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Effect of missing data in the index test on statistical estimates of specificity and sensitivity and performance of multiple imputation (MI) for handling the missingness in classical diagnostic studies – a comparative approach.

vorgelegt von

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Abbreviations

AUC	Area-under-the-curve
CCA	Complete case analysis
CI	Confidence interval
MS	Mean substitution
FN	False negative
FP	False positive
MAR	Missing at random
MCAR	Missing completely at random
MNAR	Missing not at random
MI	Multiple Imputation
MICE	Multivariate imputation using chained equations
PMM	Predictive mean matching
RMSE	Root mean square error
ROC	Receiver operating characteristic
SN	Sensitivity
SP	Specificity
TN	True negative
TP	True positive

Abstract

Background: For diagnostic accuracy studies specificity (SP) and sensitivity (SN) are co-primary endpoints in the confirmatory phase. Performance of multiple imputation (MI) in handling missing data in the index test when SP and SN are endpoints has not been systematically investigated.

Methods: Missing data - missing completely at random (MCAR), missing at random (MAR), missing not at random (MNAR) – was introduced in the index test and the performance of MI (multivariate imputation using chained equations employing predictive mean matching), single imputation via mean value substitution (MS) and complete case analysis (CCA) was compared in estimating SP and SN using simulation in a single-arm diagnostic accuracy study design. Performance measures analysed included RMSE, coverage probability of the Wald-confidence interval, and absolute and relative bias.

Results: CCA and MI performed comparably when the data was MCAR (with CCA exhibiting a slightly higher coverage probability) whereas MI was the superior method (lowest bias, highest coverage probability) when the data were MAR. MS introduced large bias under both MCAR and MAR. All three methods showed a comparatively high bias when the data were MNAR. The difference in the performance between the three methods were more pronounced for SP compared to SN. Lower levels of bias were evident when the levels of SP and SN were high (0.95) and proportion of missing data were low.

Conclusions: While both CCA and MI performed well under MCAR, MI may be the most appropriate method handling MAR data in diagnostic accuracy studies with SP and SN as endpoints. However, in an unbalanced sample, e.g. when disease prevalence is low, the performance of MI could be limited for SN by the comparatively smaller diseased sub-population. Single imputation methods such as MS are not optimal for MAR and MCAR data and over-estimate SP and SN under both conditions. None of the examined methods are suitable under MNAR.

1. Introduction and state-of-the-art

1.1. Background

Missing values in clinical studies can affect the accuracy and validity of the results as they can lead to bias in the calculation of statistical estimates. There is currently no standardized strategy for handling missing values in clinical studies as missing data are tied to assumptions in relation to the observed data, and these assumptions cannot always be categorically verified or generalized. Little and Rubin (2020) have identified three types of mechanisms for missingness: missing completely at random (MCAR), missing at random (MAR) and missing not at random (MNAR). Data are MCAR if the probability of missingness is independent of both observed and unobserved data. Data are MAR if the probability of missingness is independent of the missing values but dependent on the observed data. Data are MNAR if the probability of missingness depends on the unobserved missing values themselves.

For therapeutic studies the effects of missing data on estimates is well-investigated (e.g. Austin et al, 2021) and several approaches have been proposed depending on the type of missingness and clinical endpoints (e.g. Dziura et al, 2013). However, handling of missing data has been relatively less researched for diagnostic studies. European Medical Agency's (EMA) "Guideline on Missing Data in Confirmatory Clinical Trials" (guideline-missing-data-confirmatory-clinical-trials_en.pdf (europa.eu)) do not include diagnostic study designs. Diagnostic studies differ from therapeutic studies in terms of phases, designs and particularly endpoints. With the introduction of the new EU Medical devices regulations (MDR 2017/745/EU), it is all the more imperative to develop standardized approaches to handle missing data in diagnostic studies.

While area-under-the-curve (AUC) is the standard endpoint for diagnostic studies in the development phase, sensitivity (SN) and specificity (SP) are recommended as co-primary endpoints in the confirmatory phase. In single-arm diagnostic accuracy study design, the index test (test under investigation) and reference standard (defining the true disease state) are applied in all participants, and accuracy measures (SN and SP) are computed for the index test (e.g. Vach et al, 2021). SN is the probability for a positive test result, given an individual is diseased while SP is the probability for a negative test result given an individual is non-diseased (as established by the reference standard). The accuracy measures are estimated as defined in Table 1.

Table 1: Estimation of SP and SN of the index test against the reference standard

Index test	**Reference standard**		
	Positive (diseased)	Negative (non-diseased)	**SP = TP/(TP+FN)**
Positive	True Positive (TP)	False Positive (FP)	**SN = TN/(TN +FP)**
Negative	False Negative (FN)	True Negative (TN)	

Missing values in the index test can lead to bias in the calculation of these endpoints, but systematic research investigating this question is lacking.

1.2. Previous research

Several methods have been suggested in previous literature for handling missing values in the index test where complete dataset for reference test is present (reviewed in Stahlmann et al, submitted). Methods that have been examined in previous literature aim to estimate ROC curves in the presence of missing data – these include random hot deck imputation for handling MCAR data (An, 2021), inverse probability weighted imputation for MAR and MNAR (Long et al, 2011a), regression based approaches for MAR (Bianco et al., 2022) empirical-likelihood-based imputation plus a combination of inverse probability weighted imputation and multiple imputation for MAR (Cheng and Tang, 2019), non-parametric multiple imputation for MAR (Long et al, 2011b) as well as Bayesian empirical likelihood estimation of the AUC (Lin et al, 2021). Schmidt (2021, unpublished thesis) established MI as a suitable method (compared to CCA and SI) in restoring true values of AUC with missing data in diagnostic accuracy study design.

For the estimation of SN and SP, single imputation methods have been employed such as the intention-to-diagnose approach where missing values are considered false negative or false positive depending on the results of the reference standard – this approach is considered overly conservative but can yield realistic estimates of the lower bounds of SP and SN. Likewise, positive or negative imputation have been proposed (Scheutz et al, 2012) wherein all missing results are either considered as positive or negative. These single imputation approaches are too simplistic and ignore patterns of missingness in the data. Ma et al, 2014 showed via simulations that the single imputation approaches tend to give biased results under MCAR and MAR patterns and proposed a trivariate generalized linear mixed model (TGLMM) approach for handling MAR data for the estimation of SP, SN and predictive values. Maximum likelihood approach utilising the multinomial distribution of diagnostic data has also been proposed (Poleto et al, 2011). Bayesian approaches for handling missing values in index test have likewise been developed with multinomial distribution of the diagnostic tests for the estimation of SP, SN and predictive values. (Paulino and Silva, 2019).

2. Rationale and objectives

All of the methods in the previous literature are based on classification probabilities or bi-/multi-nomial distribution of diagnostic test classifications and do not utilise the information in the underlying continuous distribution of the index test and only a subset of them exploit correlational structures with the covariates. Gad et al. (2022) have recently examined the performance of multivariate imputation using chained equations (MICE) for handling MCAR data in the index test and consequent estimation for sensitivity and specificity. However, they only examined the special case of MCAR and also modelled the binary (success vs failure) outcome of diagnostic tests while ignoring other possible patterns of missingness.

Studies from responder analysis have shown that multiple imputation performs better when a continuous outcome is imputed before transformation (dichotomization in responder studies) as compared to imputation of outcomes derived from the continuous variable (e.g. Floden and Bell, 2019). The objective of the current study is therefore to evaluate the performance of multiple imputation (MI) using multivariate imputation via chained equations (MICE) (van Beuren et al, 2011) for handling missing data in the index test *prior to* dichotomizing the test result (binary outcome = positive/negative). To our knowledge this question has not been examined before in the context of diagnostic accuracy study design with SP and SN as outcome parameters. Moreover, we employ a comparative approach which simultaneously allowed for assessing the performance of other methods for handling missing data and investigate this question in a variety of scenarios relating to the sample population and missingness of data.

The objective of the current study was to use a comparative approach to examine the performance of MICE employing the predictive mean matching (PMM) method for imputing missing data with different mechanisms of missingness – MCAR, MAR as well as MNAR – and contrast it against the performance of complete case analysis (CCA) and single imputation (via mean substitution (MS)) in a number of data scenarios. The current work will examine the performance of MICE (PMM) for handling missing values in a normally distributed continuous index test in a diagnostic study design with SP and SN as outcome measures. MI approaches have been developed to handle MAR data (of which MCAR is a special case) in the presence of auxiliary variables, in which pattern of the missingness is associated with the distribution of the covariates and therefore allows for a prediction of the missing values based on these covariates. We expect MI to reduce the bias due to missingness in the index test data (and consequently in SP and SN) in both MCAR and MAR settings but not in MNAR setting.

3. Data generation, estimands and performance measures

3.1. Data generating mechanisms for the index test and auxiliary variables

We employed R function *rmvnorm* (library: mvtnorm) to generate the normally distributed index test as well as two continuous normally distributed covariates. The index test distribution was generated separately for the diseased and non-diseased populations along with the respective covariates. The cut-off (c) was set to 0 and expectation (μ) for the index test distributions were calculated by using the formula μ_{SP}=c - z_{SP}*SD, where z_{SP} is the value for the standard normally distributed variable at the quantile corresponding to the level of SP and μ_{SN}=c + z_{SN}*SD where z_{SN} is the value for the standard normally distributed variable at the quantile corresponding to the level of SN. Standard deviation (SD) was set to 1 for both non-diseased and diseased populations.

The expectation values for the covariates was set to 0, SD to 1, and the correlation with index test was set to 0.4 (moderate correlation). After the multivariate normal distribution for the index test and covariates was generated using *rmvnorm*, one of the continuous covariates was transformed into a categorical covariate by breaking down the distribution into three subsets (interval breaks at minimum, μ – SD, μ + SD, maximum) with interval values set to 0, 1 and 2.

Missing values in the index test were generated using the R function *ampute* (package: MICE) corresponding to the following mechanisms of missingness - MCAR, MAR, MNAR.

3.2. Estimands

Figure 1 shows an example for the generated distributions of the index test for diseased and non-diseased for SN =0.95 and SP=0.95.

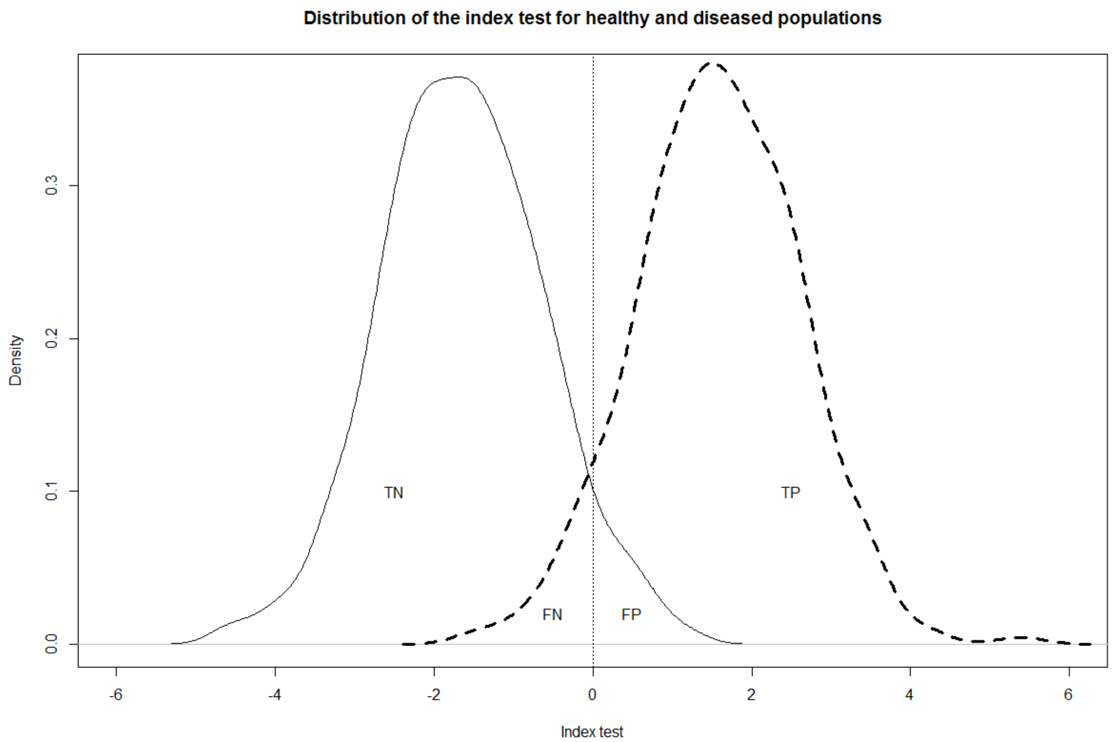


Figure 1: Simulated distribution of the index test for the non-diseased (solid line) and diseased (dotted line) populations with SD =1, μ_{SP}=c - z_{SP}*SD, μ_{SN}=c + z_{SN}*SD for SP =0.95 and SN=0.95 at cut-off = 0. TN=true negatives, FN=false positives, TP=true positives, FP=false positives.

$\widehat{SP}$ was calculated as the number of correctly classified negative cases (TN) divided by the total number of non-diseased individuals (TN plus FP). $\widehat{SN}$ was calculated as the number of correctly classified positive cases (TP) divided by total number diseased individuals (TP plus FN). The sample size for diseased sample ($n_{diseased)}$ was calculated as prevalence*N and the sample size ($n_{non-diseased)}$ for non-diseased sample was calculated as (1 – prevalence) *N, where N was the complete sample size (diseased plus non-diseased).

Parameters as seen in Table 2 were varied to generate different data scenarios. A total number of 243 scenarios were simulated separately for diseased and non-diseased - SP/SN (3) * N (3) * Prevalence (3) * Proportion missing (3) * Mechanism missing (3). For each scenario, 1000 simulations were run to generate the resulting data distributions

Table 2: Parameters varied in the study to generate different data scenarios

SP/SN	Proportion of missing data	Total sample size (N) (diseased + non-diseased)	Disease prevalence	Mechanism of missingness
0.75	10%	200	10%	MCAR
0.85	30%	500	20%	MAR
0.95	50%	1000	30%	MNAR

3.3. Methods for handling missing data

For each of the generated scenarios, and separately for the diseased and non-diseased populations, three different techniques for treating missing data in the index test were compared – CCA (cases with missing data are excluded), single imputation via MS (missing values are replaced by complete case mean) and multiple imputation via PMM (MI).

MICE (http://lib.stat.cmu.edu/R/CRAN/web/packages/mice/index.html) is a flexible method that involves predicting the missing values multiple times based on a pre-specified model, conditional upon the observed values of the auxiliary variables, creating multiple 'complete' datasets (van Beuren et al, 2011). The predicted values are then pooled to create one prediction for every missing data value. Since multiple imputation involves creating multiple rounds of prediction for each missing value, it introduces 'uncertainty' in each round of prediction, and therefore, yields more accurate standard errors by restoring the error variance lost in single imputations. The predictions for missing observations that are generated during multiple rounds of imputation using the chosen method are then pooled in accordance with Rubin's rules (Little and Rubin, 2020) generating a single prediction for each missing data. If θ(i) denotes the estimated statistic of interest obtained from the analysis in the i^{th} imputed data set (i = 1,…,m), the pooled estimated of the statistic of interest according to Rubin's rules is θ=1/m ∑θ(i) (i.e. average value of the estimated statistic across the M imputed data sets).

PMM generates a predicted value for the missing data by regressing the variable with missing data on the auxiliary variables and then drawing from the posterior distribution of the regression coefficient to predict the missing values (Little and Rubin, 2020). For each missing observation, values from a complete-case donor (chosen randomly from a set of possible donors) which are closest to the predicted value for the missing entry is used to replace the missing data under the assumption that the distribution of the missing data is the same as the that of the observed data from donors, an assumption that could be violated when the data is MNAR (Little and Rubin, 2020). One of the two main advantages of PMM are that the imputed values are taken from the existing data and therefore, imputed values are always within the data range. Moreover, PMM is also robust to misspecification as the model is implicit (hot deck method) and therefore does not require an explicitly specified model from which imputations are generated. CCA and MS were implemented using the base R-functions and MI was implemented using the R-package *Mice* with 10 rounds of imputation performed for every simulation run. As reference the analysis was also performed in the complete data set (before introducing missing data).

3.4. Performance measures

$\widehat{SP}$ and $\widehat{SN}$ were the statistical estimates of interest. For every scenario and for the four conditions/methods – no missing data, CCA, MS and MI – following performance measures were calculated:

- Absolute bias: $SP - \widehat{SP}$ and $SN - \widehat{SN}$
- Relative bias: $(\widehat{SP} - SP)/SP$ and $(\widehat{SN} - SN)/SN$
- Root mean square error (RMSE): $\sqrt{(\widehat{SP}\ - SP)\text{^}2/nsim)}$ and $\sqrt{(\widehat{SN}\ - SN)\text{^}2/nsim)}$ where nsim = the number of simulations
- Coverage probability of the 95% Wald confidence interval (CI) $(\widehat{SN}(/\widehat{SP}) \pm z_{0.95}\sqrt{\widehat{SN}(/\widehat{SP})\,(1 - \widehat{SN}(/\widehat{SP})/n_{diseased(/non-diseased)}})$ calculated as the proportion of simulation runs for which the true value was contained within the estimated Wald-CI.

RMSE, coverage probability, and mean absolute bias for every scenario and imputation method were visualised using dot-line plots (see results) to assess the influence of the examined factors on the estimation of $\widehat{SP}$ and $\widehat{SN}$. Relative and absolute bias over 1000 simulations runs for different scenarios and imputation methods were visualised using box-whisker plots (see results).

4. Results

Performance measures for each scenario and imputation method are reported in supplementary tables (section 9) STable 1 and STable 2 for $\widehat{SP}$ and $\widehat{SN}$, respectively. Given the large number of scenarios (243), the results were visualised using diverse plots (see below) to discern influence of different factors and imputation methods on the performance measures.

4.1. RMSE

Figure 2 and Figure 3 depict the RMSE for the different scenarios and imputation methods for $\widehat{SP}$ and $\widehat{SN}$, respectively. As evident in the plots, levels of SP or SN, proportion of missingness and mechanism of missingness have the largest influence on RMSE while sample size (total N combined for diseased and non-diseased) and prevalence seem to have little effect, especially for $\widehat{SP}$.

For $\widehat{SP}$ (Figure 2), MI had the lowest RMSE for all scenarios, CCA and MI were comparable for MCAR, while MS yielded the highest RMSE for all scenarios. Comparatively high RMSE was evident for MNAR condition for all methods and when the proportion of missing data was high (50%).

