UNIVERSITI SAINS MALAYSIA

Webinar

Correcting Partial Verification Bias in Diagnostic Accuracy Studies Using R

Wan Nor Arifin
PhD Candidate, School of Computer Sciences,
Universiti Sains Malaysia.

UNIVERSITI SAINS MALAYSIA
www.usm.my

Organized by

Epidemiological and Statistical Modelling Team, USM

Background

- Diagnostic test
  - Discriminate diseased vs non-diseased O'Sullivan et al. (2018)
  - Extremely important role in medical care Kosinski & Barnhart (2003)
  - Objective assessment Gotzche (2007)
- Requires evaluation Linnet et al. (2012) → Diagnostic accuracy study.

Background

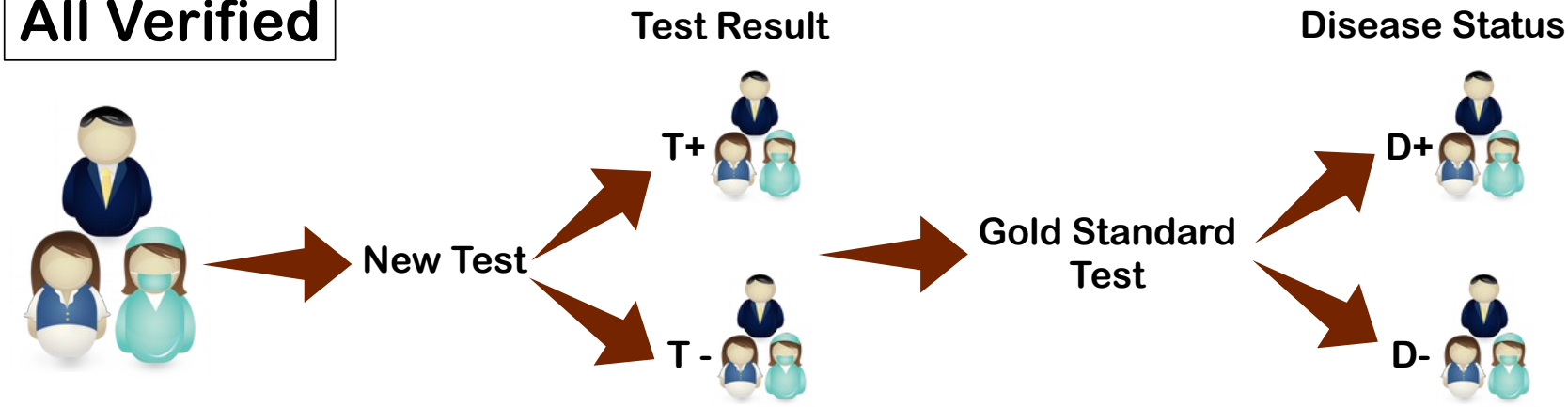
- Diagnostic accuracy study: New test vs Gold Standard[Hall et al. (2019), O'Sullivan et al. (2018)]
  - Covid-19: RT-Ag vs RT-PCR
  - HIV: HIV Rapid Test vs ELISA
  - Breast CA: Mammogram vs Histology

Background

- Accuracy measures for binary test:
  - Sensitivity (True Positive Rate)
  - Specificity (True Negative Rate)
  - Positive Predictive Value (PPV)
  - Negative Predictive Value (NPV)

Background

All Verified



	Disease Status			
Test Result	D+	D-		
T+	TP	FP	PPV= TP/(TP+FP)	Positive Predictive Value
T-	FN	TN	NPV= TN/(FN+TN)	Negative Predictive Value
	Sn= TP/(TP+FN)	Sp= TN/(TN+FP)		
	Sensitivity	Specificity		

