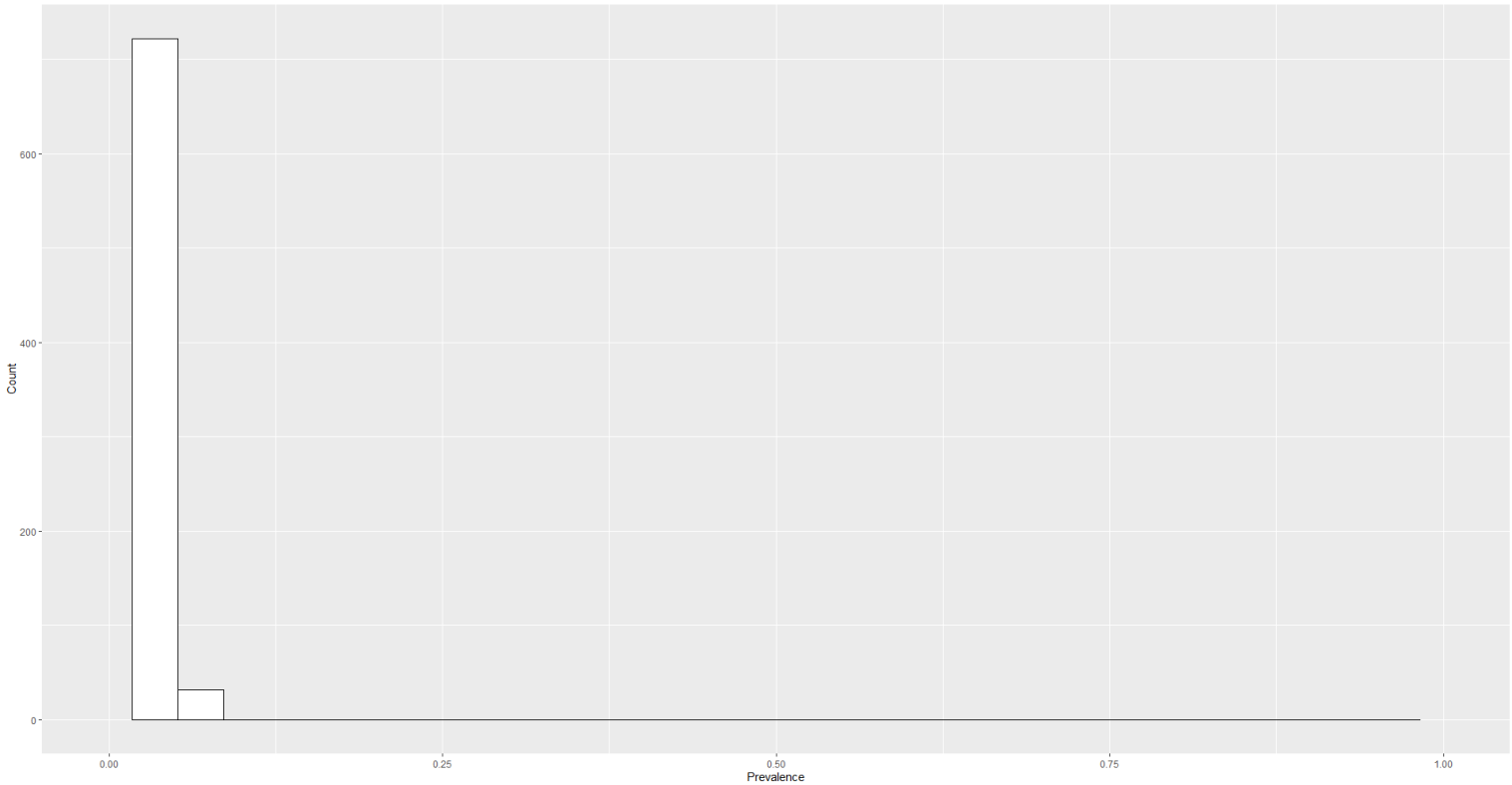


Figure 3: B(4.53,163.96)

Materials and Methodology

- Median = 0.025, Upper = 0.15 (less sure depression prevalence is very low)