The pattern for RMSE was less clear for $\widehat{SN}$ (Figure 3) with relatively higher RMSEs for all scenarios, differences between the methods less pronounced and prevalence had a relatively larger influence on RMSE (RMSE decreasing with increasing prevalence). Just like for $\widehat{SP}$, for $\widehat{SN}$ MI exhibited the lowest RMSE for MAR condition, while MI and CCA were comparable for MCAR. For $\widehat{SN}$, MI and CCA methods exhibited higher RMSE for MNAR than MS when the proportion of missing data was high.

The slightly different distribution of RMSE for $\widehat{SN}$ as compared to $\widehat{SP}$ could be a result of the relatively smaller sample size for the diseased – the highest prevalence level modelled in the study was 0.3, hence maximum sample size for the diseased was 30% of N. The performance of imputation methods, which in any case are not optimal for MNAR, is known to decrease with decreasing sample size and with high proportion of missing data (e.g. Barnes et al, 2005) and therefore, could have resulted in less conspicuous difference for the diseased population.

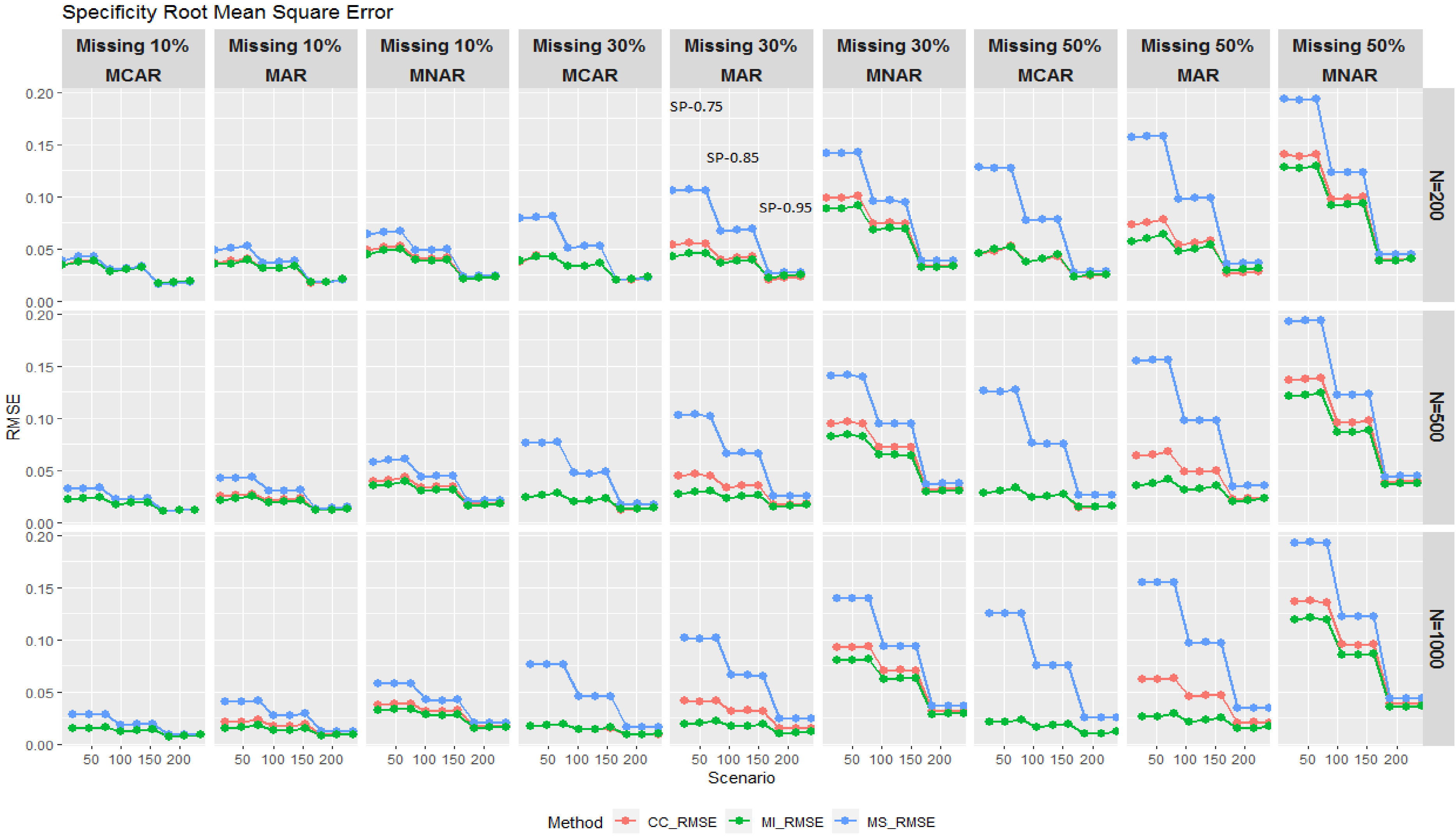


Figure 2: RMSE for $\widehat{SP}$ with increasing scenario-index indicating increasing SP-levels (0.75, 0.85, 0.95) and with each SP-level containing three points representing increasing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for non-diseased is was calculated as (1 – prevalence) *N.

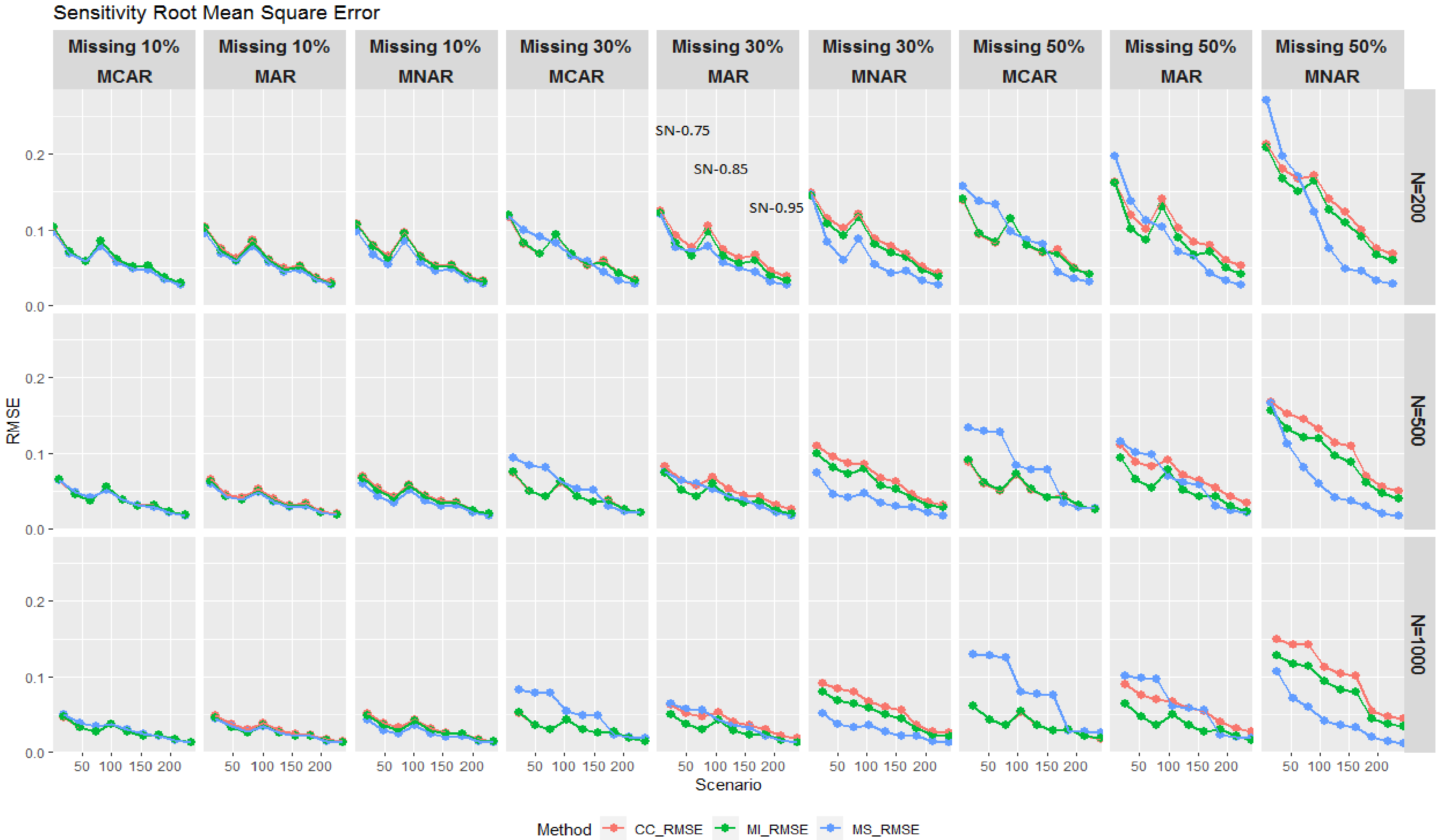


Figure 3: RMSE for $\widehat{SN}$ with increasing scenario-index indicating increasing SN-levels (0.75, 0.85, 0.95) and with each SN-level containing three points representing increasing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for diseased is was calculated as prevalence *N.

4.2. Relative and absolute bias

Given that the total sample size and prevalence had relatively smaller influence on the bias in the estimation of $\widehat{SP}$ and $\widehat{SN}$, Figure 4 and Figure 5 depict the box plots for the distribution of relative bias for the three methods (CCA, MS and MI) for $\widehat{SP}$ and $\widehat{SN}$, respectively, pooled over different levels of prevalence and sample size.

The corresponding plots depicting absolute bias (over 1000 simulations) for $\widehat{SP}$ and $\widehat{SN}$ pooled for sample size and prevalence are shown in supplementary figures SFigure 1 and SFigure 2, respectively. Absolute mean bias for all scenarios for $\widehat{SP}$ and $\widehat{SN}$ is plotted in supplementary figures SFigure 3 and SFigure 4, respectively.

4.3. Coverage probability of the Wald-CI

Coverage probability of the 95% Wald-CI for both $\widehat{SP}$ and $\widehat{SN}$ for all scenarios is plotted in Figure 6 and Figure 7, respectively.

MS had the lowest coverage probability for most scenarios, CCA had the highest coverage probability for MCAR and MI had the highest coverage probability for MAR, while all methods exhibiting relatively lower coverage probability for MNAR. Similar to RMSE, the difference between imputation methods for coverage probability were not as clearly distinguishable for $\widehat{SN}$ as for $\widehat{SP}$ for some scenarios, which could again be likely be due to smaller sample sizes for the diseased. CCA indicated better coverage than MI for both MCAR and MAR conditions for $\widehat{SN}$ (especially when the proportion of missing data was 0.5), which could be indicative of poorer MI performance with decreasing population size and increasing missing data.

It should be noted here that the coverage probability has limited interpretability when the estimates are biased – nevertheless, they serve to provide an index for the performance of the imputation methods.

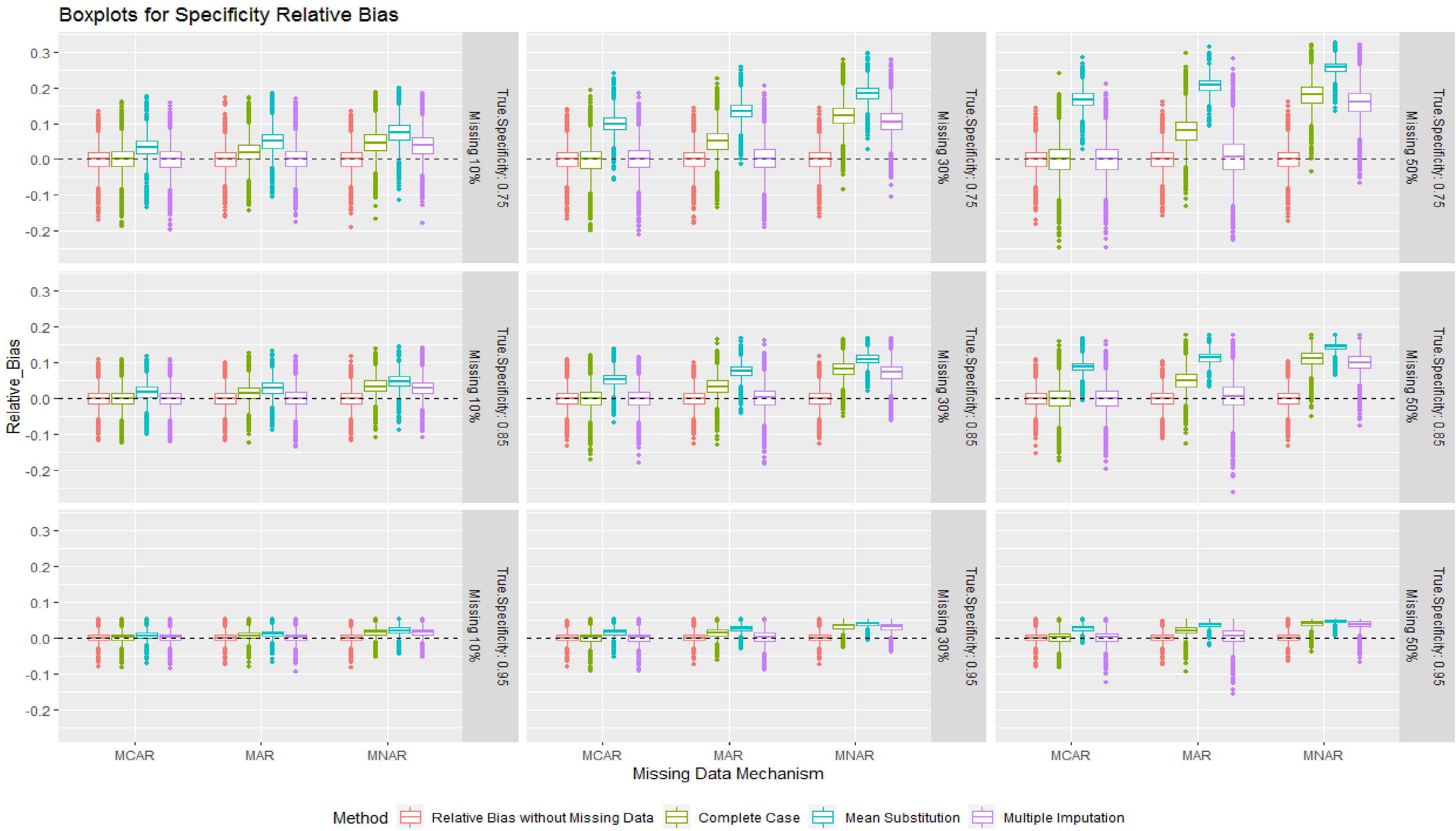


Figure 4: Relative bias for $\widehat{SP}$ pooled over different levels of sample size and prevalence depicted for the imputation methods (CCA, MS and MI) and for condition without missing data. Dotted line depicts null bias.

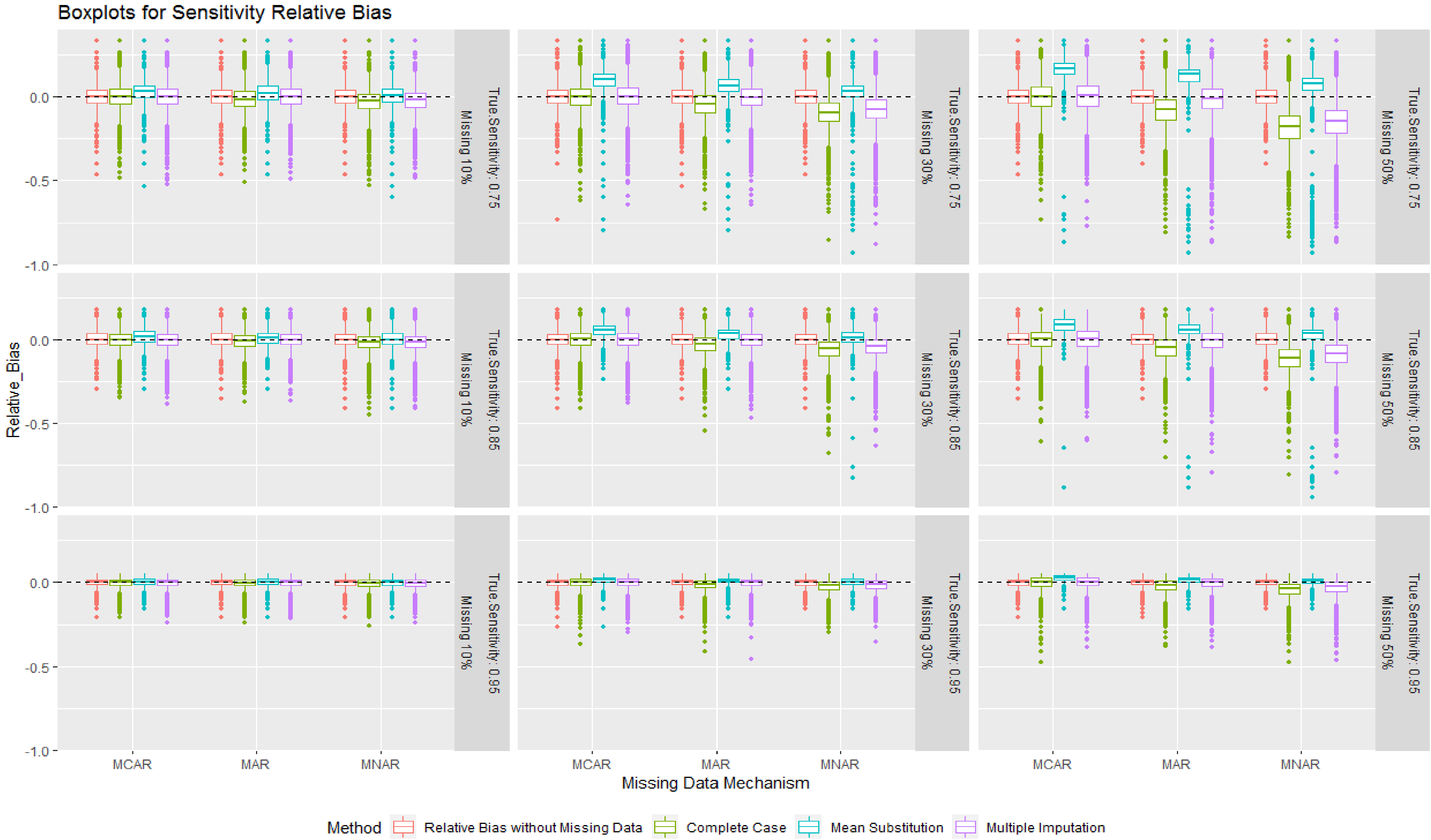


Figure 5: Relative bias for $\widehat{SN}$ pooled over different levels of sample size and prevalence depicted for the imputation methods (CCA, MS and MI) and for condition without missing data. Dotted line depicts null bias.