Background

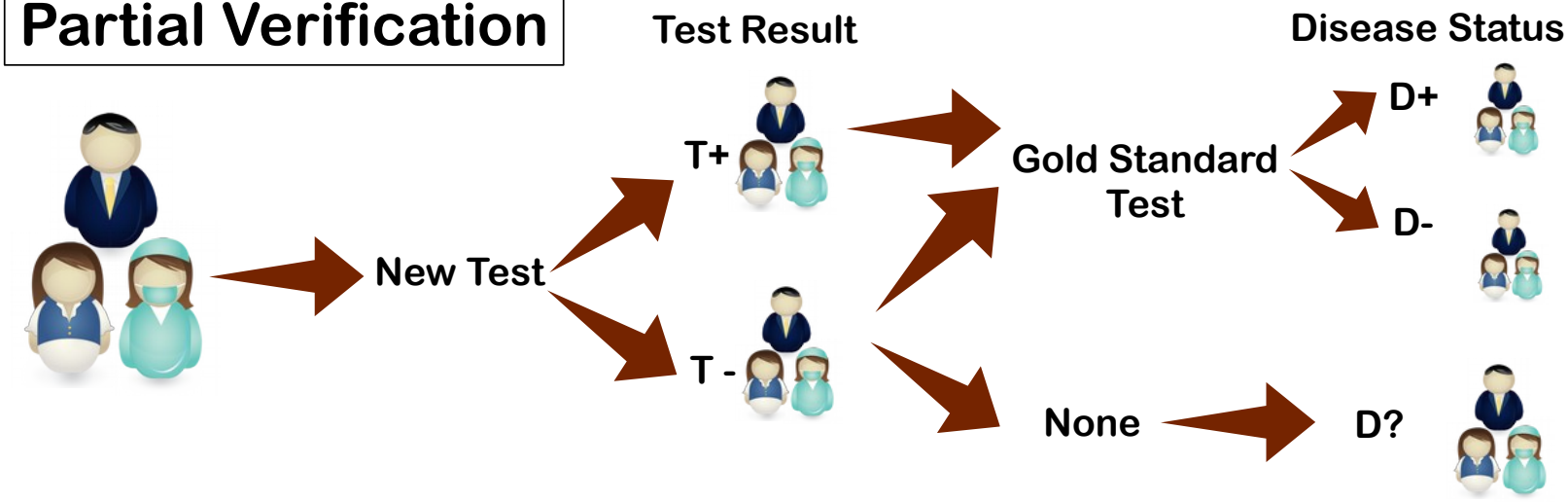
- Estimates, esp. Sensitivity and Specificity are often biased.
- Sampling bias in diagnostic accuracy study → Verification bias (VB)O'Sullivan et al. (2018)

Background

- Patients are selectively chosen for verification by gold standard.
- Test positive more likely selected + other clinical criteria O'Sullivan et al. (2018)
- Reasons Naaktgeboren et al (2016):
  - Study design: Efficiency, technical, ethical.
  - Clinical practice: Clinical likelihood.
  - Infeasibility: Invasive procedures, postmortem diagnosis.
- Partial and Differential Verification bias de Groot et al. (2011a)

Background

Partial Verification



	Disease Status		
Test Result	D+	D-	D?
T+	TP	FP	?
T-	FN	TN	?

Positive Predictive Value?