$Prev \sim B(0.71, 14.89)$

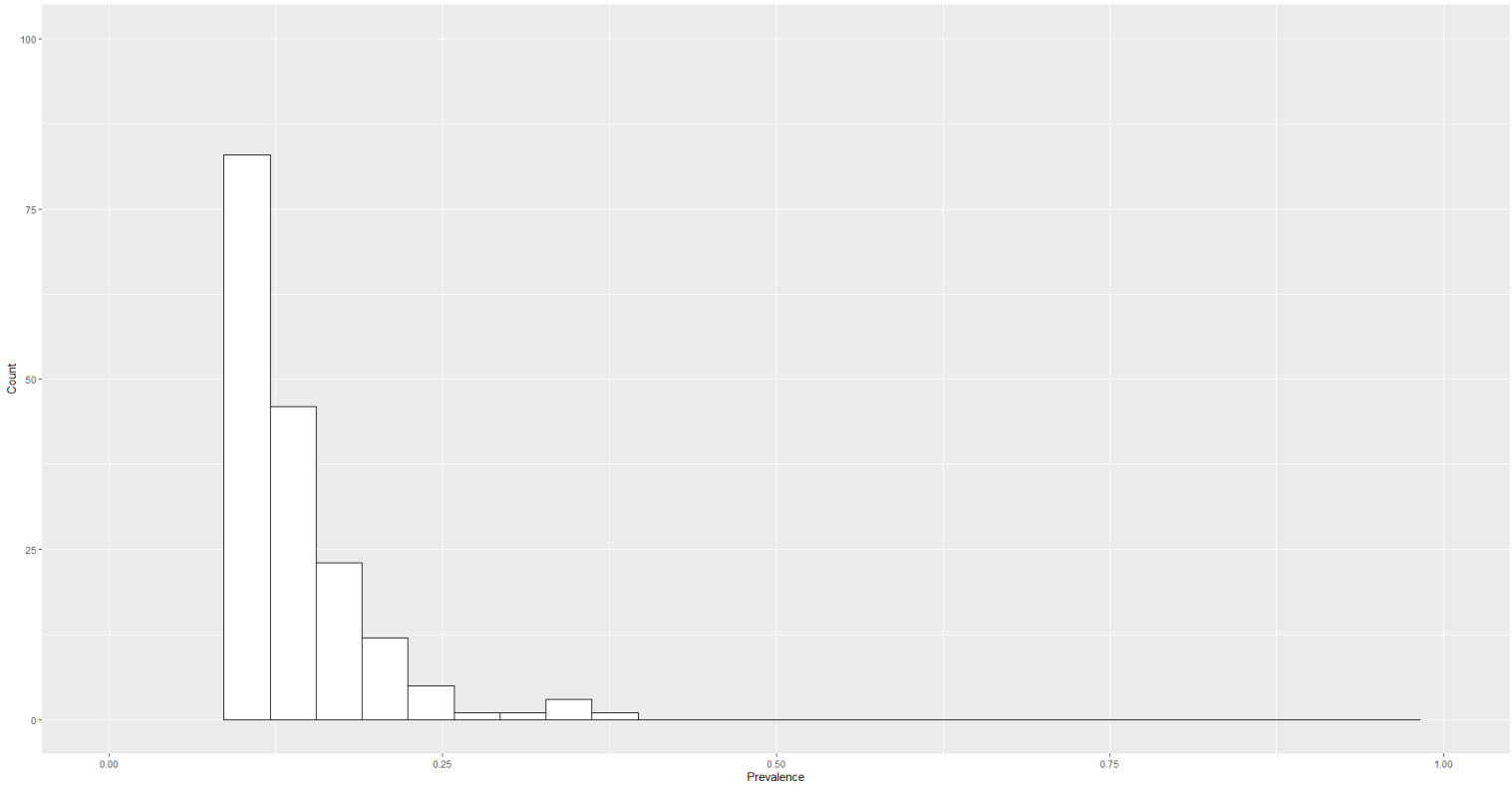


Figure 4: B(0.71,14.89)

Materials and Methodology

- Median = 0.05, Upper = 0.15 (less sure depression prevalence is higher)