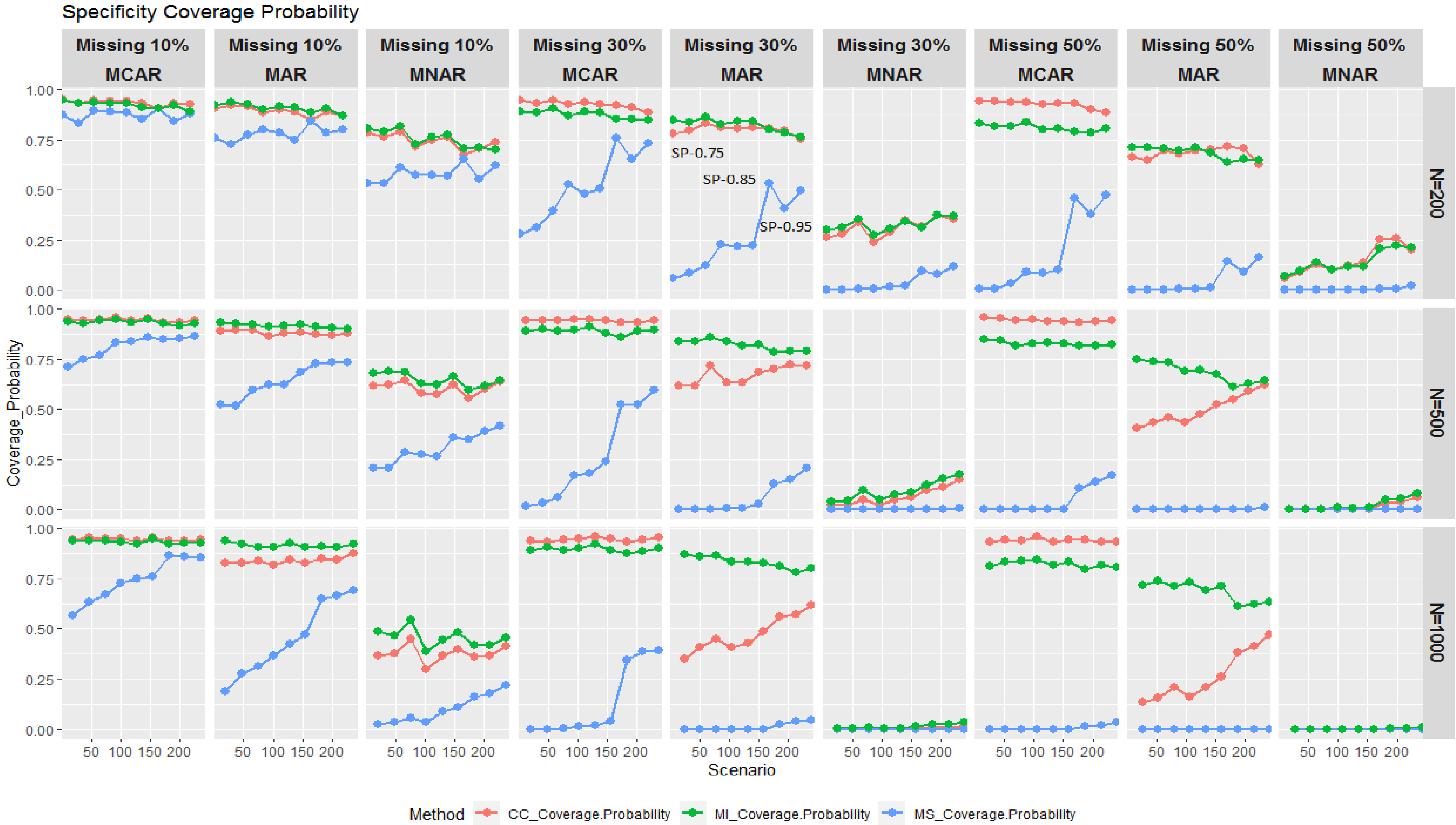


Figure 6: Coverage probability of the 95% Wald-CI for $\widehat{SP}$ with increasing scenario-index indicating increasing SP-levels (0.75, 0.85, 0.95) with each SP-level containing three points representing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for non-diseased is was calculated as (1 – prevalence) *N.

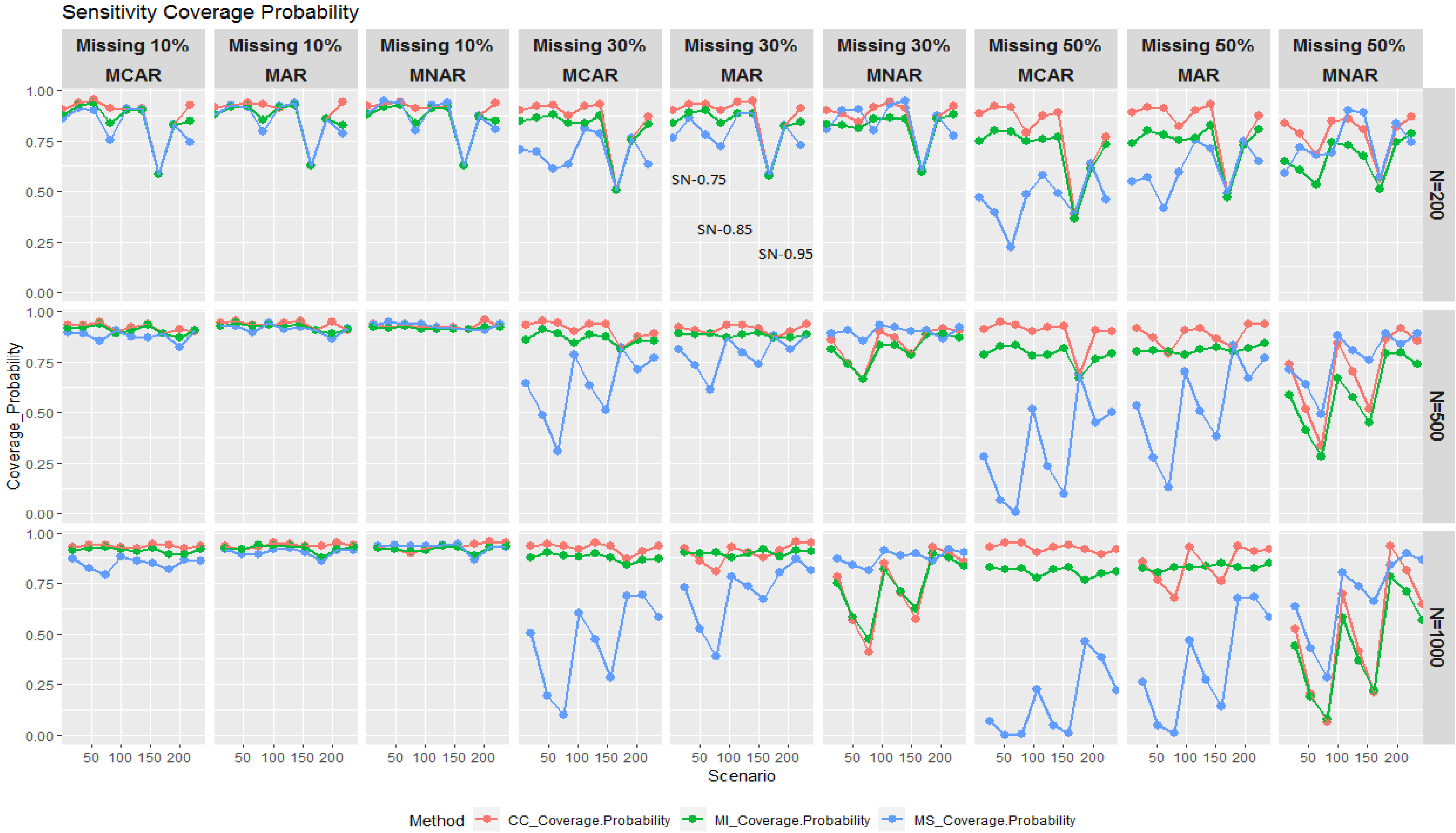


Figure 7: Coverage probability of the 95% Wald-CI for $\widehat{SN}$ with increasing scenario-index indicating increasing SN-levels (0.75, 0.85, 0.95) with each SN-level containing three points representing increasing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for diseased is was calculated as prevalence *N.

It is evident from the above plots that the simulated data and resulting estimates $\widehat{SP}$ and $\widehat{SN}$ with no missing observations approximated the true value for SP and SN as indicated by very low absolute and relative bias as a proxy for Monte Carlo Error.

Both CCA and MI performed well for the MCAR condition, while for the MAR condition MI showed the best performance (the lowest bias) for both $\widehat{SP}$ and $\widehat{SN}$, even when the proportion of missing data was high (50%). The bias for all conditions was generally higher for $\widehat{SN}$ than for $\widehat{SP}$ as evident in the relative bias plots.

For $\widehat{SP}$, MS overestimated the SP for all three conditions of missingness, CCA overestimated the SP for MAR and MNAR, and all three methods overestimated SP for MNAR. Similarly, for $\widehat{SN}$, both CCA and MI appeared to restore the true values for the MCAR condition, whereas only MI performed well for the MAR condition. MS overestimated the SN for all three conditions of missingness, CCA underestimated the SN for MAR and both CCA and MI appeared to underestimate the SN for MNAR.

5. Discussion

Our results are consistent with available evidence from other types of clinical study designs (e.g. reviewed in Jakobsen et al, 2017) and endpoints (e.g. Austin et al, 2021) which propose MI to be an appropriate method for imputing missing data for MAR whereas CCA may be recommended for MCAR data. In the current work, MI using MICE (PMM) clearly outperformed the other two methods in restoring the true distribution of SP and SN for MAR data with the lowest bias, RMSE and the highest coverage for the 95% Wald-CI compared to the other two methods. For MCAR condition, CCA and MI performed equally well in reducing the bias for the endpoints but CCA showed better coverage for the Wald-CI.

While it is clear from our results that MI was the superior method for handling MAR data in the current setting, for MCAR the choice between CCA or MI could depend on various factors as CCA may lead to better coverage but invariably yields larger standard errors for estimates on account of smaller number of observations. Depending on the exact objectives of the study (e.g. confirmatory versus hypothesis generating) or the proportion of missing data, CCA or MI could be more appropriate for handling MCAR data in diagnostic accuracy studies with SP and SN as endpoints. It should be noted that in our study, the setting was ideal for an optimal performance of MI with two different covariates moderately correlated to the index test (and therefore, informative covariates), which enabled good performance even with a modest number (10) of the multiple rounds of imputation. In real settings, the MI procedure may not perform as well if the model is not highly informative and inclusion of appropriate covariates and specification of the correct model should be considered carefully. Future studies should investigate this aspect whether MI performs as well in a different setting with other types of covariates with varying degrees of correlation with the index test.

Single mean substitution led to biased estimates (over-estimation) in both MCAR and MAR settings for SP as well as SN and therefore may be an unsuitable choice for handling MCAR and MAR data. As expected all methods performed comparatively poorly for the MNAR (compared to MAR and MCAR) condition and had highest RMSE when the proportion of missing data was high (50%). The bias for all methods was comparatively low when the levels of SP and SN were high. On the other hand, the bias generally increased with increasing proportion of missing data and was higher in all conditions for SN compared to SP.

Another interesting pattern to emerge from the current results was that for SN the differences in the performance of the three methods were less pronounced (as evident in plots for RMSE, CP and mean bias) than for SP. We speculate that one of the reasons for this could be the unbalanced study design typical for confirmatory diagnostic accuracy studies, where depending on the prevalence one or the other sub-populations (diseased or non-diseased) have a relatively larger/smaller sample size, which in turn could impact the performance of imputation procedures in the smaller population. The variation in sample size with prevalence could also underly the relatively larger influence of disease prevalence and sample size on the bias in SN as compared to SP seen in our results, where the maximum modelled disease prevalence was 0.3. This aspect should be considered while selecting approaches for handling missing data in diagnostic studies to ensure that the selected method is suitable for imputing missing data patterns in both sub-populations. This aspect may be especially relevant for rare diseases (with low prevalence) and should be further optimised in future research. Future work should also assess the performance of MI after dichotomizing the index test decision (binary outcome = positive/negative) compared to imputing the values in natural distribution of the index test.

6. Conclusions

We argue along similar lines to previous literature for other types of clinical study designs/endpoints, that the assumptions for mechanisms underlying the missing data as well as patterns of association with covariates must be thoroughly investigated before deciding on the most appropriate method for handling missing data in diagnostic study designs with SP and SN as endpoints. MI seems promising for MAR data in the presence of correlated auxiliary variables and substituting the missing values with the available sample mean is not recommended in any scenario.

7. References

Austin, PC, White, IR, Lee, DS, van Buuren, S. Missing Data in Clinical Research: A Tutorial on Multiple Imputation. Canadian Journal of Cardiology 2021; 37(9), 1322-1331. DOI: https://doi.org/10.1016/j.cjca.2020.11.010.

An Y. Smoothed empirical likelihood inference for ROC curves with missing data. Open J Stat 2012; 2: 7. DOI: 10.4236/ojs.2012.21003.

Barnes SA, Lindborg SR, Seaman JW Jr. Multiple imputation techniques in small sample clinical trials. Stat Med. 2006 Jan 30;25(2):233-45. doi: 10.1002/sim.2231. PMID: 16220515.

Bianco AM, Boente G, González-Manteiga W, et al. Estimators for covariate-adjusted ROC curves with missing biomarkers values. arXiv preprint arXiv:220106483 2022.

Cheng W and Tang N. Smoothed empirical likelihood inference for ROC curve in the presence of missing biomarker values. Biom J 2020; 62: 1038-1059. 20200120. DOI: 10.1002/bimj.201900121.

Dziura JD, Post LA, Zhao Q, Fu Z, Peduzzi P. Strategies for dealing with missing data in clinical trials: from design to analysis. Yale J Biol Med. 2013; 86(3):343-58. PMID: 24058309; PMCID: PMC3767219.

Floden L, Bell ML. Imputation strategies when a continuous outcome is to be dichotomized for responder analysis: a simulation study. BMC Med Res Methodol. 2019 Jul 23;19(1):161. doi: 10.1186/s12874-019-0793-x. PMID: 31345166; PMCID: PMC6659229.

Gad AM, Ali AAM and Mohamed RH. A multiple imputation approach to evaluate the accuracy of diagnostic tests in presence of missing values. Commun Math Biol Neurosci 2022.

Jakobsen JC, Gluud C, Wetterslev J. et al. When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. BMC Med Res Methodol. 2017. 17: 162. DOI: https://doi.org/10.1186/s12874-017-0442-1

Little RJA and Rubin DB. Statistical analysis with missing data. 3rd Edition 2020. Hoboken, New Jersey, USA: Wiley.

Lin R, Chan KG and Shi H. A unified Bayesian framework for exact inference of area under the receiver operating characteristic curve. Stat Methods Med Res 2021; 30: 2269-2287. 20210901. DOI: 10.1177/09622802211037070.

Long Q, Zhang X and Hsu C-H. Nonparametric multiple imputation for receiver operating characteristics analysis when some biomarker values are missing at random. Stat Med 2011; 30: 3149-3161. DOI: 10.1002/sim.4338.

Long Q, Zhang X and Johnson BA. Robust estimation of area under ROC curve using auxiliary variables in the presence of missing biomarker values. Biometrics 2011; 67: 559-567. 20100903. DOI: 10.1111/j.1541-0420.2010.01487.x.

Ma X, K Suri MF and Chu H. A trivariate meta-analysis of diagnostic studies accounting for prevalence and non-evaluable subjects: re-evaluation of the meta-analysis of coronary CT angiography studies. BMC Med Res Methodol 2014; 14: 128. DOI: 10.1186/1471-2288-14-128.

Stahlmann K, Reitsma JB, Zapf A. Missing values and inconclusive results in diagnostic studies – a scoping review of method. Statistical Methods in Medical Research. Submitted.

Paulino CD and Silva GL. Bayesian comparison of diagnostic tests with largely non-informative missing data. J Stat Comput Simul 2019; 89: 1877-1886. DOI: 10.1080/00949655.2019.1601726.

Poleto FZ, Singer JM and Paulino CD. Comparing diagnostic tests with missing data. J Appl Stat 2011; 38: 1207-1222. DOI: 10.1080/02664763.2010.491860.