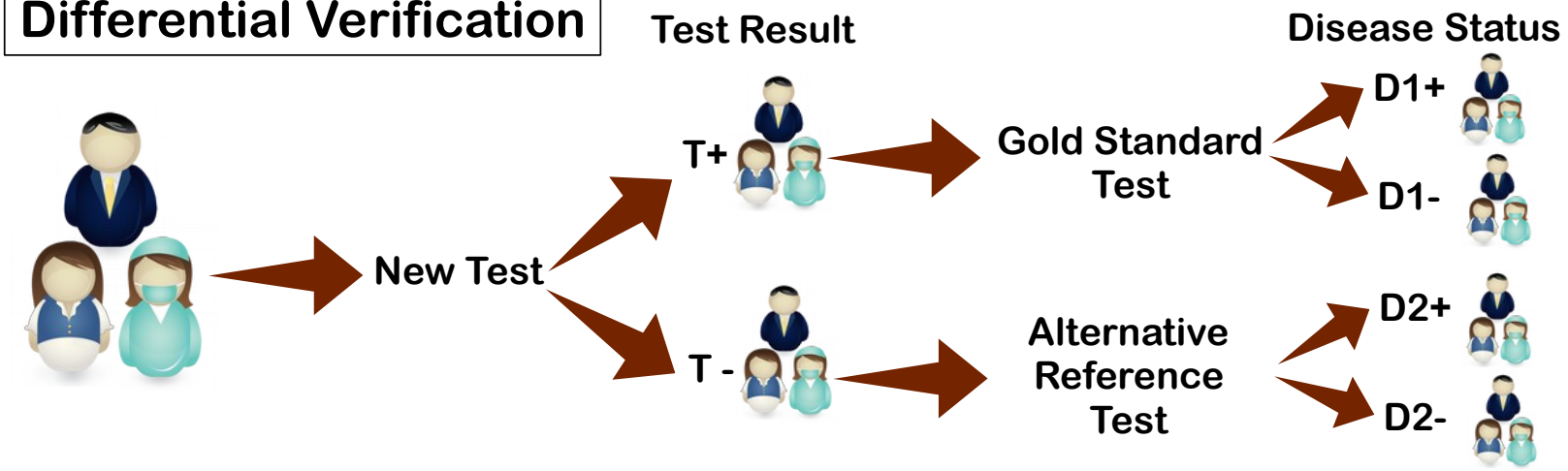
Negative Predictive Value?

Sensitivity?

Specificity?

Background

Differential Verification



	Disease Status (Gold)		Disease Status (Alternative)		
Test Result	D1+	D1-	D2+	D2-	
T+	TP	FP	TP?	FP?	Positive Predictive Value?
T-	FN	TN	FN?	TN?	Negative Predictive Value?

Sensitivity?

Specificity?

Background

- VBs → Inaccurate estimates of accuracy measures[Naaktkeboren et al. (2016), Hall et al. (2019)]
- Impact on the clinical practice
  - Invalid diagnostic tests[Chikere et al. (2019)]
  - Clinical errors[Hall et al. (2019)]
- Cannot eliminate verification bias in medical data → Relies on methods to correct VB[O'Sullivan (2018)]

Literature Review

Existing Correction Methods

Partial Verification Bias

MAR

- Begg & Greenes' Begg & Greenes (1983)
- Mean Score Imputation Alonzo & Pepe (2005)
- Inverse Probability Weighting Alonzo & Pepe (2005)
- Semi-parametric Efficient Estimator Alonzo & Pepe (2005)
- Multiple Imputation Harel & Zhou (2006)
- Propensity Score Stratification He & McDermott (2012)

MNAR

- Zhou's Begg & Greenes' Extension Zhou (1993)
- Logistic Regression Kosinski & Barnhart (2003a)
- Global Sensitivity Analysis Kosinski & Barnhart (2003b)
- Neural Networks Ünal & Burgut (2014)
- Log-Linear Regression Rochani et al. (2015)
- Bayesian Appoaches Martinez et al. (2006), Buzoianu & Kadane (2008), Pennello (2011), Hajivandi et al. (2018)

Differential Verification Bias

- Bayesian Approach Lu et al. (2010)
- Bayesian Latent Class Approach de Groot et al. (2011c)

Thank You

References

Alonzo, T. A., & Pepe, M. S. (2005). Assessing accuracy of a continuous screening test in the presence of verification bias. *Journal of the Royal Statistical Society: Series C (Applied Statistics), 54*(1), 173–190.

Begg, C. B., & Greenes, R. A. (1983). Assessment of diagnostic tests when disease verification is subject to selection bias. *Biometrics, 39*(1), 207-215.

Buzoianu, M., & Kadane, J. B. (2008). Adjusting for verification bias in diagnostic test evaluation: a Bayesian approach. *Statistics in Medicine, 27*(13), 2453-2473.

