RconfeRence 2022

Introduction to PVBcorrect:
An R Package for Partial Verification Bias Correction

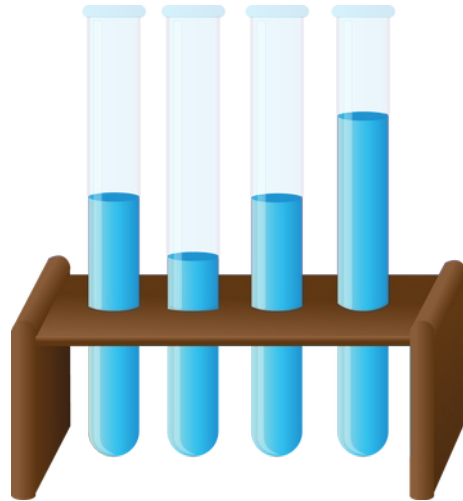**27 November 2022**

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Outlines

- Background

- About PVBcorrect package

- Using PVBcorrect package

- Conclusion

Background

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Background

Diagnostic Tests → Very important role in medical care[1]

Objective assessment[2]

Disease vs No disease[3]

Diagnostic Tests

Newly Developed Tests → Evaluation[4] → **Diagnostic Accuracy Studies**

[1]O'Sullivan et al. (2018). [2]Kosinski & Barnhart (2003). [3]Gotzche (2007). [4]Linnet et al. (2012).

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Diagnostic accuracy studies

Newly Developed Test

Gold Standard Test

Compare*

| New Covid-19 Test Kit |

| Reverse Transcription Polymerase Chain Reaction (RT-PCR) |

| New Pregnancy Test Kit |

| Human Chorionic Gonadotropin (hCG) |

Binary Accuracy Measures

Sensitivity (True Positive Rate)

Specificity (True Negative Rate)

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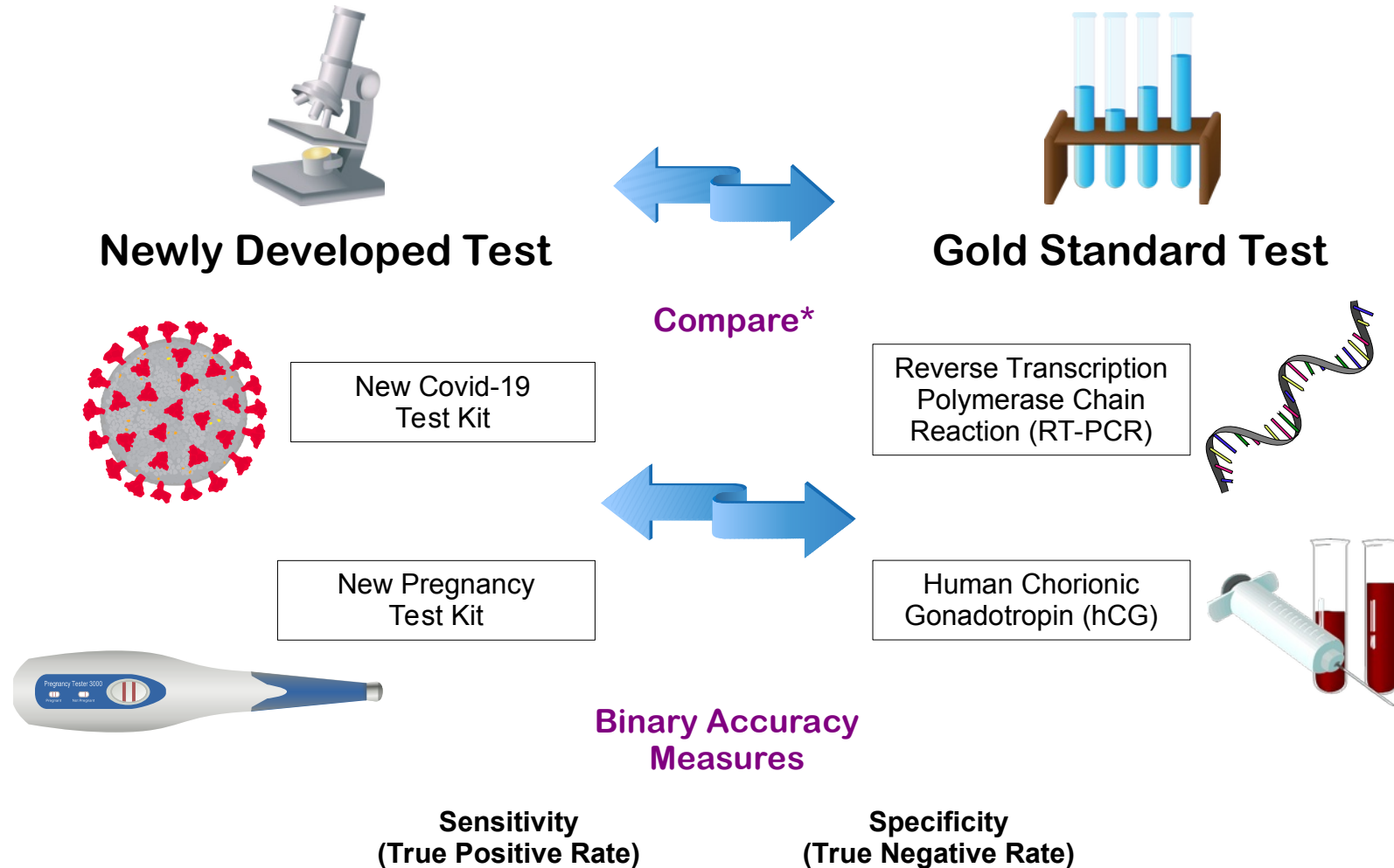
*Hall et al. (2019), O'Sullivan et al. (2018).