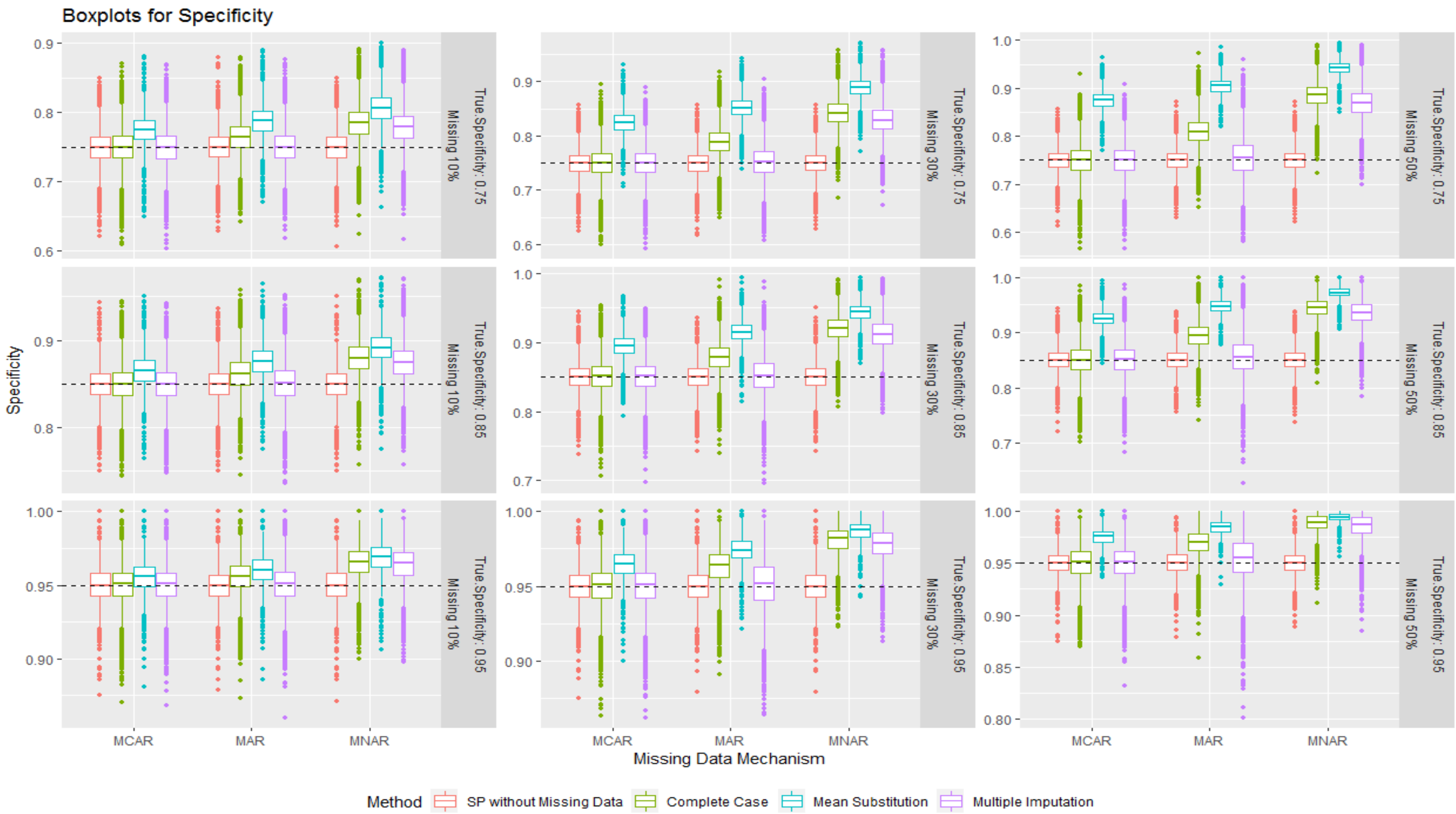
Schmidt, M. A comparison of multiple imputation methods for missing values in diagnostic studies. 2021. Unpublished master's thesis. Berlin School of Public Health, Charité Hospital, Berlin.Schuetz GM,

Schlattmann P and Dewey M. Use of 3×2 tables with an intention to diagnose approach to assess clinical performance of diagnostic tests: meta-analytical evaluation of coronary CT angiography studies. BMJ 2012; 345: e6717. DOI: 10.1136/bmj.e6717

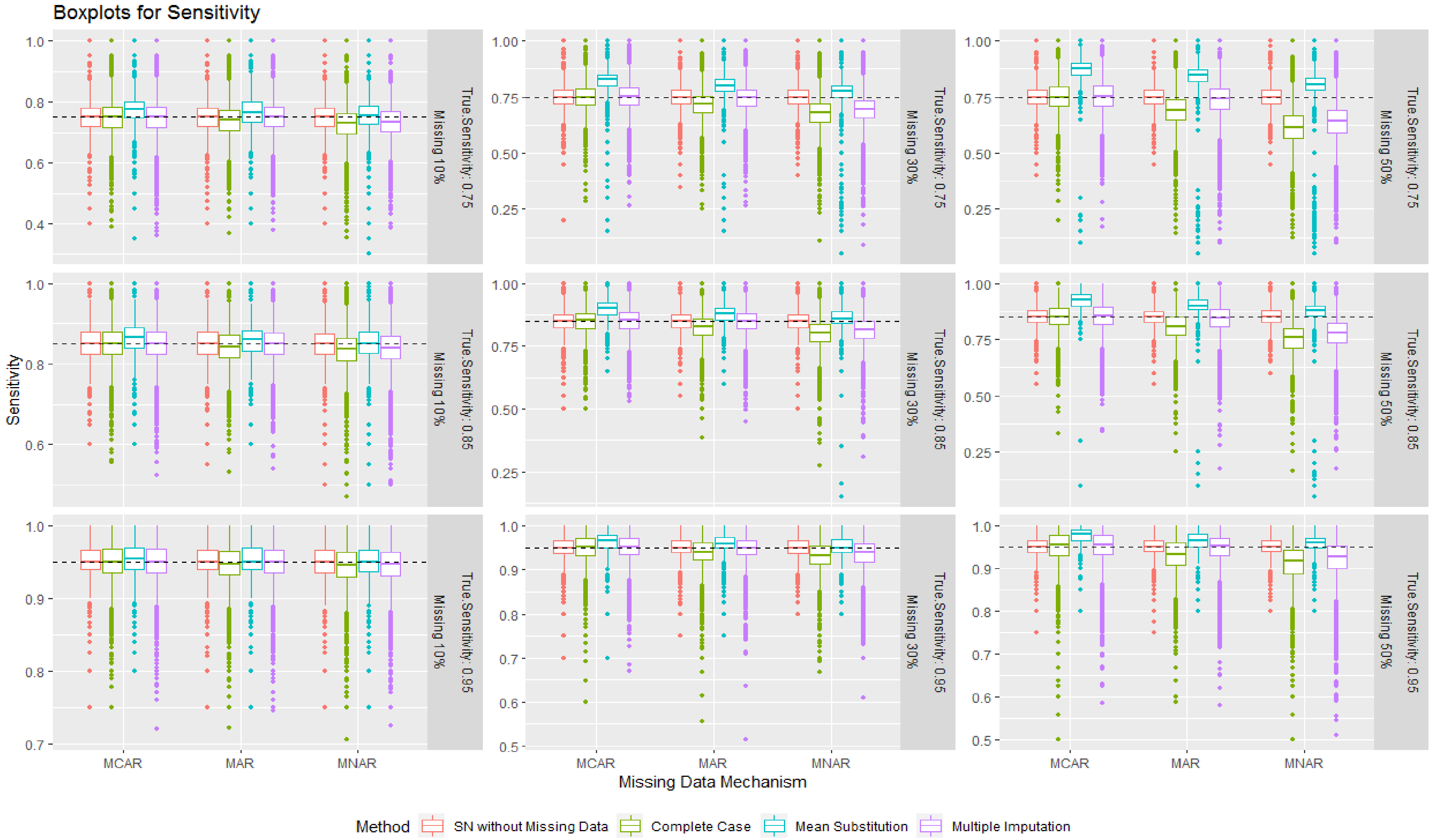
Vach, W, Bibiza, E, Gerke, O, Bossuyt, PM, Friede, T, Zapf, A. A potential for seamless designs in diagnostic research could be identified. Journal of Clinical Epidemiology 2021, 129: 51-59, ISSN 0895-4356, https://doi.org/10.1016/j.jclinepi.2020.09.019

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate Imputation by Chained Equations in R. Journal of Statistical Software, 45(3), 1–67. https://doi.org/10.18637/jss.v045.i03

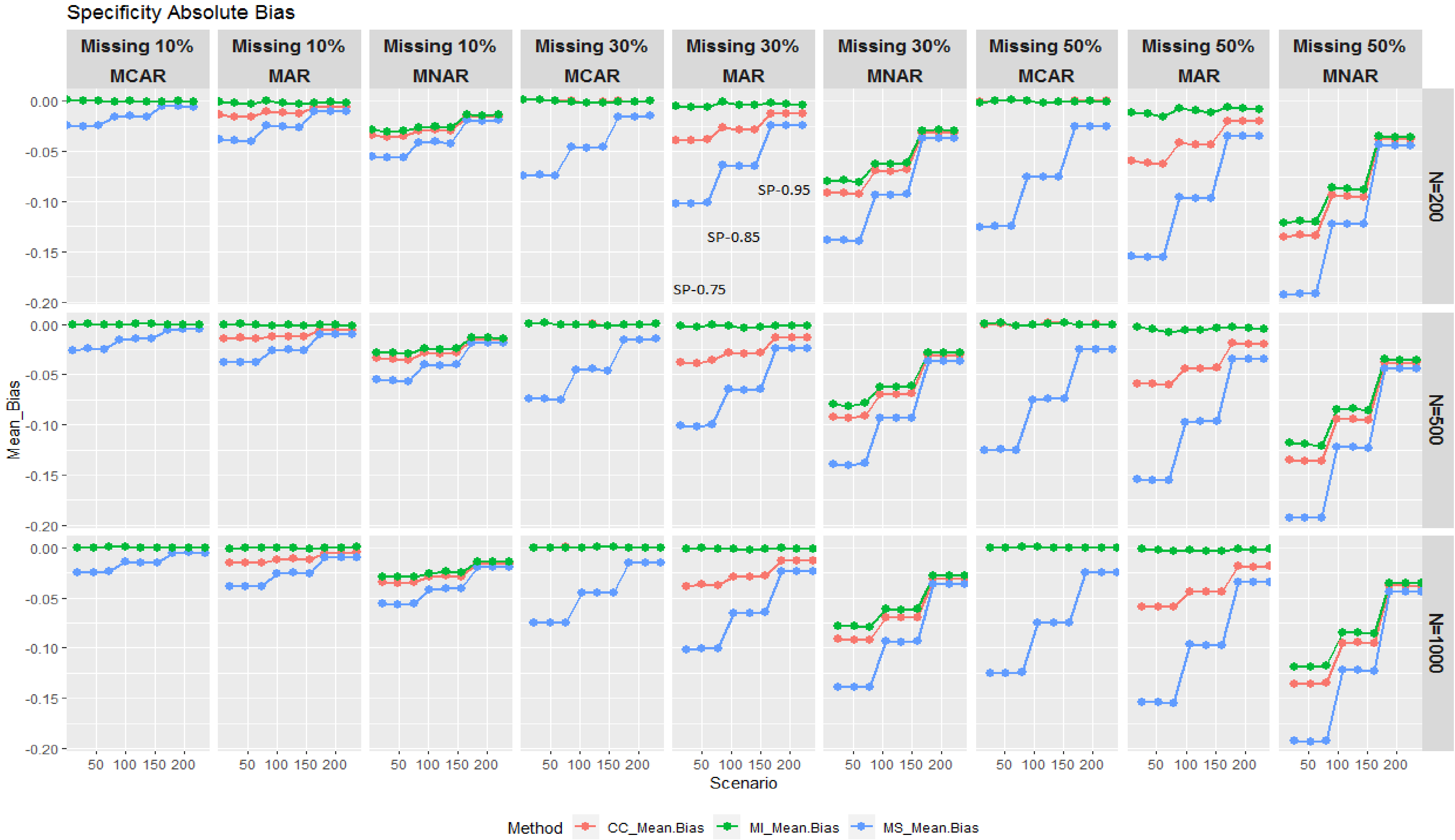
8. Supplementary Figures



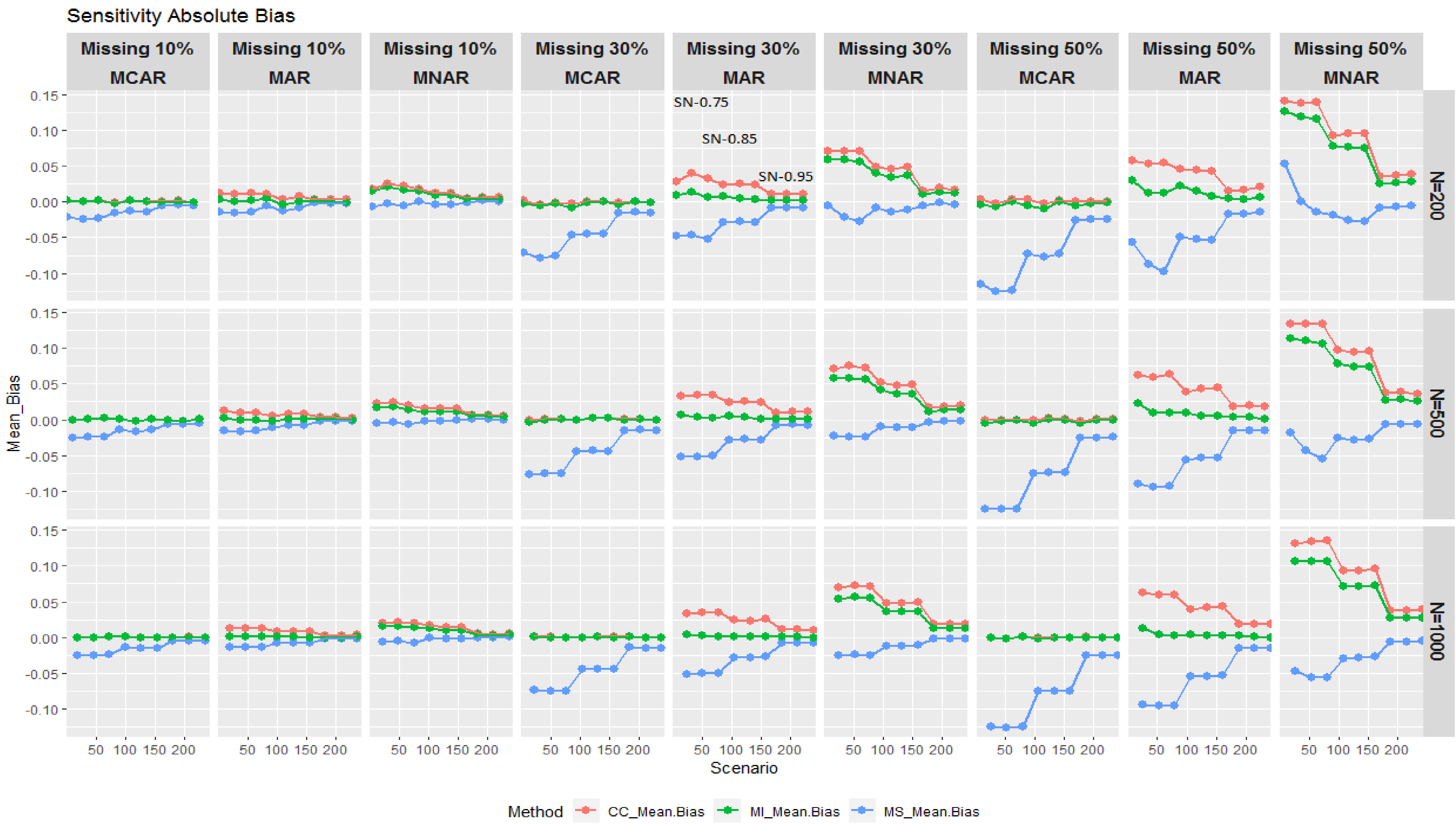
SFigure 1: Absolute bias for $\widehat{SP}$ pooled over different levels of sample size and prevalence depicted for the imputation methods (CCA, MS and MI) and for condition without missing data. Dotted line depicts the true value of SP.



SFigure 2: Absolute bias for $\widehat{SN}$ pooled over different levels of sample size and prevalence depicted for the imputation methods (CCA, MS and MI) and for condition without missing data. Dotted line depicts the true value of SN.



SFigure 3: Absolute mean bias for $\widehat{SP}$ with increasing scenario-index indicating increasing SP-levels (0.75, 0.85, 0.95) with each SP-level containing three points representing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for non-diseased is was calculated as (1 – prevalence) *N.



SFigure 4: Absolute mean bias for $\widehat{SN}$ with increasing scenario-index indicating increasing SN-levels (0.75, 0.85, 0.95) with each SP-level containing three points representing consecutive levels of disease prevalence (0.1, 0.2, 0.3). N denotes the complete sample (diseased + non-diseased) and the corresponding sample size for diseased is was calculated as prevalence *N.

9. Supplementary Tables

STable 1: Performance measures for $\widehat{SP}$ for all scenarios and imputation methods

Scenario	True SP	Prevalence	Sample Size (N)	Proportion Missing	Mechanism Missing	CCA RMSE	CCA Mean Bias	CCA Coverage Probability	MS RMSE	MS Mean Bias	MS Coverage Probability	MI RMSE	MI Mean Bias	MI Coverage Probability
1	0.75	0.1	200	0.1	MCAR	0.033865	0.001648	0.955	0.038835	-0.02362	0.876	0.03389	0.001284	0.946
2	0.75	0.1	200	0.1	MAR	0.036291	-0.01378	0.905	0.048642	-0.03742	0.758	0.034997	-0.00016	0.922
3	0.75	0.1	200	0.1	MNAR	0.048185	-0.03338	0.783	0.063909	-0.05515	0.533	0.044941	-0.02822	0.806
4	0.75	0.1	200	0.3	MCAR	0.037617	0.001095	0.948	0.079292	-0.07417	0.278	0.038325	0.001059	0.889
5	0.75	0.1	200	0.3	MAR	0.053366	-0.03863	0.777	0.105518	-0.10207	0.058	0.042792	-0.00474	0.85
6	0.75	0.1	200	0.3	MNAR	0.098186	-0.09136	0.265	0.141172	-0.1386	0.002	0.087977	-0.07915	0.302
7	0.75	0.1	200	0.5	MCAR	0.045576	-0.00092	0.941	0.127995	-0.12557	0.008	0.045438	-0.00115	0.831
8	0.75	0.1	200	0.5	MAR	0.072713	-0.05962	0.666	0.156321	-0.15476	0	0.056665	-0.01083	0.71
9	0.75	0.1	200	0.5	MNAR	0.140319	-0.13562	0.058	0.193792	-0.19286	0	0.127847	-0.12088	0.069
10	0.75	0.1	500	0.1	MCAR	0.021977	-0.00078	0.948	0.032718	-0.02578	0.714	0.021984	-0.00059	0.937
11	0.75	0.1	500	0.1	MAR	0.025159	-0.01433	0.89	0.042341	-0.03783	0.522	0.02134	-0.00015	0.934
12	0.75	0.1	500	0.1	MNAR	0.039699	-0.03325	0.615	0.058424	-0.05482	0.205	0.035265	-0.02765	0.678
13	0.75	0.1	500	0.3	MCAR	0.024388	0.000292	0.943	0.076666	-0.07455	0.02	0.024449	0.000352	0.892
14	0.75	0.1	500	0.3	MAR	0.044409	-0.0375	0.616	0.102643	-0.10114	0	0.027586	-0.00104	0.836
15	0.75	0.1	500	0.3	MNAR	0.094586	-0.09198	0.023	0.140388	-0.13944	0	0.082867	-0.07953	0.041
16	0.75	0.1	500	0.5	MCAR	0.028245	9.4E-05	0.96	0.125986	-0.12505	0	0.028233	0.00051	0.847
17	0.75	0.1	500	0.5	MAR	0.064114	-0.05872	0.408	0.155025	-0.15441	0	0.035529	-0.00284	0.75
18	0.75	0.1	500	0.5	MNAR	0.136429	-0.13464	0	0.192766	-0.19242	0	0.120721	-0.11805	0.002
19	0.75	0.1	1000	0.1	MCAR	0.015277	-0.00011	0.946	0.028602	-0.02503	0.564	0.015191	-0.00021	0.938
20	0.75	0.1	1000	0.1	MAR	0.020947	-0.01505	0.83	0.040813	-0.03854	0.188	0.014942	-0.00076	0.94
21	0.75	0.1	1000	0.1	MNAR	0.037808	-0.0345	0.368	0.05801	-0.05616	0.024	0.032756	-0.02873	0.486
22	0.75	0.1	1000	0.3	MCAR	0.017446	-0.00044	0.938	0.076389	-0.07534	0	0.017599	-0.00045	0.889