$Prev \sim B(1.65, 25.26)$

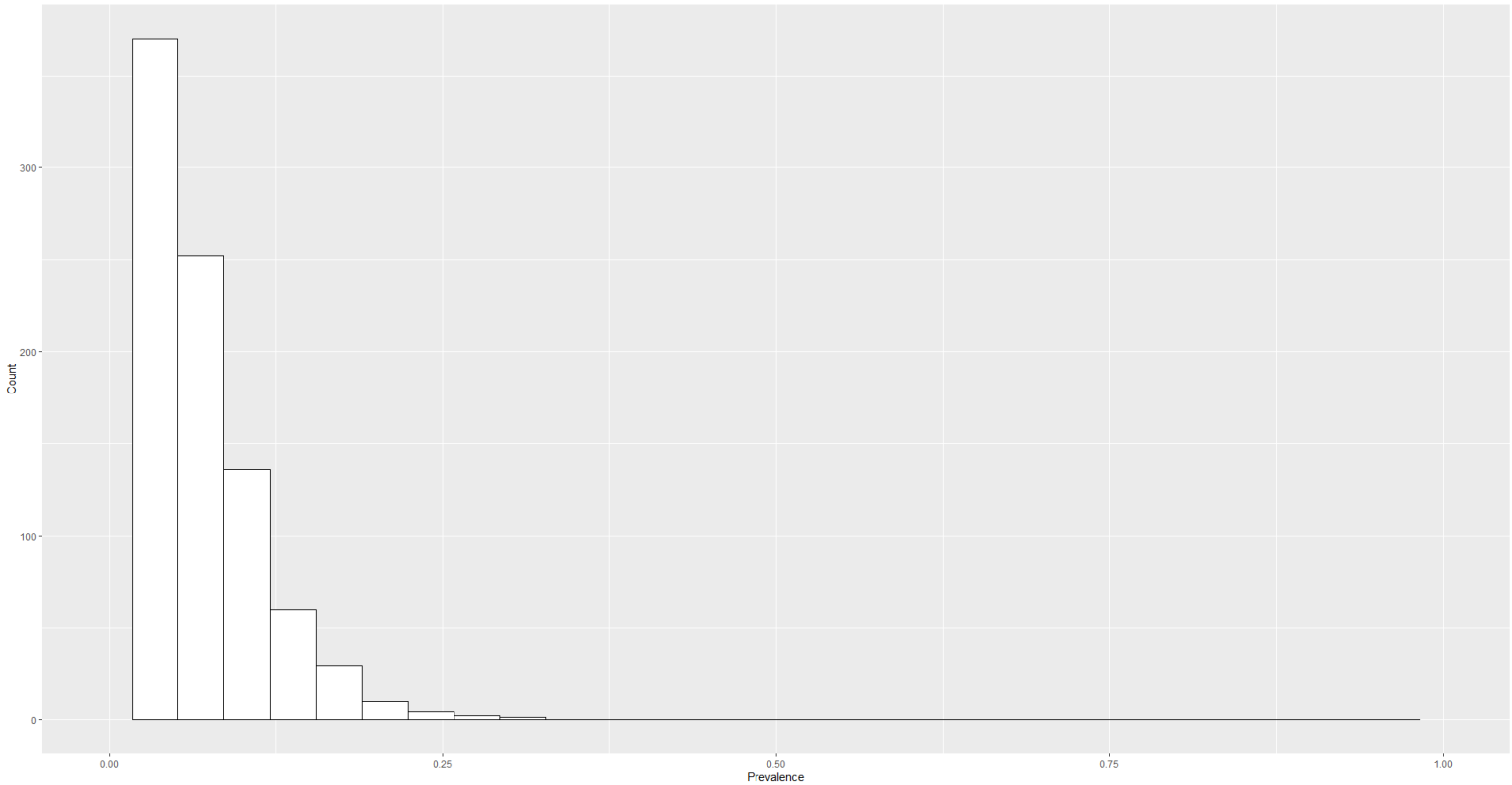


Figure 5: B(1.65,25.26)

Materials and Methodology

- Median = 0.10, Upper = 0.20 (prevalence rather high)