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Ideal

Test Result

Disease Status

Positive

Disease

New Test

Gold Standard Test

Negative
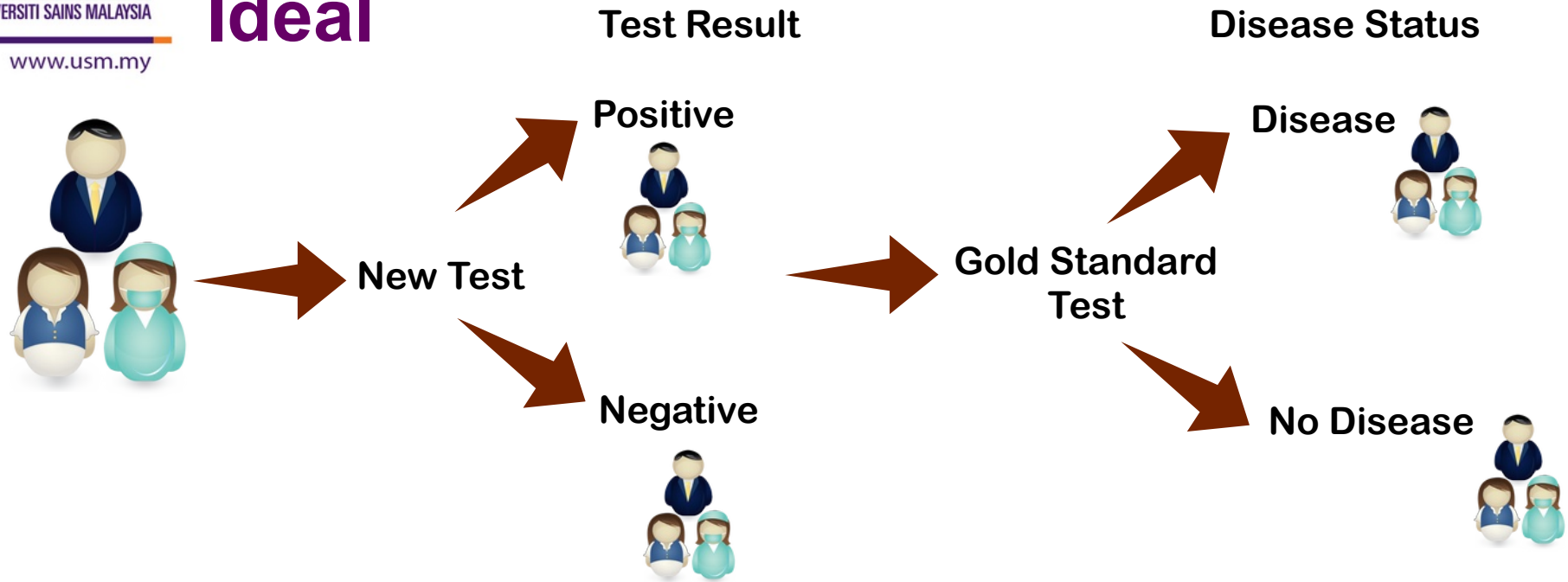
No Disease

Test Result	Disease Status	
	P	**N**
P	**TP**	**FP**
N	**FN**	**TN**

Sensitivity= TP/(TP+FN)

Specificity= TN/(TN+FP)

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Abbreviations: TP, true positive; TN, true negative; FP, false positive; FN, false negative.