23	0.75	0.1	1000	0.3	MAR	0.041373	-0.03816	0.349	0.102364	-0.1017	0	0.018857	-0.00086	0.868
24	0.75	0.1	1000	0.3	MNAR	0.092589	-0.09119	0	0.139279	-0.13876	0	0.080148	-0.07829	0.001
25	0.75	0.1	1000	0.5	MCAR	0.021021	-0.00044	0.934	0.12577	-0.12525	0	0.021388	-0.00047	0.815
26	0.75	0.1	1000	0.5	MAR	0.061757	-0.05863	0.132	0.154675	-0.15432	0	0.026085	-0.00084	0.719
27	0.75	0.1	1000	0.5	MNAR	0.136277	-0.13536	0	0.192774	-0.19259	0	0.119768	-0.11835	0
28	0.75	0.2	200	0.1	MCAR	0.037884	0.000297	0.934	0.042537	-0.02489	0.831	0.037851	0.000111	0.932
29	0.75	0.2	200	0.1	MAR	0.03804	-0.01543	0.923	0.050891	-0.03932	0.728	0.035446	-0.00179	0.935
30	0.75	0.2	200	0.1	MNAR	0.051274	-0.03535	0.761	0.066375	-0.05646	0.53	0.048085	-0.03011	0.788
31	0.75	0.2	200	0.3	MCAR	0.042994	0.001757	0.934	0.07985	-0.07373	0.312	0.042894	0.001143	0.883
32	0.75	0.2	200	0.3	MAR	0.055571	-0.03913	0.793	0.106259	-0.10221	0.084	0.045043	-0.00594	0.838
33	0.75	0.2	200	0.3	MNAR	0.098121	-0.09136	0.278	0.141306	-0.13886	0	0.088065	-0.07899	0.311
34	0.75	0.2	200	0.5	MCAR	0.047652	0.0003	0.94	0.127467	-0.12482	0.006	0.049445	0.000118	0.815
35	0.75	0.2	200	0.5	MAR	0.075219	-0.06146	0.646	0.157455	-0.1557	0	0.060144	-0.01264	0.71
36	0.75	0.2	200	0.5	MNAR	0.138619	-0.1335	0.09	0.192726	-0.1917	0	0.12693	-0.11948	0.097
37	0.75	0.2	500	0.1	MCAR	0.02311	0.000588	0.945	0.032323	-0.02435	0.746	0.023194	0.000623	0.925
38	0.75	0.2	500	0.1	MAR	0.026183	-0.01346	0.896	0.042652	-0.03726	0.517	0.023237	0.000635	0.926
39	0.75	0.2	500	0.1	MNAR	0.041088	-0.03452	0.625	0.059558	-0.05586	0.207	0.036576	-0.02868	0.69
40	0.75	0.2	500	0.3	MCAR	0.026499	0.001474	0.944	0.076469	-0.07396	0.035	0.026098	0.001538	0.9
41	0.75	0.2	500	0.3	MAR	0.046394	-0.03881	0.617	0.103934	-0.10219	0	0.029782	-0.00246	0.836
42	0.75	0.2	500	0.3	MNAR	0.096514	-0.09377	0.024	0.14146	-0.14042	0	0.084919	-0.08138	0.043
43	0.75	0.2	500	0.5	MCAR	0.030118	0.001198	0.952	0.12536	-0.12434	0	0.030327	0.0014	0.841
44	0.75	0.2	500	0.5	MAR	0.06556	-0.05963	0.431	0.155595	-0.15491	0	0.037481	-0.00436	0.739
45	0.75	0.2	500	0.5	MNAR	0.137826	-0.13574	0	0.193225	-0.19282	0	0.122196	-0.11919	0
46	0.75	0.2	1000	0.1	MCAR	0.015596	0.000251	0.955	0.028513	-0.02461	0.634	0.015538	0.000178	0.941
47	0.75	0.2	1000	0.1	MAR	0.021807	-0.0148	0.828	0.041083	-0.03827	0.277	0.016644	-0.00039	0.922
48	0.75	0.2	1000	0.1	MNAR	0.038528	-0.03497	0.376	0.05856	-0.05658	0.036	0.033645	-0.02939	0.464
49	0.75	0.2	1000	0.3	MCAR	0.018349	-0.0005	0.935	0.076435	-0.07525	0	0.018313	-0.0003	0.905
50	0.75	0.2	1000	0.3	MAR	0.040861	-0.03698	0.409	0.10141	-0.10059	0	0.020574	-7E-06	0.861
51	0.75	0.2	1000	0.3	MNAR	0.093111	-0.09156	0	0.139521	-0.13897	0	0.080735	-0.07871	0.002

52	0.75	0.2	1000	0.5	MCAR	0.021786	-0.00034	0.946	0.125654	-0.12509	0	0.021727	-0.00045	0.836
53	0.75	0.2	1000	0.5	MAR	0.06219	-0.0589	0.157	0.154647	-0.15427	0	0.026867	-0.00275	0.738
54	0.75	0.2	1000	0.5	MNAR	0.137226	-0.13609	0	0.193357	-0.19313	0	0.121015	-0.1193	0
55	0.75	0.3	200	0.1	MCAR	0.038177	0.000677	0.947	0.042394	-0.02409	0.896	0.03811	0.0006	0.937
56	0.75	0.3	200	0.1	MAR	0.040676	-0.01598	0.916	0.052787	-0.03963	0.772	0.038905	-0.00282	0.928
57	0.75	0.3	200	0.1	MNAR	0.052312	-0.03425	0.792	0.066904	-0.05575	0.61	0.049135	-0.02903	0.814
58	0.75	0.3	200	0.3	MCAR	0.042761	0.000511	0.949	0.080954	-0.07471	0.395	0.042911	-7E-06	0.905
59	0.75	0.3	200	0.3	MAR	0.054619	-0.03794	0.833	0.105362	-0.10121	0.124	0.045958	-0.0058	0.864
60	0.75	0.3	200	0.3	MNAR	0.100243	-0.09231	0.338	0.142204	-0.13918	0.008	0.091002	-0.08059	0.351
61	0.75	0.3	200	0.5	MCAR	0.052289	0.001994	0.935	0.127431	-0.12438	0.031	0.051987	0.001554	0.814
62	0.75	0.3	200	0.5	MAR	0.0779	-0.06203	0.694	0.157786	-0.1557	0	0.06405	-0.01541	0.707
63	0.75	0.3	200	0.5	MNAR	0.1405	-0.1341	0.129	0.192959	-0.19165	0	0.128869	-0.11974	0.138
64	0.75	0.3	500	0.1	MCAR	0.023795	-0.00059	0.95	0.033537	-0.02544	0.772	0.023801	-0.00069	0.941
65	0.75	0.3	500	0.1	MAR	0.027777	-0.01404	0.897	0.043688	-0.03766	0.595	0.02499	-1.3E-05	0.922
66	0.75	0.3	500	0.1	MNAR	0.04319	-0.03529	0.643	0.061264	-0.05661	0.286	0.039122	-0.02974	0.683
67	0.75	0.3	500	0.3	MCAR	0.027953	5.7E-05	0.941	0.077721	-0.07502	0.058	0.028023	-0.00015	0.888
68	0.75	0.3	500	0.3	MAR	0.044661	-0.03614	0.717	0.102021	-0.10014	0.004	0.030859	0.000141	0.86
69	0.75	0.3	500	0.3	MNAR	0.094172	-0.09079	0.052	0.139577	-0.13834	0	0.082768	-0.07823	0.095
70	0.75	0.3	500	0.5	MCAR	0.033406	-0.00165	0.941	0.126924	-0.12565	0	0.033297	-0.00117	0.818
71	0.75	0.3	500	0.5	MAR	0.067933	-0.06069	0.458	0.156308	-0.15546	0	0.041424	-0.00799	0.731
72	0.75	0.3	500	0.5	MNAR	0.138451	-0.13619	0.002	0.193481	-0.19304	0	0.123951	-0.12059	0.003
73	0.75	0.3	1000	0.1	MCAR	0.016675	0.001045	0.948	0.028539	-0.0241	0.672	0.016749	0.00101	0.94
74	0.75	0.3	1000	0.1	MAR	0.023222	-0.01483	0.837	0.041906	-0.03846	0.312	0.018401	-0.00038	0.907
75	0.75	0.3	1000	0.1	MNAR	0.038728	-0.03456	0.451	0.058432	-0.05613	0.058	0.033811	-0.02882	0.543
76	0.75	0.3	1000	0.3	MCAR	0.019446	0.000372	0.942	0.07612	-0.07474	0.001	0.019489	0.000229	0.891
77	0.75	0.3	1000	0.3	MAR	0.042148	-0.03764	0.452	0.102053	-0.10106	0	0.021944	-0.00072	0.864
78	0.75	0.3	1000	0.3	MNAR	0.093748	-0.09209	0.002	0.140156	-0.13954	0	0.081756	-0.07956	0.009
79	0.75	0.3	1000	0.5	MCAR	0.023031	0.000863	0.938	0.125045	-0.12444	0	0.023098	0.000602	0.84
80	0.75	0.3	1000	0.5	MAR	0.063074	-0.0594	0.207	0.155133	-0.15472	0	0.02917	-0.00295	0.714

81	0.75	0.3	1000	0.5	MNAR	0.135651	-0.13445	0	0.192442	-0.19221	0	0.119712	-0.11793	0
82	0.85	0.1	200	0.1	MCAR	0.02848	-1.5E-05	0.941	0.029865	-0.01509	0.89	0.028272	-0.00021	0.93
83	0.85	0.1	200	0.1	MAR	0.03081	-0.01024	0.886	0.035988	-0.02444	0.798	0.030956	5.3E-05	0.898
84	0.85	0.1	200	0.1	MNAR	0.041005	-0.02955	0.717	0.049057	-0.04143	0.572	0.039012	-0.02611	0.728
85	0.85	0.1	200	0.3	MCAR	0.033263	8E-05	0.929	0.050736	-0.04494	0.528	0.033507	-3E-05	0.868
86	0.85	0.1	200	0.3	MAR	0.039791	-0.02611	0.809	0.066766	-0.06312	0.228	0.036833	-0.00055	0.828
87	0.85	0.1	200	0.3	MNAR	0.074049	-0.06938	0.239	0.095422	-0.09359	0.008	0.06833	-0.06206	0.272
88	0.85	0.1	200	0.5	MCAR	0.037264	6.3E-05	0.939	0.077494	-0.075	0.088	0.037592	0.000139	0.837
89	0.85	0.1	200	0.5	MAR	0.053376	-0.04162	0.682	0.09733	-0.09576	0.005	0.047661	-0.00708	0.693
90	0.85	0.1	200	0.5	MNAR	0.097291	-0.09392	0.102	0.122572	-0.12188	0	0.091015	-0.08596	0.099
91	0.85	0.1	500	0.1	MCAR	0.017085	-0.00082	0.957	0.022126	-0.01581	0.833	0.016911	-0.0008	0.949
92	0.85	0.1	500	0.1	MAR	0.02142	-0.01202	0.863	0.030557	-0.0259	0.62	0.018757	-0.00103	0.911
93	0.85	0.1	500	0.1	MNAR	0.033045	-0.02788	0.578	0.043349	-0.04013	0.274	0.029925	-0.02386	0.628
94	0.85	0.1	500	0.3	MCAR	0.01998	-0.00015	0.948	0.047318	-0.04508	0.17	0.019794	-0.0001	0.897
95	0.85	0.1	500	0.3	MAR	0.033687	-0.02822	0.635	0.066007	-0.06466	0.007	0.023593	-0.00137	0.836
96	0.85	0.1	500	0.3	MNAR	0.071813	-0.06975	0.024	0.094533	-0.09373	0	0.064729	-0.06199	0.048
97	0.85	0.1	500	0.5	MCAR	0.023793	-0.00041	0.946	0.076306	-0.0753	0.001	0.023932	-0.00051	0.827
98	0.85	0.1	500	0.5	MAR	0.049141	-0.04426	0.433	0.097777	-0.09715	0	0.031362	-0.00611	0.69
99	0.85	0.1	500	0.5	MNAR	0.09559	-0.09421	0.001	0.122352	-0.12207	0	0.086532	-0.0843	0.01
100	0.85	0.1	1000	0.1	MCAR	0.01261	0.00043	0.951	0.018535	-0.01453	0.73	0.012564	0.000386	0.936
101	0.85	0.1	1000	0.1	MAR	0.017164	-0.01164	0.817	0.027916	-0.02543	0.364	0.013476	-0.00068	0.907
102	0.85	0.1	1000	0.1	MNAR	0.031797	-0.02948	0.299	0.042914	-0.04148	0.035	0.02826	-0.02549	0.387
103	0.85	0.1	1000	0.3	MCAR	0.014132	-7.1E-05	0.949	0.046086	-0.04497	0.012	0.014078	-0.0002	0.901
104	0.85	0.1	1000	0.3	MAR	0.031847	-0.02893	0.407	0.065845	-0.06513	0	0.016845	-0.0012	0.832
105	0.85	0.1	1000	0.3	MNAR	0.070409	-0.06943	0	0.094006	-0.09363	0	0.062679	-0.06136	0.002
106	0.85	0.1	1000	0.5	MCAR	0.016475	0.000557	0.958	0.075199	-0.07471	0	0.016383	0.000601	0.842
107	0.85	0.1	1000	0.5	MAR	0.045926	-0.04373	0.161	0.097129	-0.09686	0	0.021186	-0.00278	0.732
108	0.85	0.1	1000	0.5	MNAR	0.095544	-0.09486	0	0.122563	-0.12242	0	0.085918	-0.08479	0
109	0.85	0.2	200	0.1	MCAR	0.030219	0.000547	0.94	0.031023	-0.01441	0.882	0.030227	0.000435	0.93

110	0.85	0.2	200	0.1	MAR	0.031712	-0.01157	0.898	0.037078	-0.02545	0.783	0.031489	-0.00181	0.915
111	0.85	0.2	200	0.1	MNAR	0.04047	-0.02846	0.749	0.048433	-0.04058	0.573	0.038561	-0.0249	0.764
112	0.85	0.2	200	0.3	MCAR	0.033308	-0.00204	0.939	0.052234	-0.04658	0.478	0.03371	-0.0021	0.892
113	0.85	0.2	200	0.3	MAR	0.041747	-0.02796	0.804	0.068214	-0.0643	0.216	0.037881	-0.00344	0.844
114	0.85	0.2	200	0.3	MNAR	0.075508	-0.06997	0.29	0.09603	-0.09384	0.017	0.069749	-0.06233	0.307
115	0.85	0.2	200	0.5	MCAR	0.040458	-0.00116	0.925	0.078282	-0.07546	0.084	0.040855	-0.00211	0.801
116	0.85	0.2	200	0.5	MAR	0.055402	-0.04343	0.697	0.098086	-0.09639	0.005	0.050059	-0.00948	0.709
117	0.85	0.2	200	0.5	MNAR	0.098354	-0.09438	0.122	0.122934	-0.1221	0	0.092644	-0.08658	0.119
118	0.85	0.2	500	0.1	MCAR	0.018775	0.000771	0.945	0.022214	-0.01426	0.837	0.018819	0.000867	0.935
119	0.85	0.2	500	0.1	MAR	0.022025	-0.01159	0.88	0.030695	-0.02546	0.622	0.019836	-0.00068	0.917
120	0.85	0.2	500	0.1	MNAR	0.034473	-0.02922	0.574	0.044663	-0.04133	0.264	0.031545	-0.02518	0.622
121	0.85	0.2	500	0.3	MCAR	0.020809	0.000199	0.948	0.047149	-0.04467	0.183	0.020799	0.000125	0.912
122	0.85	0.2	500	0.3	MAR	0.035929	-0.02963	0.635	0.067322	-0.06571	0.007	0.02513	-0.00312	0.819
123	0.85	0.2	500	0.3	MNAR	0.072342	-0.06989	0.05	0.094785	-0.0938	0	0.065425	-0.06214	0.075
124	0.85	0.2	500	0.5	MCAR	0.025779	0.001567	0.939	0.075654	-0.0745	0.002	0.025464	0.000817	0.834
125	0.85	0.2	500	0.5	MAR	0.04883	-0.04382	0.477	0.097498	-0.09684	0	0.032866	-0.00544	0.694
126	0.85	0.2	500	0.5	MNAR	0.095482	-0.09388	0.004	0.122177	-0.12184	0	0.086691	-0.08424	0.007
127	0.85	0.2	1000	0.1	MCAR	0.013648	7E-05	0.939	0.019314	-0.01488	0.747	0.013706	0.000181	0.925
128	0.85	0.2	1000	0.1	MAR	0.016913	-0.01098	0.845	0.027589	-0.02492	0.421	0.013516	0.000136	0.929
129	0.85	0.2	1000	0.1	MNAR	0.031235	-0.02819	0.365	0.042214	-0.04035	0.088	0.027829	-0.02419	0.447
130	0.85	0.2	1000	0.3	MCAR	0.014226	0.000361	0.959	0.04577	-0.04464	0.018	0.01419	0.000456	0.923
131	0.85	0.2	1000	0.3	MAR	0.032322	-0.02931	0.429	0.066269	-0.06554	0	0.017587	-0.00199	0.833
132	0.85	0.2	1000	0.3	MNAR	0.070905	-0.0698	0	0.094271	-0.09384	0	0.063224	-0.06175	0.004
133	0.85	0.2	1000	0.5	MCAR	0.018275	7.5E-05	0.936	0.075455	-0.07485	0	0.018496	-1.4E-05	0.818
134	0.85	0.2	1000	0.5	MAR	0.046792	-0.04412	0.209	0.097401	-0.09706	0	0.023913	-0.00322	0.691
135	0.85	0.2	1000	0.5	MNAR	0.095046	-0.09429	0	0.122286	-0.12213	0	0.08568	-0.0845	0
136	0.85	0.3	200	0.1	MCAR	0.032109	-0.00049	0.93	0.032885	-0.01551	0.852	0.032497	-0.0006	0.912
137	0.85	0.3	200	0.1	MAR	0.033727	-0.01266	0.89	0.038827	-0.02644	0.746	0.033521	-0.00283	0.909
138	0.85	0.3	200	0.1	MNAR	0.04175	-0.02988	0.763	0.049584	-0.04169	0.57	0.039794	-0.02614	0.773