$Prev \sim B(3.99, 33.22)$

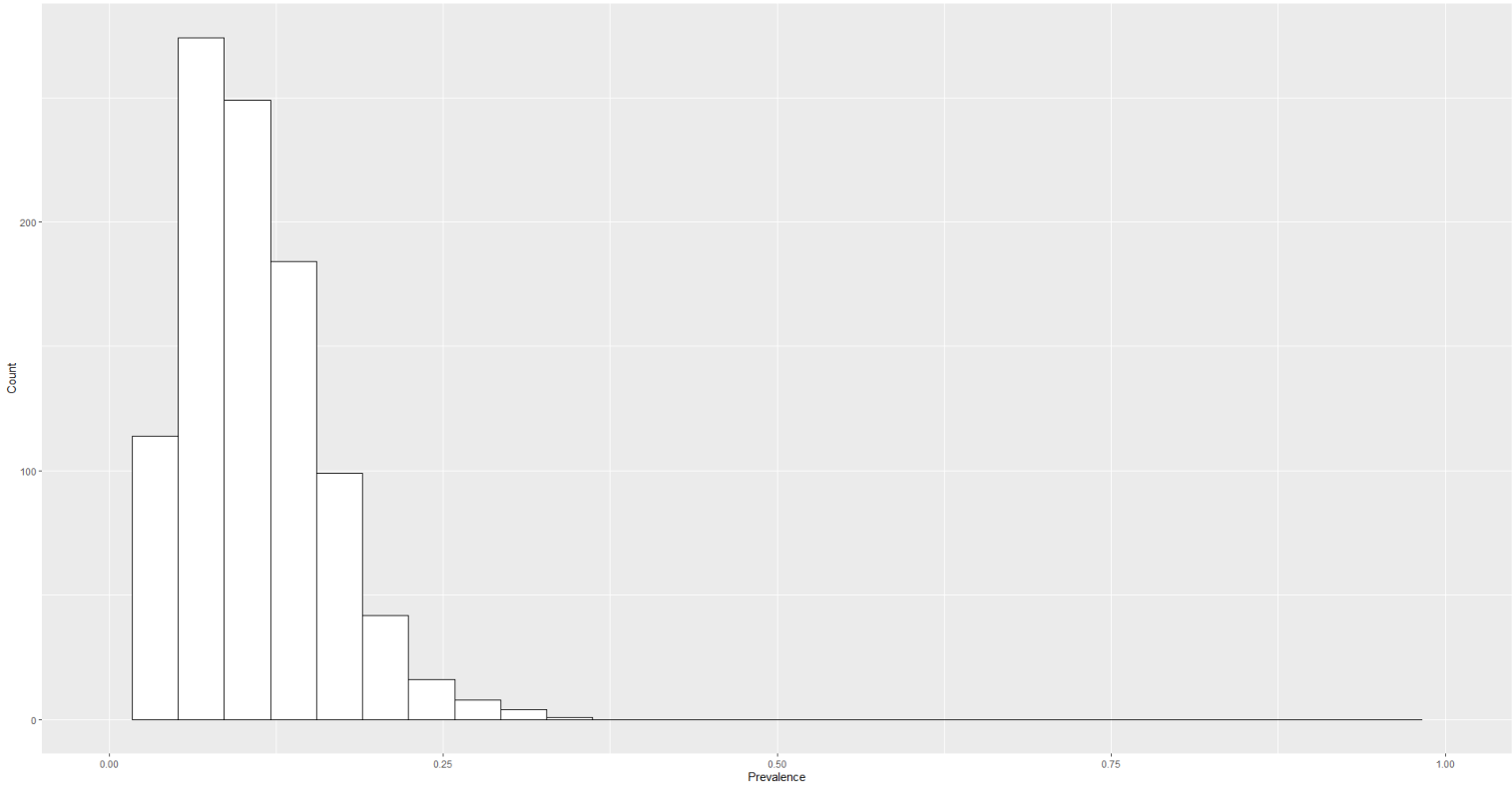


Figure 6: B(3.99,33.22)

Results

All models were fitted in Stan using MCMC sampling 4 chains and 5,000 iterations. We further assessed effective sample size (ESS).

Results

Semi Structured Diagnostic Uninformative B(1,1)

PHQ-9 Cut Off	Prev	Spe	Sen
PHQ-9 $\geq$ 5	0.16	0.76	0.74
PHQ-9 $\geq$ 6	0.18	0.80	0.65
PHQ-9 $\geq$ 7	0.17	0.84	0.63
PHQ-9 $\geq$ 8	0.11	0.88	0.66
PHQ-9 $\geq$ 9	0.07	0.91	0.67
PHQ-9 $\geq$ 10	0.06	0.93	0.68
PHQ-9 $\geq$ 11	0.06	0.95	0.63
PHQ-9 $\geq$ 12	0.04	0.96	0.60
PHQ-9 $\geq$ 13	0.04	0.95	0.53
PHQ-9 $\geq$ 14	0.04	0.97	0.48
PHQ-9 $\geq$ 15	0.05	0.98	0.40

Results

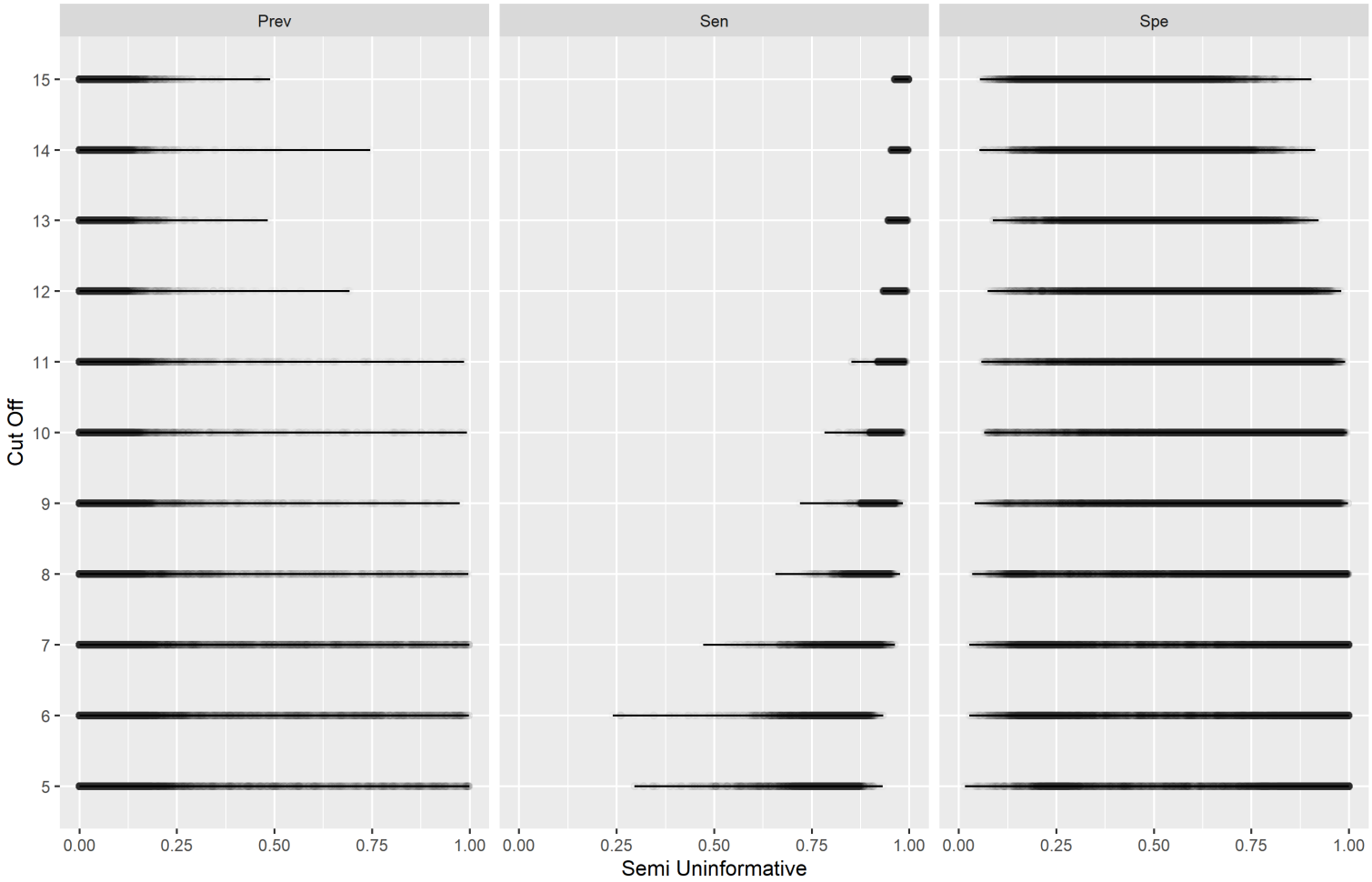


Figure 7: Semi Uninformative B(1,1).