Partial Verification Bias (PVB)
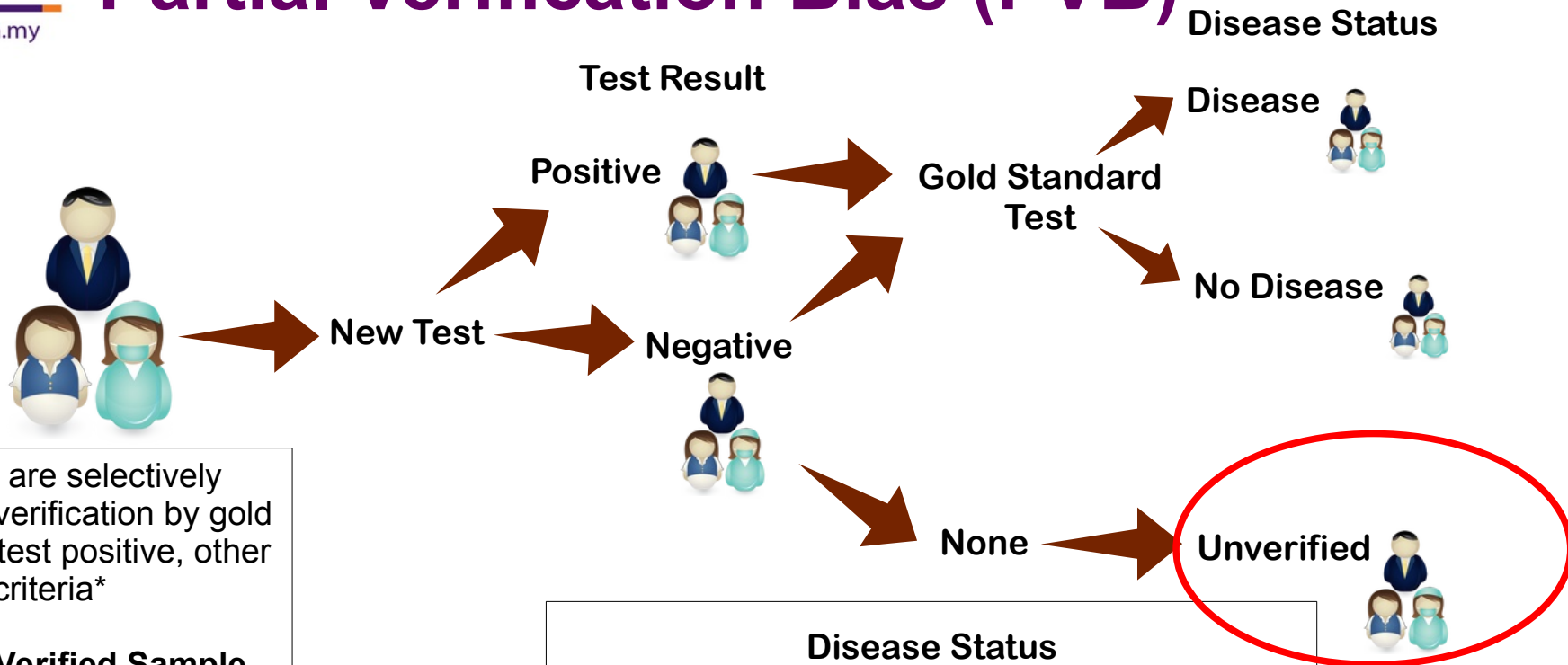
Patients are selectively chosen for verification by gold standard – test positive, other criteria*

Partially Verified Sample

Test Result	Disease Status		
	P	**N**	**Unverified**
P	TP	FP	?TP/FP
N	FN	TN	?FN/TN

Sensitivity?   Specificity?

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*O'Sullivan et al. (2018). Abbreviations: TP, true positive; TN, true negative; FP, false positive; FN, false negative.

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Background

- Reasons:

  - Study design: Efficiency, technical, ethical.

  - Clinical practice: Clinical likelihood.