139	0.85	0.3	200	0.3	MCAR	0.036104	-0.0007	0.928	0.052323	-0.04553	0.507	0.036588	-0.00111	0.883
140	0.85	0.3	200	0.3	MAR	0.042936	-0.02795	0.813	0.068762	-0.0645	0.223	0.039764	-0.00361	0.84
141	0.85	0.3	200	0.3	MNAR	0.074044	-0.0681	0.35	0.09489	-0.09256	0.02	0.069147	-0.06131	0.343
142	0.85	0.3	200	0.5	MCAR	0.04289	-0.00019	0.932	0.078322	-0.0751	0.1	0.044132	-0.00063	0.803
143	0.85	0.3	200	0.5	MAR	0.057766	-0.04351	0.701	0.098545	-0.09655	0.01	0.054007	-0.01105	0.684
144	0.85	0.3	200	0.5	MNAR	0.099443	-0.09526	0.138	0.12328	-0.12236	0	0.093701	-0.08769	0.116
145	0.85	0.3	500	0.1	MCAR	0.019599	0.000588	0.956	0.022994	-0.01452	0.859	0.019618	0.00054	0.948
146	0.85	0.3	500	0.1	MAR	0.022874	-0.01167	0.884	0.031248	-0.02558	0.683	0.020829	-0.00102	0.923
147	0.85	0.3	500	0.1	MNAR	0.034441	-0.02828	0.623	0.044189	-0.04029	0.359	0.031609	-0.02433	0.663
148	0.85	0.3	500	0.3	MCAR	0.022946	-0.00118	0.944	0.04867	-0.04583	0.241	0.023118	-0.00098	0.882
149	0.85	0.3	500	0.3	MAR	0.035412	-0.0283	0.684	0.066444	-0.06461	0.03	0.02681	-0.00238	0.822
150	0.85	0.3	500	0.3	MNAR	0.071734	-0.06922	0.058	0.094346	-0.09335	0	0.064554	-0.06119	0.084
151	0.85	0.3	500	0.5	MCAR	0.027477	0.001459	0.94	0.075501	-0.07414	0.004	0.027753	0.001694	0.826
152	0.85	0.3	500	0.5	MAR	0.049576	-0.04345	0.52	0.097507	-0.09671	0	0.035162	-0.00396	0.676
153	0.85	0.3	500	0.5	MNAR	0.09732	-0.09564	0.005	0.12311	-0.12276	0	0.088633	-0.08592	0.01
154	0.85	0.3	1000	0.1	MCAR	0.013951	-0.00023	0.956	0.019824	-0.01524	0.762	0.013971	-0.00023	0.948
155	0.85	0.3	1000	0.1	MAR	0.018998	-0.01222	0.83	0.029206	-0.02598	0.469	0.015322	-0.00137	0.909
156	0.85	0.3	1000	0.1	MNAR	0.032303	-0.0292	0.398	0.043208	-0.04128	0.107	0.028862	-0.0252	0.483
157	0.85	0.3	1000	0.3	MCAR	0.015688	0.000503	0.951	0.046071	-0.04466	0.04	0.015878	0.000401	0.894
158	0.85	0.3	1000	0.3	MAR	0.032097	-0.02835	0.487	0.065643	-0.06472	0	0.018972	-0.00113	0.829
159	0.85	0.3	1000	0.3	MNAR	0.070528	-0.06919	0.003	0.093961	-0.09344	0	0.062905	-0.06106	0.011
160	0.85	0.3	1000	0.5	MCAR	0.019096	-0.00011	0.944	0.075688	-0.07505	0	0.019183	-0.0005	0.836
161	0.85	0.3	1000	0.5	MAR	0.047031	-0.04403	0.258	0.097283	-0.09689	0	0.025106	-0.00359	0.714
162	0.85	0.3	1000	0.5	MNAR	0.096155	-0.0953	0	0.122788	-0.12261	0	0.086984	-0.08561	0
163	0.95	0.1	200	0.1	MCAR	0.01701	-0.00029	0.908	0.016343	-0.00525	0.907	0.016972	-0.00026	0.903
164	0.95	0.1	200	0.1	MAR	0.016972	-0.00614	0.845	0.017777	-0.01052	0.841	0.017702	-0.00181	0.887
165	0.95	0.1	200	0.1	MNAR	0.021574	-0.01501	0.676	0.023192	-0.01842	0.654	0.021128	-0.01356	0.706
166	0.95	0.1	200	0.3	MCAR	0.019858	0.000101	0.923	0.020505	-0.015	0.757	0.020148	-0.00033	0.853
167	0.95	0.1	200	0.3	MAR	0.020201	-0.0125	0.803	0.026205	-0.02372	0.534	0.022342	-0.00199	0.8

168	0.95	0.1	200	0.3	MNAR	0.034035	-0.03154	0.314	0.03801	-0.03693	0.097	0.032666	-0.02931	0.312
169	0.95	0.1	200	0.5	MCAR	0.022886	0.000285	0.931	0.027407	-0.02483	0.46	0.023378	-6E-05	0.791
170	0.95	0.1	200	0.5	MAR	0.026351	-0.01945	0.715	0.035713	-0.03457	0.144	0.029706	-0.00574	0.635
171	0.95	0.1	200	0.5	MNAR	0.039639	-0.03765	0.251	0.044089	-0.04364	0.006	0.038448	-0.03514	0.206
172	0.95	0.1	500	0.1	MCAR	0.010898	-0.00024	0.934	0.011111	-0.00523	0.847	0.010866	-0.00025	0.926
173	0.95	0.1	500	0.1	MAR	0.011543	-0.00536	0.876	0.013493	-0.00983	0.727	0.011553	-0.0002	0.911
174	0.95	0.1	500	0.1	MNAR	0.017743	-0.01523	0.554	0.020438	-0.01868	0.35	0.016618	-0.01366	0.596
175	0.95	0.1	500	0.3	MCAR	0.01246	0.000112	0.934	0.017307	-0.01491	0.52	0.012601	-0.00016	0.858
176	0.95	0.1	500	0.3	MAR	0.017154	-0.01325	0.702	0.025404	-0.02421	0.126	0.015106	-0.00185	0.787
177	0.95	0.1	500	0.3	MNAR	0.031747	-0.03066	0.097	0.036882	-0.03642	0	0.029681	-0.02813	0.122
178	0.95	0.1	500	0.5	MCAR	0.014438	-2.3E-05	0.933	0.026124	-0.02508	0.108	0.014625	-0.00035	0.815
179	0.95	0.1	500	0.5	MAR	0.022306	-0.01896	0.55	0.034948	-0.03444	0.001	0.020616	-0.00301	0.613
180	0.95	0.1	500	0.5	MNAR	0.038564	-0.03781	0.032	0.044143	-0.04397	0	0.03632	-0.035	0.047
181	0.95	0.1	1000	0.1	MCAR	0.007553	-0.00064	0.939	0.008788	-0.00558	0.866	0.007591	-0.00062	0.921
182	0.95	0.1	1000	0.1	MAR	0.009082	-0.00564	0.847	0.011937	-0.01003	0.652	0.008004	-0.00046	0.915
183	0.95	0.1	1000	0.1	MNAR	0.016988	-0.01547	0.36	0.019965	-0.01892	0.16	0.015711	-0.0139	0.419
184	0.95	0.1	1000	0.3	MCAR	0.008931	-0.00038	0.934	0.016494	-0.01525	0.346	0.009039	-0.00037	0.878
185	0.95	0.1	1000	0.3	MAR	0.014962	-0.01314	0.562	0.024697	-0.02417	0.024	0.010568	-0.00041	0.812
186	0.95	0.1	1000	0.3	MNAR	0.031195	-0.03066	0.008	0.036697	-0.03647	0	0.028822	-0.02803	0.022
187	0.95	0.1	1000	0.5	MCAR	0.010173	-0.00014	0.946	0.025635	-0.0251	0.016	0.01055	-0.00011	0.798
188	0.95	0.1	1000	0.5	MAR	0.020537	-0.01878	0.384	0.034643	-0.03438	0	0.015419	-0.00142	0.613
189	0.95	0.1	1000	0.5	MNAR	0.038291	-0.03795	0	0.044009	-0.04393	0	0.035624	-0.03496	0.003
190	0.95	0.2	200	0.1	MCAR	0.018475	0.000501	0.931	0.017138	-0.00447	0.844	0.018385	0.000511	0.922
191	0.95	0.2	200	0.1	MAR	0.017512	-0.00538	0.89	0.01796	-0.00982	0.782	0.018386	-0.00078	0.904
192	0.95	0.2	200	0.1	MNAR	0.022474	-0.01593	0.708	0.024085	-0.0193	0.554	0.022093	-0.01455	0.71
193	0.95	0.2	200	0.3	MCAR	0.020482	-0.00079	0.911	0.021205	-0.01552	0.652	0.020893	-0.00083	0.853
194	0.95	0.2	200	0.3	MAR	0.021845	-0.01281	0.794	0.027094	-0.02398	0.406	0.023779	-0.00303	0.783
195	0.95	0.2	200	0.3	MNAR	0.033666	-0.03079	0.376	0.037921	-0.03663	0.08	0.032593	-0.02866	0.373
196	0.95	0.2	200	0.5	MCAR	0.024399	0.000425	0.899	0.027821	-0.02488	0.382	0.02533	1.6E-05	0.782

197	0.95	0.2	200	0.5	MAR	0.027096	-0.01985	0.708	0.036289	-0.03503	0.088	0.029912	-0.00689	0.651
198	0.95	0.2	200	0.5	MNAR	0.039718	-0.03769	0.259	0.044415	-0.04397	0.007	0.038619	-0.03528	0.222
199	0.95	0.2	500	0.1	MCAR	0.011552	-8.6E-05	0.932	0.01157	-0.00502	0.852	0.011538	-4.9E-05	0.915
200	0.95	0.2	500	0.1	MAR	0.012197	-0.00567	0.872	0.014048	-0.01008	0.731	0.012197	-0.00061	0.905
201	0.95	0.2	500	0.1	MNAR	0.018536	-0.01508	0.599	0.020975	-0.01856	0.391	0.017581	-0.01355	0.615
202	0.95	0.2	500	0.3	MCAR	0.013051	-0.00017	0.933	0.017697	-0.01514	0.521	0.013167	-0.00016	0.888
203	0.95	0.2	500	0.3	MAR	0.017266	-0.01316	0.721	0.025443	-0.02419	0.148	0.015958	-0.00123	0.793
204	0.95	0.2	500	0.3	MNAR	0.031993	-0.03084	0.112	0.037065	-0.03657	0.002	0.029898	-0.02824	0.153
205	0.95	0.2	500	0.5	MCAR	0.015052	0.000332	0.936	0.025916	-0.02476	0.141	0.01516	3.8E-05	0.818
206	0.95	0.2	500	0.5	MAR	0.023025	-0.01955	0.589	0.035297	-0.03476	0.004	0.021534	-0.00365	0.629
207	0.95	0.2	500	0.5	MNAR	0.039357	-0.03858	0.038	0.044512	-0.04433	0	0.037277	-0.03589	0.054
208	0.95	0.2	1000	0.1	MCAR	0.008299	-1.8E-05	0.941	0.008996	-0.00498	0.861	0.008321	-5.5E-05	0.927
209	0.95	0.2	1000	0.1	MAR	0.009676	-0.00564	0.844	0.012329	-0.01007	0.665	0.008798	-0.00047	0.906
210	0.95	0.2	1000	0.1	MNAR	0.017582	-0.01594	0.365	0.020471	-0.01933	0.175	0.016347	-0.01442	0.416
211	0.95	0.2	1000	0.3	MCAR	0.009493	0.000326	0.945	0.016191	-0.01475	0.387	0.009616	0.000337	0.886
212	0.95	0.2	1000	0.3	MAR	0.015541	-0.01318	0.57	0.024874	-0.02418	0.038	0.011655	-0.00099	0.781
213	0.95	0.2	1000	0.3	MNAR	0.031374	-0.03081	0.008	0.036819	-0.03658	0	0.029101	-0.02829	0.022
214	0.95	0.2	1000	0.5	MCAR	0.01058	-0.00049	0.935	0.025757	-0.02519	0.019	0.010626	-0.00052	0.82
215	0.95	0.2	1000	0.5	MAR	0.021029	-0.0192	0.413	0.034878	-0.03461	0	0.015638	-0.00235	0.622
216	0.95	0.2	1000	0.5	MNAR	0.038447	-0.03805	0.002	0.044098	-0.04401	0	0.035807	-0.03506	0.004
217	0.95	0.3	200	0.1	MCAR	0.018442	-0.00094	0.925	0.017564	-0.0058	0.88	0.018598	-0.00095	0.89
218	0.95	0.3	200	0.1	MAR	0.019699	-0.00568	0.87	0.019852	-0.01003	0.798	0.020654	-0.00125	0.867
219	0.95	0.3	200	0.1	MNAR	0.023274	-0.01509	0.739	0.024576	-0.01854	0.619	0.023062	-0.01381	0.701
220	0.95	0.3	200	0.3	MCAR	0.02236	0.00023	0.886	0.021587	-0.01478	0.733	0.022654	6.1E-05	0.848
221	0.95	0.3	200	0.3	MAR	0.022713	-0.01275	0.754	0.027465	-0.02394	0.497	0.024914	-0.00332	0.761
222	0.95	0.3	200	0.3	MNAR	0.034034	-0.03101	0.353	0.03815	-0.03683	0.115	0.033038	-0.02901	0.367
223	0.95	0.3	200	0.5	MCAR	0.024712	0.000183	0.883	0.027947	-0.02493	0.475	0.025126	-0.00037	0.805
224	0.95	0.3	200	0.5	MAR	0.02844	-0.01968	0.629	0.036458	-0.03493	0.165	0.031402	-0.00779	0.65
225	0.95	0.3	200	0.5	MNAR	0.040556	-0.03809	0.203	0.044691	-0.04416	0.021	0.040038	-0.03624	0.21

226	0.95	0.3	500	0.1	MCAR	0.012108	-5.1E-05	0.941	0.012028	-0.00503	0.865	0.012042	-9.6E-05	0.927
227	0.95	0.3	500	0.1	MAR	0.013172	-0.00612	0.881	0.014901	-0.01052	0.734	0.013105	-0.00125	0.903
228	0.95	0.3	500	0.1	MNAR	0.018767	-0.01519	0.636	0.021137	-0.01862	0.42	0.017932	-0.01372	0.643
229	0.95	0.3	500	0.3	MCAR	0.013636	0.000667	0.943	0.017291	-0.01444	0.594	0.013853	0.00075	0.894
230	0.95	0.3	500	0.3	MAR	0.017817	-0.01294	0.718	0.025519	-0.02401	0.206	0.01704	-0.00176	0.79
231	0.95	0.3	500	0.3	MNAR	0.032075	-0.03069	0.149	0.03705	-0.03647	0.007	0.030239	-0.0283	0.177
232	0.95	0.3	500	0.5	MCAR	0.01624	-2.7E-05	0.941	0.026357	-0.02504	0.168	0.01643	-0.00021	0.824
233	0.95	0.3	500	0.5	MAR	0.02337	-0.01917	0.622	0.035266	-0.03461	0.011	0.022934	-0.00428	0.644
234	0.95	0.3	500	0.5	MNAR	0.03921	-0.03829	0.06	0.044195	-0.044	0	0.037097	-0.03542	0.08
235	0.95	0.3	1000	0.1	MCAR	0.008726	1E-06	0.946	0.00933	-0.005	0.856	0.008782	-2.4E-05	0.928
236	0.95	0.3	1000	0.1	MAR	0.009449	-0.00486	0.878	0.011918	-0.00942	0.692	0.009225	0.000383	0.925
237	0.95	0.3	1000	0.1	MNAR	0.017743	-0.01594	0.414	0.020604	-0.01935	0.221	0.016571	-0.01444	0.455
238	0.95	0.3	1000	0.3	MCAR	0.009601	0.000129	0.954	0.016374	-0.01491	0.392	0.00973	0.000132	0.901
239	0.95	0.3	1000	0.3	MAR	0.015671	-0.01314	0.617	0.024946	-0.0242	0.046	0.012308	-0.00096	0.8
240	0.95	0.3	1000	0.3	MNAR	0.031614	-0.03095	0.014	0.036922	-0.03664	0	0.029212	-0.02824	0.033
241	0.95	0.3	1000	0.5	MCAR	0.011809	-0.00033	0.931	0.02581	-0.0251	0.037	0.011921	-0.00015	0.807
242	0.95	0.3	1000	0.5	MAR	0.020868	-0.01868	0.473	0.034663	-0.03434	0	0.016809	-0.00169	0.634
243	0.95	0.3	1000	0.5	MNAR	0.038764	-0.03831	0.002	0.044245	-0.04414	0	0.036488	-0.03569	0.007

STable 2: Performance measures for $\widehat{SN}$ for all scenarios and imputation methods