Results

Semi Structured Diagnostic Informative B(4.53,163.96)

PHQ-9 Cut Off	Prev	Spe	Sen
PHQ-9 $\geq$ 5	0.03	0.75	0.89
PHQ-9 $\geq$ 6	0.03	0.80	0.85
PHQ-9 $\geq$ 7	0.03	0.84	0.83
PHQ-9 $\geq$ 8	0.03	0.87	0.80
PHQ-9 $\geq$ 9	0.02	0.90	0.76
PHQ-9 $\geq$ 10	0.03	0.92	0.76
PHQ-9 $\geq$ 11	0.03	0.94	0.71
PHQ-9 $\geq$ 12	0.02	0.95	0.66
PHQ-9 $\geq$ 13	0.02	0.96	0.58
PHQ-9 $\geq$ 14	0.03	0.97	0.53
PHQ-9 $\geq$ 15	0.03	0.98	0.46

Results

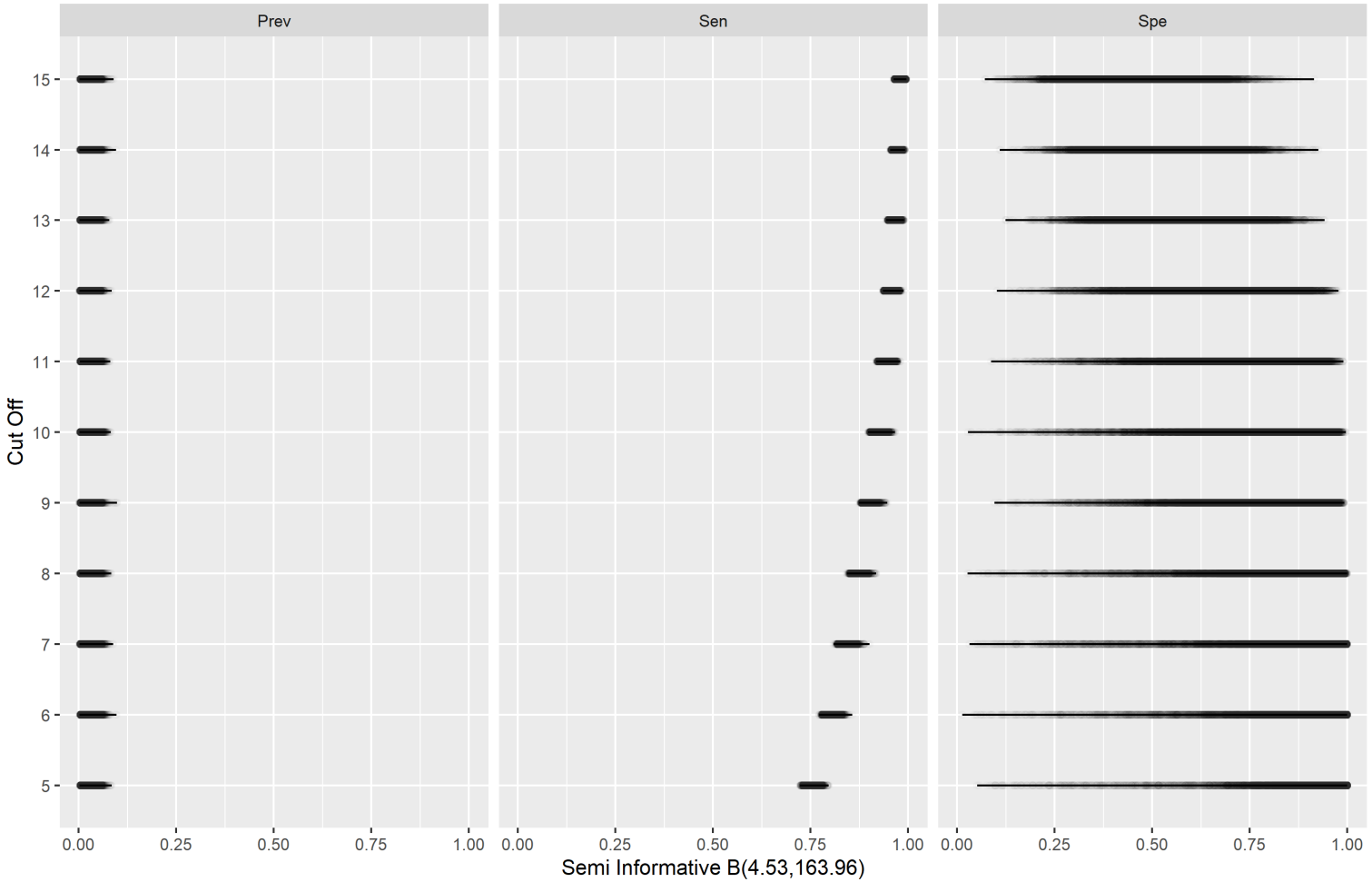


Figure 8: Semi informative B(4.53,163.96).