 - Infeasibility: Invasive procedures, postmortem diagnosis.

¹Naaktgeboren et al (2016)

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Background

- PVB → Inaccurate estimates of accuracy measures[1,2]

- Impact on the clinical practice
  - Invalid diagnostic tests[3]
  - Clinical errors[2]

- Cannot eliminate verification bias in medical data → Need methods to correct PVB[4]

[1]Naaktkeboren et al. (2016), [2]Hall et al. (2019), [3]Chikere et al. (2019), [4]O'Sullivan (2018)

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Missing Data Mechanisms in PVB

COVID-19 -- Proceed to RT-PCR regardless RTK-Ag is +ve or -ve

COVID-19 -- Proceed to RT-PCR when RTK-Ag is +ve

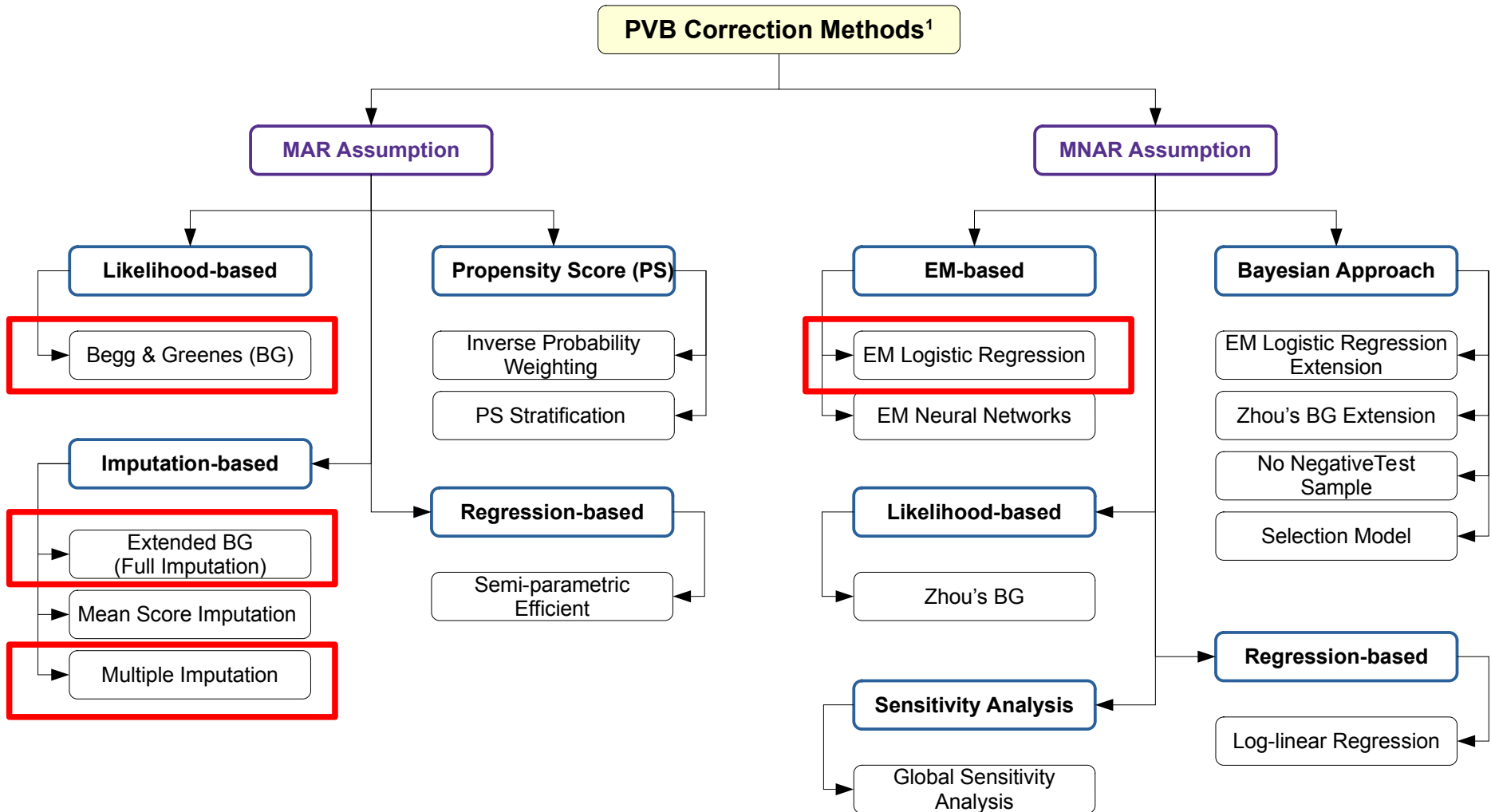COVID-19 -- Proceed to RT-PCR when RTK-Ag is +ve AND patient looks sick