Scenario	True SN	Prevalence	Sample Size (N)	Proportion Missing	Mechanism Missing	CCA RMSE	CCA Mean Bias	CCA Coverage Probability	MS RMSE	MS Mean Bias	MS Coverage Probability	MI RMSE	MI Mean Bias	MI Coverage Probability
1	0.75	0.1	200	0.1	MCAR	0.102546	0.002452	0.907	0.097173	-0.02135	0.858	0.1038	0.00153	0.874
2	0.75	0.1	200	0.1	MAR	0.103698	0.011528	0.915	0.095459	-0.01455	0.878	0.102357	0.0041	0.879
3	0.75	0.1	200	0.1	MNAR	0.107463	0.018626	0.922	0.098336	-0.0074	0.884	0.107028	0.015015	0.878
4	0.75	0.1	200	0.3	MCAR	0.116524	0.001466	0.899	0.118036	-0.07115	0.706	0.11952	-0.00201	0.848
5	0.75	0.1	200	0.3	MAR	0.125357	0.02798	0.901	0.120675	-0.04835	0.764	0.122047	0.00989	0.836
6	0.75	0.1	200	0.3	MNAR	0.148479	0.070634	0.899	0.146731	-0.0056	0.804	0.145425	0.059665	0.835
7	0.75	0.1	200	0.5	MCAR	0.138571	0.003308	0.886	0.157186	-0.11515	0.471	0.14105	-0.00462	0.75
8	0.75	0.1	200	0.5	MAR	0.163857	0.05702	0.892	0.197718	-0.05665	0.548	0.161658	0.029855	0.74
9	0.75	0.1	200	0.5	MNAR	0.213199	0.141717	0.839	0.271685	0.05395	0.591	0.208189	0.126895	0.648
10	0.75	0.1	500	0.1	MCAR	0.064498	-0.00067	0.934	0.064144	-0.0252	0.898	0.065248	-0.00067	0.917
11	0.75	0.1	500	0.1	MAR	0.065468	0.011845	0.946	0.059498	-0.01472	0.927	0.0627	0.00242	0.926
12	0.75	0.1	500	0.1	MNAR	0.069682	0.022325	0.939	0.059505	-0.005	0.935	0.067634	0.017162	0.925
13	0.75	0.1	500	0.3	MCAR	0.0739	-0.0014	0.935	0.093505	-0.0766	0.644	0.074882	-0.0031	0.862
14	0.75	0.1	500	0.3	MAR	0.082663	0.033403	0.924	0.076131	-0.05216	0.814	0.07374	0.006038	0.89
15	0.75	0.1	500	0.3	MNAR	0.109267	0.070861	0.861	0.074774	-0.02298	0.894	0.100324	0.057236	0.81
16	0.75	0.1	500	0.5	MCAR	0.08825	-0.00143	0.911	0.13423	-0.1257	0.28	0.090936	-0.00522	0.785
17	0.75	0.1	500	0.5	MAR	0.110949	0.062215	0.916	0.114884	-0.09076	0.533	0.094521	0.022692	0.801
18	0.75	0.1	500	0.5	MNAR	0.16845	0.133425	0.74	0.16692	-0.0185	0.715	0.156557	0.114252	0.588
19	0.75	0.1	1000	0.1	MCAR	0.046615	-0.00067	0.929	0.049861	-0.02581	0.871	0.04671	-0.00051	0.916
20	0.75	0.1	1000	0.1	MAR	0.048984	0.012365	0.935	0.044656	-0.0142	0.92	0.04565	0.00105	0.924
21	0.75	0.1	1000	0.1	MNAR	0.051426	0.020645	0.929	0.042491	-0.00657	0.937	0.048889	0.015531	0.925
22	0.75	0.1	1000	0.3	MCAR	0.051527	0.001267	0.934	0.083126	-0.07384	0.502	0.052552	0.000729	0.878
23	0.75	0.1	1000	0.3	MAR	0.062498	0.033952	0.923	0.063985	-0.05167	0.727	0.049957	0.004254	0.903
24	0.75	0.1	1000	0.3	MNAR	0.090867	0.06926	0.784	0.051066	-0.02609	0.873	0.079496	0.054469	0.749

25	0.75	0.1	1000	0.5	MCAR	0.06181	0.000127	0.928	0.129762	-0.12543	0.066	0.062071	-0.00079	0.83
26	0.75	0.1	1000	0.5	MAR	0.090546	0.062565	0.858	0.100822	-0.09497	0.263	0.065008	0.012054	0.822
27	0.75	0.1	1000	0.5	MNAR	0.148921	0.131667	0.524	0.10645	-0.04677	0.634	0.12769	0.106185	0.441
28	0.75	0.2	200	0.1	MCAR	0.070061	0.000608	0.937	0.068629	-0.024	0.913	0.070473	-9.4E-05	0.926
29	0.75	0.2	200	0.1	MAR	0.075321	0.010519	0.93	0.068752	-0.01523	0.929	0.072398	0.001113	0.918
30	0.75	0.2	200	0.1	MNAR	0.079383	0.025476	0.932	0.06669	-0.00205	0.949	0.077797	0.020947	0.915
31	0.75	0.2	200	0.3	MCAR	0.081571	-0.00444	0.922	0.098815	-0.07838	0.696	0.082686	-0.0054	0.863
32	0.75	0.2	200	0.3	MAR	0.092764	0.040667	0.935	0.076738	-0.04675	0.864	0.082222	0.013719	0.888
33	0.75	0.2	200	0.3	MNAR	0.114938	0.0707	0.885	0.084213	-0.02128	0.903	0.107394	0.058977	0.829
34	0.75	0.2	200	0.5	MCAR	0.09375	-0.00273	0.924	0.137954	-0.1251	0.394	0.095571	-0.00645	0.8
35	0.75	0.2	200	0.5	MAR	0.118688	0.053626	0.918	0.137382	-0.08715	0.57	0.101422	0.01285	0.802
36	0.75	0.2	200	0.5	MNAR	0.180345	0.137938	0.784	0.197358	0	0.717	0.168141	0.119805	0.608
37	0.75	0.2	500	0.1	MCAR	0.046006	0.000795	0.934	0.048203	-0.02441	0.889	0.045836	0.000898	0.923
38	0.75	0.2	500	0.1	MAR	0.046056	0.010187	0.955	0.043574	-0.01615	0.929	0.043402	-0.00095	0.945
39	0.75	0.2	500	0.1	MNAR	0.054044	0.023909	0.924	0.043103	-0.00423	0.948	0.051265	0.018256	0.92
40	0.75	0.2	500	0.3	MCAR	0.049957	0.000353	0.954	0.083697	-0.07474	0.487	0.049938	-0.0002	0.912
41	0.75	0.2	500	0.3	MAR	0.063876	0.034385	0.907	0.064154	-0.05129	0.734	0.051818	0.003292	0.885
42	0.75	0.2	500	0.3	MNAR	0.094933	0.075563	0.743	0.045281	-0.02348	0.908	0.081198	0.058394	0.739
43	0.75	0.2	500	0.5	MCAR	0.060227	-0.00112	0.947	0.12954	-0.12548	0.067	0.060685	-0.0022	0.828
44	0.75	0.2	500	0.5	MAR	0.088914	0.059259	0.869	0.101035	-0.09486	0.276	0.06563	0.008998	0.805
45	0.75	0.2	500	0.5	MNAR	0.152205	0.13406	0.517	0.112072	-0.04336	0.641	0.132367	0.110221	0.413
46	0.75	0.2	1000	0.1	MCAR	0.033005	7.1E-05	0.941	0.039223	-0.02478	0.826	0.033063	-9.5E-05	0.925
47	0.75	0.2	1000	0.1	MAR	0.036796	0.012683	0.918	0.034064	-0.01369	0.895	0.033385	0.00131	0.921
48	0.75	0.2	1000	0.1	MNAR	0.038952	0.021886	0.918	0.029165	-0.00558	0.94	0.035482	0.016095	0.921
49	0.75	0.2	1000	0.3	MCAR	0.036414	0.000595	0.945	0.07917	-0.07454	0.192	0.036073	0.000244	0.904
50	0.75	0.2	1000	0.3	MAR	0.052328	0.035023	0.859	0.057917	-0.0506	0.525	0.037311	0.00248	0.898
51	0.75	0.2	1000	0.3	MNAR	0.083728	0.07253	0.565	0.037833	-0.02446	0.842	0.069266	0.056088	0.583
52	0.75	0.2	1000	0.5	MCAR	0.042641	-0.00142	0.951	0.127901	-0.12587	0	0.043654	-0.00168	0.817
53	0.75	0.2	1000	0.5	MAR	0.075731	0.059089	0.766	0.099009	-0.09597	0.044	0.047518	0.004472	0.803

54	0.75	0.2	1000	0.5	MNAR	0.142502	0.133988	0.201	0.071175	-0.05595	0.43	0.117242	0.107014	0.187
55	0.75	0.3	200	0.1	MCAR	0.057843	0.00193	0.956	0.057671	-0.0229	0.902	0.058033	0.001894	0.939
56	0.75	0.3	200	0.1	MAR	0.063125	0.012257	0.936	0.057687	-0.01404	0.916	0.060218	0.001922	0.924
57	0.75	0.3	200	0.1	MNAR	0.064704	0.021836	0.944	0.05442	-0.00572	0.936	0.062512	0.016867	0.929
58	0.75	0.3	200	0.3	MCAR	0.067873	-0.0011	0.925	0.090631	-0.07574	0.611	0.067491	-0.00286	0.88
59	0.75	0.3	200	0.3	MAR	0.076025	0.032766	0.932	0.07136	-0.05193	0.782	0.065329	0.005657	0.902
60	0.75	0.3	200	0.3	MNAR	0.102454	0.070296	0.845	0.059437	-0.02722	0.909	0.092821	0.056004	0.813
61	0.75	0.3	200	0.5	MCAR	0.08246	0.002684	0.916	0.133076	-0.12381	0.222	0.084071	-0.00023	0.798
62	0.75	0.3	200	0.5	MAR	0.1007	0.054191	0.914	0.111613	-0.09752	0.416	0.086867	0.01247	0.779
63	0.75	0.3	200	0.5	MNAR	0.167346	0.139163	0.682	0.169752	-0.01447	0.68	0.150551	0.115647	0.533
64	0.75	0.3	500	0.1	MCAR	0.03743	0.00165	0.949	0.041699	-0.02369	0.853	0.037495	0.0017	0.941
65	0.75	0.3	500	0.1	MAR	0.040746	0.010246	0.933	0.038858	-0.01582	0.898	0.038044	-0.00092	0.927
66	0.75	0.3	500	0.1	MNAR	0.042441	0.019785	0.932	0.034289	-0.00722	0.939	0.039389	0.014072	0.93
67	0.75	0.3	500	0.3	MCAR	0.042182	0.000222	0.946	0.081062	-0.075	0.307	0.042562	0.000572	0.892
68	0.75	0.3	500	0.3	MAR	0.056379	0.034651	0.889	0.059856	-0.05109	0.61	0.042192	0.002758	0.89
69	0.75	0.3	500	0.3	MNAR	0.086273	0.072175	0.664	0.040905	-0.02449	0.854	0.073189	0.056527	0.666
70	0.75	0.3	500	0.5	MCAR	0.05023	-0.00092	0.931	0.128625	-0.12577	0.009	0.050905	-0.00135	0.835
71	0.75	0.3	500	0.5	MAR	0.083058	0.063453	0.793	0.097606	-0.09346	0.128	0.053953	0.009862	0.802
72	0.75	0.3	500	0.5	MNAR	0.145265	0.133937	0.336	0.080973	-0.05483	0.492	0.120403	0.106778	0.281
73	0.75	0.3	1000	0.1	MCAR	0.02745	0.001279	0.94	0.034502	-0.02392	0.795	0.027413	0.00128	0.931
74	0.75	0.3	1000	0.1	MAR	0.029636	0.012254	0.928	0.028003	-0.01389	0.895	0.026098	0.000994	0.938
75	0.75	0.3	1000	0.1	MNAR	0.032792	0.019504	0.899	0.024536	-0.00757	0.937	0.029492	0.013881	0.91
76	0.75	0.3	1000	0.3	MCAR	0.03056	-0.00031	0.937	0.078406	-0.0751	0.099	0.030108	-9.6E-05	0.885
77	0.75	0.3	1000	0.3	MAR	0.046878	0.034611	0.808	0.055426	-0.0505	0.386	0.029663	0.000941	0.902
78	0.75	0.3	1000	0.3	MNAR	0.079515	0.071929	0.409	0.033765	-0.0247	0.811	0.064706	0.055309	0.471
79	0.75	0.3	1000	0.5	MCAR	0.03572	0.001055	0.948	0.12603	-0.12456	0.001	0.036016	0.000296	0.824
80	0.75	0.3	1000	0.5	MAR	0.069982	0.058945	0.676	0.097529	-0.09548	0.008	0.036013	0.002964	0.829
81	0.75	0.3	1000	0.5	MNAR	0.141774	0.13624	0.059	0.060285	-0.05667	0.281	0.113973	0.107116	0.075
82	0.85	0.1	200	0.1	MCAR	0.084902	-0.00108	0.914	0.078294	-0.016	0.755	0.084949	-0.00279	0.837

83	0.85	0.1	200	0.1	MAR	0.087066	0.010482	0.931	0.077974	-0.0057	0.796	0.08404	0.00485	0.853
84	0.85	0.1	200	0.1	MNAR	0.097256	0.018357	0.911	0.08475	0.00055	0.803	0.095808	0.015255	0.836
85	0.85	0.1	200	0.3	MCAR	0.094234	-0.00308	0.876	0.082158	-0.0465	0.632	0.094139	-0.00808	0.84
86	0.85	0.1	200	0.3	MAR	0.105178	0.02337	0.902	0.077427	-0.0286	0.723	0.097578	0.007765	0.837
87	0.85	0.1	200	0.3	MNAR	0.120945	0.049425	0.918	0.08836	-0.00805	0.799	0.116738	0.03977	0.858
88	0.85	0.1	200	0.5	MCAR	0.114492	0.003344	0.79	0.097327	-0.07255	0.486	0.115153	-0.00542	0.747
89	0.85	0.1	200	0.5	MAR	0.140568	0.045228	0.824	0.103392	-0.0488	0.597	0.130183	0.022915	0.754
90	0.85	0.1	200	0.5	MNAR	0.171226	0.092795	0.849	0.123238	-0.01905	0.692	0.165223	0.077522	0.743
91	0.85	0.1	500	0.1	MCAR	0.0553	0.000652	0.902	0.051869	-0.01446	0.905	0.055467	6.4E-05	0.89
92	0.85	0.1	500	0.1	MAR	0.052703	0.004979	0.932	0.048291	-0.01062	0.942	0.050359	-0.00209	0.934
93	0.85	0.1	500	0.1	MNAR	0.058943	0.015161	0.923	0.050975	-0.00156	0.938	0.05697	0.011312	0.915
94	0.85	0.1	500	0.3	MCAR	0.061702	-0.00015	0.902	0.062738	-0.04496	0.786	0.063033	-0.00132	0.842
95	0.85	0.1	500	0.3	MAR	0.068121	0.024423	0.936	0.052847	-0.02792	0.873	0.059309	0.004788	0.872
96	0.85	0.1	500	0.3	MNAR	0.086021	0.051795	0.902	0.047447	-0.00952	0.932	0.079099	0.041284	0.836
97	0.85	0.1	500	0.5	MCAR	0.071733	-0.00075	0.902	0.084138	-0.07538	0.519	0.072079	-0.00474	0.783
98	0.85	0.1	500	0.5	MAR	0.09105	0.038727	0.909	0.069828	-0.05604	0.7	0.078262	0.009212	0.787
99	0.85	0.1	500	0.5	MNAR	0.131643	0.097151	0.844	0.060538	-0.02634	0.881	0.120054	0.07868	0.671
100	0.85	0.1	1000	0.1	MCAR	0.037718	0.000832	0.928	0.037221	-0.01422	0.881	0.03757	0.000584	0.917
101	0.85	0.1	1000	0.1	MAR	0.038587	0.007887	0.951	0.034983	-0.00774	0.917	0.036197	0.000291	0.935
102	0.85	0.1	1000	0.1	MNAR	0.043354	0.016834	0.926	0.035645	-8E-05	0.934	0.041205	0.012939	0.915
103	0.85	0.1	1000	0.3	MCAR	0.043253	-0.00022	0.919	0.054748	-0.04501	0.601	0.043333	-0.00098	0.882
104	0.85	0.1	1000	0.3	MAR	0.05321	0.024169	0.929	0.043471	-0.02833	0.783	0.042926	0.001564	0.878
105	0.85	0.1	1000	0.3	MNAR	0.067764	0.047863	0.852	0.035357	-0.01181	0.911	0.059084	0.035907	0.82
106	0.85	0.1	1000	0.5	MCAR	0.052868	-0.00057	0.905	0.080342	-0.07548	0.226	0.054258	-0.00133	0.775
107	0.85	0.1	1000	0.5	MAR	0.067221	0.039494	0.93	0.061935	-0.05539	0.465	0.050143	0.004197	0.831
108	0.85	0.1	1000	0.5	MNAR	0.112438	0.093148	0.7	0.042367	-0.02924	0.802	0.094794	0.071481	0.584
109	0.85	0.2	200	0.1	MCAR	0.060209	0.001882	0.905	0.056364	-0.01343	0.91	0.060471	0.001764	0.902
110	0.85	0.2	200	0.1	MAR	0.061567	0.003127	0.911	0.056386	-0.01258	0.922	0.058959	-0.00338	0.916
111	0.85	0.2	200	0.1	MNAR	0.064936	0.012612	0.915	0.056751	-0.00377	0.929	0.063207	0.009242	0.912

112	0.85	0.2	200	0.3	MCAR	0.067432	0.000763	0.92	0.065192	-0.0444	0.814	0.068274	-0.00135	0.836
113	0.85	0.2	200	0.3	MAR	0.07388	0.024886	0.943	0.056872	-0.02773	0.886	0.064915	0.005595	0.883
114	0.85	0.2	200	0.3	MNAR	0.087727	0.045479	0.944	0.053706	-0.01398	0.934	0.080458	0.034773	0.862
115	0.85	0.2	200	0.5	MCAR	0.079435	-0.00285	0.873	0.086873	-0.07683	0.581	0.079976	-0.00948	0.76
116	0.85	0.2	200	0.5	MAR	0.10209	0.044397	0.903	0.070418	-0.0526	0.753	0.089018	0.015525	0.766
117	0.85	0.2	200	0.5	MNAR	0.140118	0.096062	0.859	0.075221	-0.02548	0.901	0.126584	0.077304	0.729
118	0.85	0.2	500	0.1	MCAR	0.038003	-0.0018	0.922	0.038092	-0.01676	0.877	0.038295	-0.00232	0.908
119	0.85	0.2	500	0.1	MAR	0.039948	0.008547	0.946	0.035969	-0.00734	0.914	0.037528	0.000926	0.927
120	0.85	0.2	500	0.1	MNAR	0.044636	0.015023	0.922	0.037642	-0.00153	0.924	0.0427	0.011017	0.91
121	0.85	0.2	500	0.3	MCAR	0.04267	0.002699	0.94	0.052638	-0.04288	0.635	0.042763	0.00216	0.886
122	0.85	0.2	500	0.3	MAR	0.052507	0.025176	0.935	0.042597	-0.02743	0.796	0.042096	0.003141	0.886
123	0.85	0.2	500	0.3	MNAR	0.067416	0.048263	0.873	0.034164	-0.0117	0.924	0.057509	0.035573	0.834
124	0.85	0.2	500	0.5	MCAR	0.051705	0.001491	0.925	0.078769	-0.07381	0.233	0.052535	0.000745	0.787
125	0.85	0.2	500	0.5	MAR	0.070769	0.043302	0.918	0.061003	-0.0538	0.506	0.051138	0.00517	0.811
126	0.85	0.2	500	0.5	MNAR	0.113754	0.095038	0.701	0.041644	-0.02808	0.805	0.096503	0.074384	0.578
127	0.85	0.2	1000	0.1	MCAR	0.028098	-0.00016	0.923	0.029714	-0.01516	0.861	0.028137	-0.00019	0.906
128	0.85	0.2	1000	0.1	MAR	0.028842	0.00857	0.945	0.025918	-0.00733	0.924	0.026594	0.000958	0.932
129	0.85	0.2	1000	0.1	MNAR	0.03114	0.014384	0.938	0.024837	-0.00217	0.942	0.028903	0.010432	0.937
130	0.85	0.2	1000	0.3	MCAR	0.03011	0.001446	0.949	0.048867	-0.04384	0.47	0.029996	0.001361	0.9
131	0.85	0.2	1000	0.3	MAR	0.039823	0.023582	0.905	0.036462	-0.02831	0.735	0.029087	0.000444	0.899
132	0.85	0.2	1000	0.3	MNAR	0.060208	0.047752	0.705	0.027555	-0.01173	0.887	0.050125	0.03561	0.71
133	0.85	0.2	1000	0.5	MCAR	0.035558	-0.00069	0.93	0.077501	-0.07525	0.043	0.03599	-0.00086	0.82
134	0.85	0.2	1000	0.5	MAR	0.058121	0.041892	0.833	0.05803	-0.05428	0.273	0.035525	0.002072	0.834
135	0.85	0.2	1000	0.5	MNAR	0.103594	0.093662	0.415	0.035713	-0.02844	0.735	0.08287	0.071286	0.364
136	0.85	0.3	200	0.1	MCAR	0.050669	0.000407	0.91	0.048017	-0.01483	0.908	0.050487	-0.00012	0.902
137	0.85	0.3	200	0.1	MAR	0.049175	0.007277	0.936	0.044747	-0.00842	0.938	0.047011	0.000276	0.929
138	0.85	0.3	200	0.1	MNAR	0.052756	0.012737	0.92	0.045726	-0.00389	0.936	0.051447	0.009068	0.917
139	0.85	0.3	200	0.3	MCAR	0.05326	0.000433	0.931	0.058943	-0.0454	0.786	0.053874	-0.0002	0.874
140	0.85	0.3	200	0.3	MAR	0.061896	0.023489	0.948	0.049756	-0.02862	0.885	0.054938	0.003825	0.887