Results

Semi Structured Diagnostic Informative B(0.71,14.89)

PHQ-9 Cut Off	Prev	Spe	Sen
PHQ-9 $\geq$ 5	0.03	0.75	0.88
PHQ-9 $\geq$ 6	0.03	0.80	0.84
PHQ-9 $\geq$ 7	0.03	0.84	0.82
PHQ-9 $\geq$ 8	0.02	0.87	0.80
PHQ-9 $\geq$ 9	0.02	0.90	0.76
PHQ-9 $\geq$ 10	0.02	0.92	0.75
PHQ-9 $\geq$ 11	0.02	0.94	0.70
PHQ-9 $\geq$ 12	0.02	0.95	0.66
PHQ-9 $\geq$ 13	0.02	0.96	0.58
PHQ-9 $\geq$ 14	0.02	0.97	0.53
PHQ-9 $\geq$ 15	0.02	0.98	0.46

Results

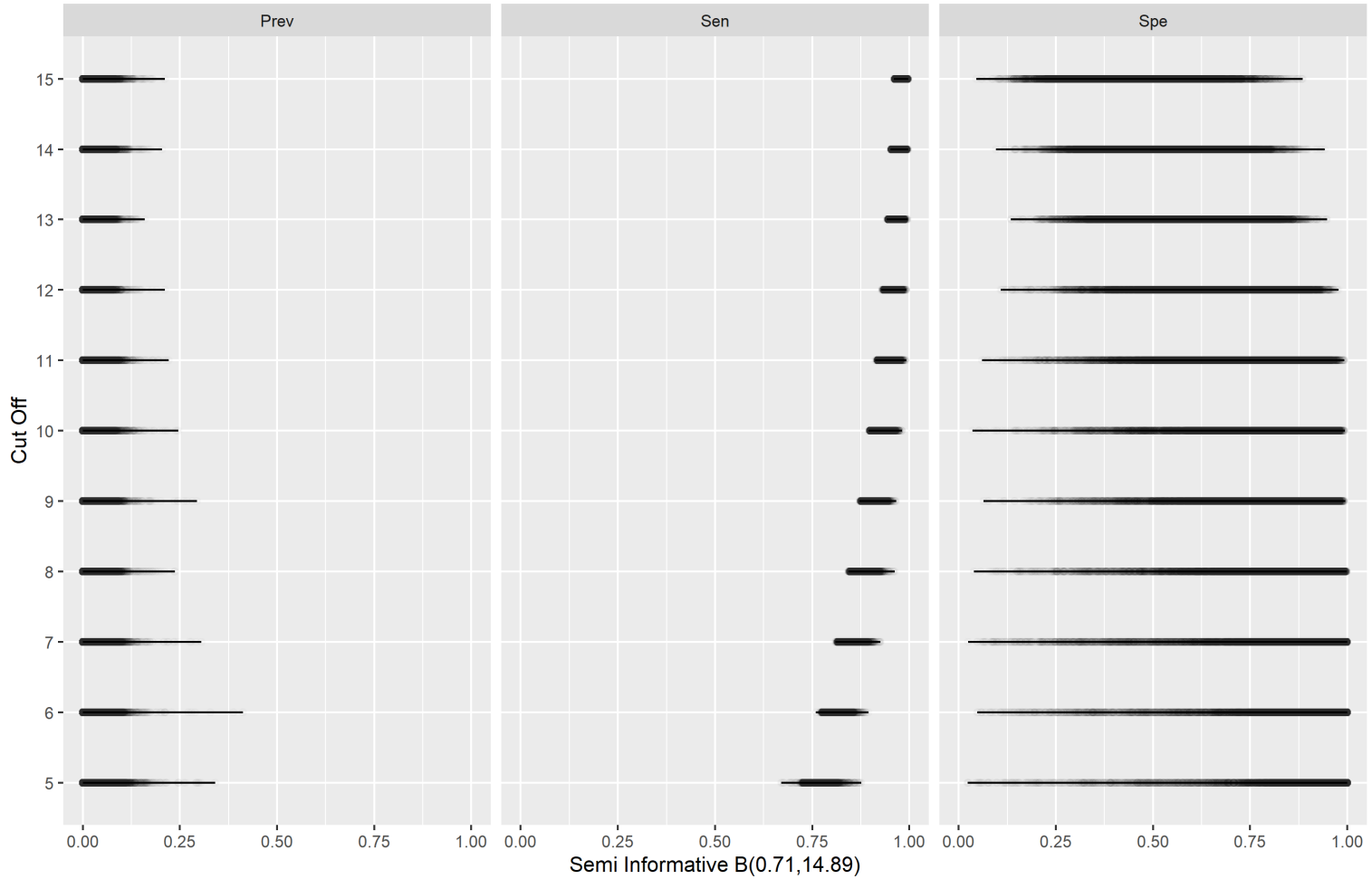


Figure 9: Semi informative B(0.71,14.89).