Test

Disease ✗ **Verified**
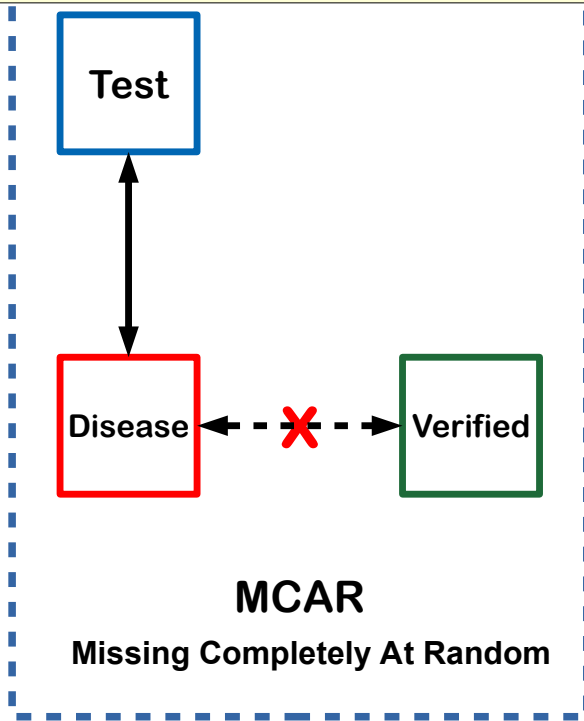
MCAR

Missing Completely At Random

No selection bias

*Adapted from Figure 2 in Schafer & Graham (2002)

With Partial Verification Bias

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Existing PVB Correction Methods

¹Arifin & Yusof, 2022. **EM**, expectation maximization; **MAR**, missing at random; **MNAR**, missing not at random; **PVB**, partial verification bias.

About PVBcorrect

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About

- Available in GitHub

  github.com/wnarifin/PVBcorrect

- Tutorial published in Statistics in Medicine

  doi.org/10.1002/sim.9311

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Features

- Version 0.1.1

- Available methods:

  – Begg and Greenes' method

  – Begg and Greenes' methods 1 and 2

  – Multiple imputation method by logistic regression

  – EM-based logistic regression method

- Point estimates & CIs

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Installation

- Pre-requisites

```
install.packages("boot", "mice")
```

- Installation

```
install.packages("devtools")
devtools::install_github("wnarifin/PVBcorrect")
```

Using PVBcorrect

Data Preparation

- Categorical variables, code as 1/0:
  - Outcome, Test variables: Binary (Yes = 1, No = 0)
  - Categorical variables: Binary/Dummy (Yes = 1, No = 0)

- Numerical variables: No issue

Load Data Set

- Load PVBcorrect

```
library(PVBcorrect)
```

- Built-in data set

```
?cad_pvb
```

SPECT Thallium test data set

- Single-photon-emission computed-tomography (SPECT) thallium is a non-invasive diagnostic test used to diagnose coronary artery disease (CAD).

- n = 2688 patients, only 471 verified, 2217 unverified (82.5%).

- Data set, five variables:

  1. SPECT thallium test, T: Binary, 1 = Positive, 0 = Negative

  2. CAD, D: Binary, 1 = Yes, 0 = No

  3. Gender, X1: Binary, 1 = Male, 0 = Female

  4. Stress mode, X2: Binary, 1 = Dipyridamole (Medication for stress test when the patient is unable to exercise), 0 = Exercise

  5. Age, X3: Binary, 1 = 60 years and above, 0 = Below 60 years

PVBcorrect Demo

wnarifin.github.io/workshop.html

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Conclusion

- To-do list for future updates:
  - Existing methods listed in LR
  - New methods developed by the presenter
  - Methods for numerical diagnostic test
  - GUI interface via R shiny

References

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Kosinski, A. S., & Barnhart, H. X. (2003b). A global sensitivity analysis of performance of a medical diagnostic test when verification bias is present. Statistics in Medicine, 22(17), 2711-2721.

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Thank You