141	0.85	0.3	200	0.3	MNAR	0.077741	0.048682	0.913	0.0431	-0.0112	0.946	0.069257	0.037124	0.861
142	0.85	0.3	200	0.5	MCAR	0.069862	0.002666	0.89	0.081584	-0.0731	0.491	0.07053	3.7E-05	0.769
143	0.85	0.3	200	0.5	MAR	0.083985	0.042811	0.931	0.065446	-0.05346	0.712	0.066293	0.008321	0.826
144	0.85	0.3	200	0.5	MNAR	0.124228	0.096059	0.806	0.047768	-0.0278	0.893	0.109399	0.075913	0.674
145	0.85	0.3	500	0.1	MCAR	0.031035	0.00076	0.94	0.031706	-0.01441	0.87	0.030723	0.000701	0.934
146	0.85	0.3	500	0.1	MAR	0.032202	0.008483	0.954	0.028886	-0.00745	0.922	0.029656	0.00075	0.937
147	0.85	0.3	500	0.1	MNAR	0.036548	0.015173	0.925	0.029836	-0.00146	0.918	0.034368	0.01129	0.913
148	0.85	0.3	500	0.3	MCAR	0.036312	0.001579	0.94	0.051028	-0.04415	0.514	0.036468	0.001565	0.875
149	0.85	0.3	500	0.3	MAR	0.044369	0.023524	0.919	0.038769	-0.02852	0.737	0.03408	0.000234	0.897
150	0.85	0.3	500	0.3	MNAR	0.062924	0.048498	0.791	0.029787	-0.01113	0.901	0.0526	0.035674	0.788
151	0.85	0.3	500	0.5	MCAR	0.041867	0.00061	0.926	0.077699	-0.07462	0.097	0.041949	-0.00025	0.817
152	0.85	0.3	500	0.5	MAR	0.064311	0.044108	0.864	0.05817	-0.05304	0.383	0.042743	0.004787	0.823
153	0.85	0.3	500	0.5	MNAR	0.109225	0.09625	0.519	0.037445	-0.02756	0.762	0.088768	0.073551	0.452
154	0.85	0.3	1000	0.1	MCAR	0.021774	-0.00018	0.943	0.025031	-0.01514	0.852	0.021909	-0.00029	0.924
155	0.85	0.3	1000	0.1	MAR	0.024174	0.008204	0.935	0.021785	-0.00754	0.905	0.021736	0.000257	0.929
156	0.85	0.3	1000	0.1	MNAR	0.026476	0.013981	0.929	0.020198	-0.0026	0.944	0.024275	0.009849	0.929
157	0.85	0.3	1000	0.3	MCAR	0.025491	0.000321	0.932	0.048324	-0.04474	0.283	0.025581	0.000121	0.878
158	0.85	0.3	1000	0.3	MAR	0.036119	0.025642	0.874	0.032625	-0.027	0.674	0.022967	0.001615	0.921
159	0.85	0.3	1000	0.3	MNAR	0.05658	0.049719	0.573	0.021642	-0.01048	0.898	0.044822	0.036671	0.623
160	0.85	0.3	1000	0.5	MCAR	0.028663	-0.00047	0.941	0.07643	-0.07498	0.007	0.028234	-0.00102	0.827
161	0.85	0.3	1000	0.5	MAR	0.053764	0.043663	0.762	0.05534	-0.05303	0.141	0.027925	0.002813	0.85
162	0.85	0.3	1000	0.5	MNAR	0.101998	0.095625	0.208	0.032472	-0.0273	0.659	0.079646	0.072135	0.219
163	0.95	0.1	200	0.1	MCAR	0.052134	-0.00023	0.586	0.047513	-0.00505	0.586	0.051856	-0.00126	0.584
164	0.95	0.1	200	0.1	MAR	0.053143	0.003986	0.63	0.047513	-0.00165	0.63	0.050568	0.001255	0.628
165	0.95	0.1	200	0.1	MNAR	0.054584	0.004526	0.627	0.048811	-0.00095	0.627	0.05324	0.00277	0.627
166	0.95	0.1	200	0.3	MCAR	0.059844	-0.00071	0.507	0.044721	-0.0153	0.509	0.056818	-0.00347	0.504
167	0.95	0.1	200	0.3	MAR	0.066385	0.010658	0.582	0.044721	-0.0081	0.584	0.059178	0.002605	0.574
168	0.95	0.1	200	0.3	MNAR	0.068073	0.014671	0.602	0.045056	-0.0055	0.604	0.063444	0.01003	0.595
169	0.95	0.1	200	0.5	MCAR	0.074283	-2.5E-05	0.386	0.043589	-0.0252	0.389	0.068692	-0.00528	0.365

170	0.95	0.1	200	0.5	MAR	0.080046	0.015419	0.488	0.042808	-0.01725	0.49	0.07079	0.004345	0.468
171	0.95	0.1	200	0.5	MNAR	0.099301	0.0351	0.565	0.044777	-0.0086	0.572	0.090894	0.025285	0.511
172	0.95	0.1	500	0.1	MCAR	0.031725	-0.00123	0.891	0.029312	-0.00606	0.891	0.031829	-0.00124	0.889
173	0.95	0.1	500	0.1	MAR	0.033679	0.003201	0.906	0.030332	-0.00206	0.907	0.031886	0.00037	0.905
174	0.95	0.1	500	0.1	MNAR	0.035156	0.006052	0.913	0.03133	0.00058	0.914	0.03433	0.004702	0.91
175	0.95	0.1	500	0.3	MCAR	0.038417	0.000549	0.819	0.03062	-0.01466	0.821	0.037701	-0.00039	0.812
176	0.95	0.1	500	0.3	MAR	0.042932	0.009805	0.873	0.029772	-0.00834	0.882	0.036549	0.000742	0.869
177	0.95	0.1	500	0.3	MNAR	0.045292	0.016915	0.902	0.028927	-0.0036	0.905	0.041324	0.011678	0.887
178	0.95	0.1	500	0.5	MCAR	0.043954	-0.00227	0.687	0.034141	-0.02612	0.691	0.043047	-0.00501	0.668
179	0.95	0.1	500	0.5	MAR	0.053631	0.018446	0.824	0.029719	-0.016	0.831	0.043189	0.00346	0.801
180	0.95	0.1	500	0.5	MNAR	0.070244	0.037365	0.864	0.029448	-0.00702	0.892	0.061162	0.026978	0.792
181	0.95	0.1	1000	0.1	MCAR	0.023163	4.7E-05	0.94	0.021473	-0.00491	0.821	0.023189	-0.00024	0.891
182	0.95	0.1	1000	0.1	MAR	0.023841	0.003087	0.932	0.021291	-0.00225	0.863	0.022364	0.000114	0.879
183	0.95	0.1	1000	0.1	MNAR	0.025307	0.005353	0.943	0.022136	-0.00028	0.864	0.024349	0.003588	0.889
184	0.95	0.1	1000	0.3	MCAR	0.02736	0.00138	0.869	0.023803	-0.01384	0.686	0.027915	0.00108	0.842
185	0.95	0.1	1000	0.3	MAR	0.03081	0.010925	0.913	0.021399	-0.00751	0.801	0.024671	0.001094	0.882
186	0.95	0.1	1000	0.3	MNAR	0.035984	0.019237	0.928	0.021218	-0.00166	0.862	0.031476	0.013335	0.9
187	0.95	0.1	1000	0.5	MCAR	0.03024	0.000277	0.919	0.029177	-0.02489	0.459	0.030373	-0.00099	0.766
188	0.95	0.1	1000	0.5	MAR	0.040832	0.018653	0.934	0.023822	-0.01581	0.676	0.030733	0.001991	0.829
189	0.95	0.1	1000	0.5	MNAR	0.054432	0.038107	0.933	0.019987	-0.00631	0.841	0.044779	0.027139	0.782
190	0.95	0.2	200	0.1	MCAR	0.037434	0.001392	0.832	0.033829	-0.00378	0.832	0.03735	0.000945	0.83
191	0.95	0.2	200	0.1	MAR	0.037425	0.003501	0.858	0.03341	-0.00195	0.86	0.035346	0.000543	0.859
192	0.95	0.2	200	0.1	MNAR	0.038382	0.006987	0.873	0.034141	0.001325	0.873	0.036977	0.00508	0.872
193	0.95	0.2	200	0.3	MCAR	0.042697	0.000995	0.762	0.033072	-0.0143	0.766	0.042173	-1.8E-05	0.754
194	0.95	0.2	200	0.3	MAR	0.045319	0.010073	0.825	0.03183	-0.00793	0.828	0.039301	0.001552	0.822
195	0.95	0.2	200	0.3	MNAR	0.051737	0.019251	0.867	0.033232	-0.00157	0.875	0.046805	0.013535	0.859
196	0.95	0.2	200	0.5	MCAR	0.050215	0.000608	0.632	0.035143	-0.025	0.637	0.04841	-0.00304	0.611
197	0.95	0.2	200	0.5	MAR	0.059988	0.016851	0.744	0.033147	-0.01655	0.751	0.049583	0.003852	0.725
198	0.95	0.2	200	0.5	MNAR	0.074658	0.0371	0.819	0.032152	-0.00725	0.838	0.066652	0.02692	0.745

199	0.95	0.2	500	0.1	MCAR	0.023044	-0.00152	0.913	0.021712	-0.00634	0.822	0.023173	-0.00146	0.868
200	0.95	0.2	500	0.1	MAR	0.023413	0.003271	0.948	0.020931	-0.00207	0.865	0.022098	0.000235	0.89
201	0.95	0.2	500	0.1	MNAR	0.02496	0.006767	0.961	0.021524	0.00099	0.905	0.02386	0.004998	0.923
202	0.95	0.2	500	0.3	MCAR	0.025524	0.000999	0.874	0.022941	-0.01427	0.71	0.025788	0.000451	0.862
203	0.95	0.2	500	0.3	MAR	0.030942	0.011076	0.904	0.021431	-0.00721	0.81	0.025097	0.001359	0.871
204	0.95	0.2	500	0.3	MNAR	0.036331	0.018765	0.917	0.021573	-0.00196	0.863	0.031698	0.013203	0.891
205	0.95	0.2	500	0.5	MCAR	0.030787	0.000386	0.909	0.029345	-0.02491	0.451	0.031284	-0.00056	0.766
206	0.95	0.2	500	0.5	MAR	0.043214	0.020386	0.939	0.024271	-0.01485	0.671	0.03053	0.002962	0.818
207	0.95	0.2	500	0.5	MNAR	0.055745	0.03854	0.916	0.020474	-0.0061	0.837	0.04668	0.027941	0.799
208	0.95	0.2	1000	0.1	MCAR	0.017329	0.000263	0.926	0.016361	-0.00471	0.865	0.017257	0.000221	0.895
209	0.95	0.2	1000	0.1	MAR	0.017231	0.003097	0.948	0.015383	-0.00218	0.914	0.016004	-7.1E-05	0.918
210	0.95	0.2	1000	0.1	MNAR	0.017446	0.004578	0.958	0.015108	-0.00088	0.929	0.016625	0.002849	0.927
211	0.95	0.2	1000	0.3	MCAR	0.018484	-0.00041	0.908	0.020054	-0.01526	0.694	0.018588	-0.00071	0.866
212	0.95	0.2	1000	0.3	MAR	0.022436	0.01102	0.954	0.015506	-0.00725	0.871	0.016784	0.000856	0.915
213	0.95	0.2	1000	0.3	MNAR	0.028052	0.017843	0.904	0.015207	-0.00248	0.919	0.023451	0.012045	0.874
214	0.95	0.2	1000	0.5	MCAR	0.021594	-0.00047	0.893	0.027454	-0.02517	0.384	0.021704	-0.00097	0.797
215	0.95	0.2	1000	0.5	MAR	0.032272	0.018666	0.906	0.020574	-0.01573	0.683	0.021231	0.000719	0.825
216	0.95	0.2	1000	0.5	MNAR	0.047312	0.037919	0.812	0.015017	-0.00626	0.899	0.037222	0.02693	0.707
217	0.95	0.3	200	0.1	MCAR	0.029546	-0.00082	0.928	0.027247	-0.0058	0.745	0.02966	-0.001	0.848
218	0.95	0.3	200	0.1	MAR	0.03058	0.002786	0.944	0.02751	-0.00264	0.784	0.02891	-0.00029	0.828
219	0.95	0.3	200	0.1	MNAR	0.032182	0.005703	0.936	0.028334	0	0.806	0.031205	0.003874	0.851
220	0.95	0.3	200	0.3	MCAR	0.033404	-0.00066	0.867	0.028139	-0.01527	0.635	0.033388	-0.00156	0.834
221	0.95	0.3	200	0.3	MAR	0.03888	0.010582	0.913	0.027132	-0.00765	0.728	0.033214	0.001831	0.842
222	0.95	0.3	200	0.3	MNAR	0.042546	0.016797	0.923	0.02719	-0.00353	0.773	0.038708	0.011807	0.878
223	0.95	0.3	200	0.5	MCAR	0.040497	0.000557	0.772	0.03194	-0.02475	0.457	0.041372	-0.00127	0.735
224	0.95	0.3	200	0.5	MAR	0.051856	0.021631	0.876	0.027268	-0.01451	0.648	0.040899	0.005974	0.807
225	0.95	0.3	200	0.5	MNAR	0.067947	0.038387	0.87	0.028207	-0.00607	0.742	0.059299	0.028092	0.783
226	0.95	0.3	500	0.1	MCAR	0.018596	0.000523	0.904	0.017372	-0.00457	0.909	0.018703	0.000627	0.906
227	0.95	0.3	500	0.1	MAR	0.020233	0.002891	0.908	0.018113	-0.00244	0.92	0.018954	-0.00025	0.915

228	0.95	0.3	500	0.1	MNAR	0.020522	0.005512	0.921	0.017758	-2.4E-05	0.938	0.019726	0.003912	0.923
229	0.95	0.3	500	0.3	MCAR	0.021213	-3.3E-05	0.889	0.02124	-0.01507	0.773	0.021513	-0.00029	0.856
230	0.95	0.3	500	0.3	MAR	0.025417	0.010696	0.938	0.01781	-0.00757	0.885	0.020015	0.000638	0.886
231	0.95	0.3	500	0.3	MNAR	0.03222	0.019133	0.908	0.017992	-0.0017	0.924	0.027987	0.013307	0.872
232	0.95	0.3	500	0.5	MCAR	0.025434	0.000415	0.9	0.027963	-0.02479	0.504	0.025638	-0.00025	0.789
233	0.95	0.3	500	0.5	MAR	0.033659	0.01785	0.937	0.021495	-0.01604	0.773	0.022955	0.000441	0.845
234	0.95	0.3	500	0.5	MNAR	0.04957	0.036638	0.856	0.017652	-0.007	0.89	0.040701	0.026364	0.738
235	0.95	0.3	1000	0.1	MCAR	0.013366	-6.6E-05	0.933	0.013072	-0.00495	0.86	0.01353	-0.00011	0.921
236	0.95	0.3	1000	0.1	MAR	0.014549	0.004058	0.94	0.012616	-0.00135	0.913	0.013165	0.000794	0.93
237	0.95	0.3	1000	0.1	MNAR	0.015268	0.005952	0.948	0.012623	0.000324	0.928	0.014307	0.004136	0.936
238	0.95	0.3	1000	0.3	MCAR	0.014652	-0.00075	0.935	0.018598	-0.01552	0.584	0.014899	-0.0008	0.873
239	0.95	0.3	1000	0.3	MAR	0.018443	0.009483	0.95	0.013871	-0.00841	0.814	0.013566	-0.00038	0.907
240	0.95	0.3	1000	0.3	MNAR	0.026138	0.018636	0.857	0.01277	-0.00197	0.901	0.021557	0.012976	0.832
241	0.95	0.3	1000	0.5	MCAR	0.017938	-3E-06	0.917	0.026599	-0.025	0.221	0.018401	-0.00042	0.808
242	0.95	0.3	1000	0.5	MAR	0.02725	0.018309	0.918	0.018788	-0.0158	0.584	0.016103	9.3E-05	0.849
243	0.95	0.3	1000	0.5	MNAR	0.04511	0.039014	0.646	0.012493	-0.00552	0.864	0.034453	0.027592	0.566

10. R-code

The R-code employed for this work is attached in the following electronic file:

ANURADH_SHARMA_Mastarbeit_2023_R-Code.zip