Cecil, M. P., Kosinski, A. S., Jones, M. T., Taylor, A., Alazraki, N. P., Pettigrew, R. I., & Weintraub, W. S. (1996). The importance of work-up (verification) bias correction in assessing the accuracy of spect thallium-201 testing for the diagnosis of coronary artery disease. *Journal of clinical epidemiology, 49*(7), 735–742.

Chikere, C. M. U., Wilson, K., Graziadio, S., Vale, L., & Allen, A. J. (2019). Diagnostic test evaluation methodology: A systematic review of methods employed to evaluate diagnostic tests in the absence of gold standard–An update. *PloS one, 14*(10), e0223832.

de Groot, J. A., Bossuyt, P. M., Reitsma, J. B., Rutjes, A. W., Dendukuri, N., Janssen, K. J., & Moons, K. G. (2011a). Verification problems in diagnostic accuracy studies: consequences and solutions. Bmj, 343, d4770.

de Groot, J. A., Dendukuri, N., Janssen, K. J., Reitsma, J. B., Bossuyt, P. M., & Moons, K. G. (2011c). Adjusting for differential-verification bias in diagnostic-accuracy studies: a bayesian approach. Epidemiology, 234–241.

References

Gotzsche, P.C. (2007). Rational diagnosis and treatment: Evidence based clinical decision making (4th ed.). West Sussex, UK: John Wiley & Sons Ltd.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. USA: MIT Press.

Hajivandi, A., Shirazi, H. R. G., Saadat, S. H., & Chehrazi, M. (2018). A bayesian analysis with informative prior on disease prevalence for predicting missing values due to verification bias. *Open Access Macedonian Journal of Medical Sciences, 6*(7), 1225.

Harel, O., & Zhou, X. H. (2006). Multiple imputation for correcting verification bias. *Statistics in Medicine, 25*(22), 3769-3786.

He, H., & McDermott, M. P. (2012). A robust method using propensity score stratification for correcting verification bias for binary tests. *Biostatistics, 13*(1), 32-47.

Kosinski, A. S., & Barnhart, H. X. (2003a). Accounting for nonignorable verification bias in assessment of diagnostic tests. *Biometrics, 59*(1), 163-171.

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.

Lu, Y., Dendukuri, N., Schiller, I., & Joseph, L. (2010). A bayesian approach to simultaneously adjusting for verification and reference standard bias in diagnostic test studies. *Statistics in medicine, 29*(24), 2532–2543.

Martinez, E. Z., Achcar, J. A., & Louzada-Neto, F. (2006). Estimators of sensitivity and specificity in the presence of verification bias: A bayesian approach. *Computational statistics & data analysis, 51*(2), 601–611.

References

Naaktgeboren, C. A., de Groot, J. A., Rutjes, A. W., Bossuyt, P. M., Reitsma, J. B., & Moons, K. G. (2016). Anticipating missing reference standard data when planning diagnostic accuracy studies. *BMJ, 352*, i402.

Pennello, G. A. (2011). Bayesian analysis of diagnostic test accuracy when disease state is unverified for some subjects. Journal of biopharmaceutical statistics, 21(5), 954–970.

O'Sullivan, J. W., Banerjee, A., Heneghan, C., & Pluddemann, A. (2018). Verification bias. *BMJ Evidence-based Medicine, 23(2)*, 54-55.

Rochani, H., Samawi, H. M., Vogel, R. L., & Yin, J. (2015). Correction of verication bias using log-linear models for a single binaryscale diagnostic tests. *Journal of Biometrics and Biostatistics, 6*(5), 266.

Ünal, İ., & Burgut, H. R. (2014). Verification bias on sensitivity and specificity measurements in diagnostic medicine: a comparison of some approaches used for correction. *Journal of Applied Statistics, 41*(5), 1091–1104.

Zhou, X.-H. (1993). Maximum likelihood estimators of sensitivity and specificity corrected for verification bias. *Communications in Statistics-Theory and Methods,, 22*(11), 3177–3198.

UNIVERSITI
SAINS
MALAYSIA

Thank You

Transforming Higher Education For A Sustainable Tomorrow