Results

Semi Structured Diagnostic Informative B(1.65,25.26)

PHQ-9 Cut Off	Prev	Spe	Sen
PHQ-9 $\geq$ 5	0.04	0.76	0.87
PHQ-9 $\geq$ 6	0.04	0.81	0.82
PHQ-9 $\geq$ 7	0.04	0.85	0.80
PHQ-9 $\geq$ 8	0.04	0.88	0.78
PHQ-9 $\geq$ 9	0.04	0.90	0.73
PHQ-9 $\geq$ 10	0.04	0.93	0.73
PHQ-9 $\geq$ 11	0.04	0.95	0.68
PHQ-9 $\geq$ 12	0.03	0.96	0.62
PHQ-9 $\geq$ 13	0.03	0.97	0.54
PHQ-9 $\geq$ 14	0.03	0.97	0.50
PHQ-9 $\geq$ 15	0.04	0.98	0.43

Results

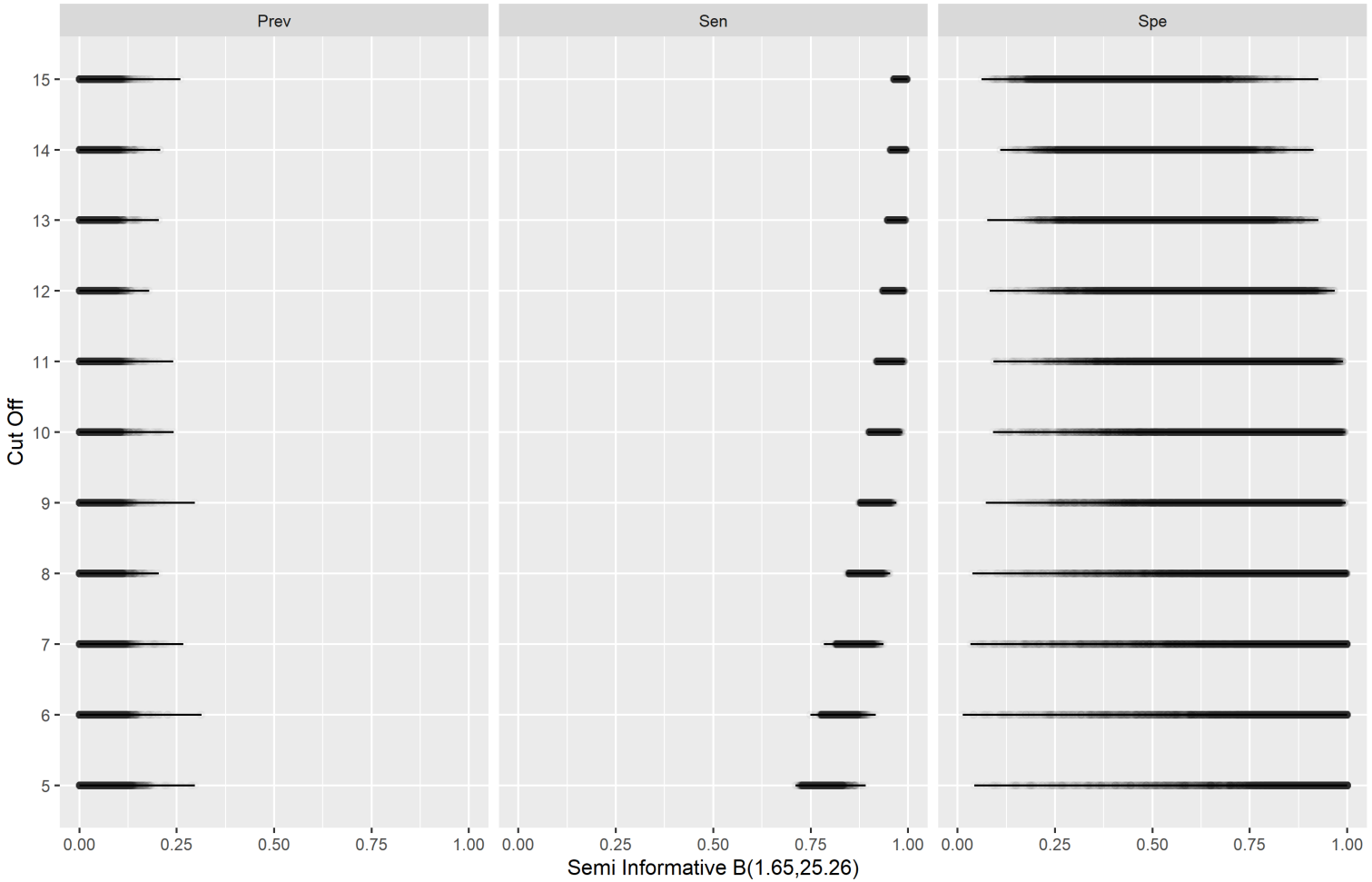


Figure 10: Semi informative B(1.65,25.26).

Results

Semi Structured Diagnostic Informative B(3.99,33.22)

PHQ-9 Cut Off	Prev	Spe	Sen
PHQ-9 $\geq$ 5	0.08	0.79	0.84
PHQ-9 $\geq$ 6	0.08	0.83	0.77
PHQ-9 $\geq$ 7	0.08	0.86	0.72
PHQ-9 $\geq$ 8	0.07	0.89	0.69
PHQ-9 $\geq$ 9	0.07	0.92	0.65
PHQ-9 $\geq$ 10	0.07	0.94	0.65
PHQ-9 $\geq$ 11	0.07	0.96	0.58
PHQ-9 $\geq$ 12	0.06	0.97	0.53
PHQ-9 $\geq$ 13	0.06	0.97	0.46
PHQ-9 $\geq$ 14	0.06	0.98	0.41
PHQ-9 $\geq$ 15	0.07	0.99	0.34

Results

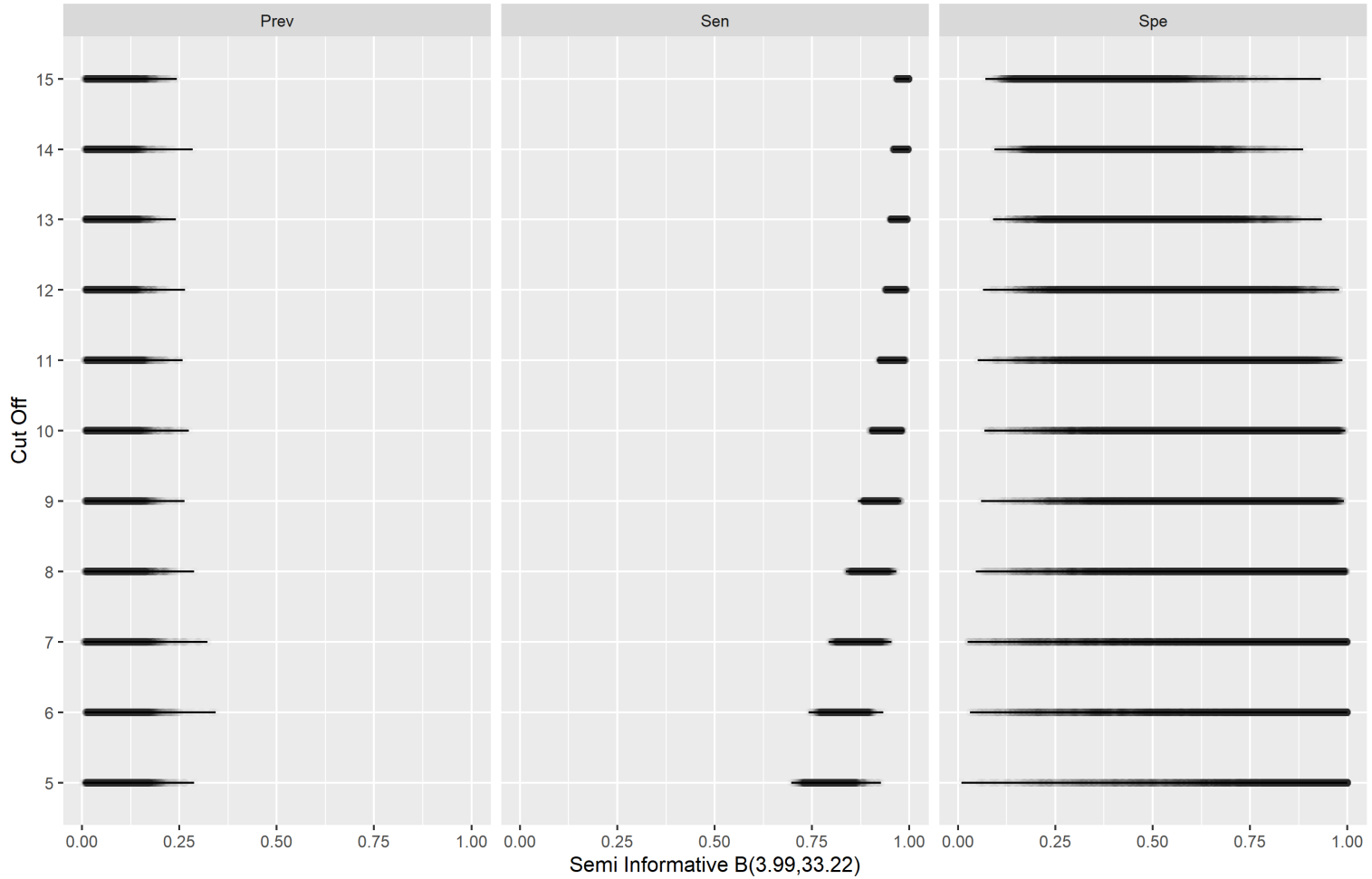


Figure 11: Semi informative B(3.99,33.22).

Conclusion

- Depression disorder evaluated via PHQ-9 questionnaire in NHANES data.
- Prevalence, Sensitivity, Specificity were estimated with using Bayesian Class Models for each cut off point.
- Results were compared each cut off point

References

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