“Bayesian Latent Class Models to evaluate diagnostic tests in the absence of a gold standard”
Day 1

Training workshop Zurich

Sonja Hart5nack & Valerie Hungerbühler

Welcome

- Introduce yourself please
- Add info on country of origin, mr/doct/prof
- Self-assessment

Intro cost action

Date	Start	End	Speaker(s)	Title
			Lecture Room Y17-M-05	
Wednesday 14 July 2021	9:00	10:15	Sonja Hartnack & Valerie Hungerbühler	Welcome & Introduction
	10:15	11:15	Sonja Hartnack	Brief historical sketch of BLCMs
	11:15	11:45		Coffee break
	11:45	12:20	Sonja Hartnack & Valerie Hungerbühler	Hands-on Hui-Walter models I
	12:20	12:55	Sonja Hartnack	Hands-on Hui-Walter models II
	12:55	14:00		Lunch Break
	14:00	14:30	Sonja Hartnack	Conditional dependencies
	14:30	15:00	Sonja Hartnack & Valerie Hungerbühler	Hands-on exercises
	15:00	15:30	Sonja Hartnack & Valerie Hungerbühler	Hands-on exercises
	15:30	16:00		Coffee break
	16:00	16:30	Sonja Hartnack & HARMONY consortium	Question rounds to core group experts
	16:30	17:00	Sonja Hartnack	MCMC modeling

House keeping notes

Information for Guests

The University of Zurich provides several options for our guests to connect to the Internet:

1. eduroam WLAN

Most universities and research institutions use eduroam. Members of such institutions have Internet access in the public areas of UZH via the eduroam WLAN network. We recommend testing eduroam access at your home university in advance to ensure that the configuration is correct.

2. Internet Access for Guests via UZH WLAN

As a guest at UZH, you can access the Internet everywhere where there is WLAN access: Simply select the uzh-guest WLAN network. After doing so, accept the Terms of Service and fill in the registration form with your mobile phone number. You will subsequently receive an access code by text message, which allows you to unlock Internet access.

This option is available for all cell phone carriers that allow the receiving of SMS in Switzerland.

Historical sketch LCM

- 1980 Hui-Walter paradigm

BIOMETRICS 36, 167–171
March, 1980

Estimating the Error Rates of Diagnostic Tests

S. L. Hui[1] and S. D. Walter

Two tests, one population

Population 1

		T2+	T2-
D+	T1+	P1*Se1*Se2	P1*Se1*(1-Se2)
	T1-	P1*(1-Se1)*Se2	P1*(1-Se1)*(1-Se2)

		T2+	T2-
D-	T1+	(1-P1)*(1-Sp1)*(1-Sp2)	(1-P1)*(1-Sp1)*Sp2
	T1-	(1-P1)*Sp1*(1-Sp2)	(1-P1)*Sp1*Sp2

Two tests, one population

Population 1

T1+T2+:	P1*Se1*Se2+(1-P1)*(1-Sp1)*(1-Sp2)
T1+T2-:	P1*Se1*(1-Se2)+(1-P1)*(1-Sp1)*Sp2
T1-T2+:	P1*(1-Se1)*Se2+(1-P1)*Sp1*(1-Sp2)
T1-T2-:	P1*(1-Se1)*(1-Se2)+(1-P1)*Sp1*Sp2

- 5 parameter and 3 degrees of freedom
- Non identifiable model

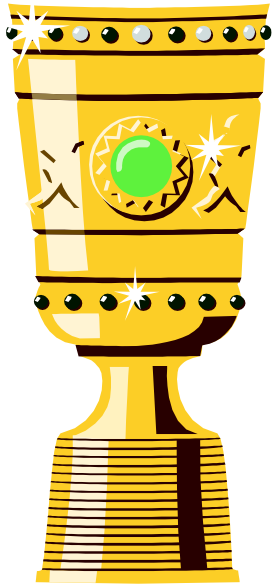
Two tests, two populations

Population 1

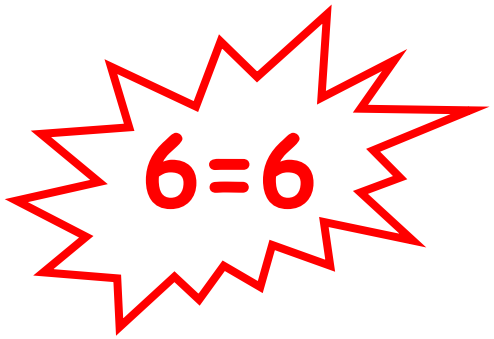
T1+T2+:	P1*Se1*Se2+(1-P1)*(1-Sp1)*(1-Sp2)
T1+T2-:	P1*Se1*(1-Se2)+(1-P1)*(1-Sp1)*Sp2
T1-T2+:	P1*(1-Se1)*Se2+(1-P1)*Sp1*(1-Sp2)
T1-T2-:	P1*(1-Se1)*(1-Se2)+(1-P1)*Sp1*Sp2

Population 2

T1+T2+:	P2*Se1*Se2+(1-P2)*(1-Sp1)*(1-Sp2)
T1+T2-:	P2*Se1*(1-Se2)+(1-P2)*(1-Sp1)*Sp2
T1-T2+:	P2*(1-Se1)*Se2+(1-P2)*Sp1*(1-Sp2)
T1-T2-:	P2*(1-Se1)*(1-Se2)+(1-P2)*Sp1*Sp2



Identifiable model!



Hui-Walter Paradigm (1980)

$$S \geq \frac{R}{(2^{R-1}-1)}$$

S: Populations, R: Tests

Assumptions

1. The population is divided into two or more populations in which two or more tests are evaluated,
2. sensitivity and specificity are the same in all populations.
3. The tests are conditionally independent given the disease status.

$$P(T_1^+|T_2^+) = P(T_1^+|T_2^-)$$

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TABLE 2. Maximum Number of Estimable Parameters and Number of Parameters to Be Estimated in the Absence of Conditional Independence and Under Conditional Independence as a Function of the Number of Tests per Subject

Number of Tests	Maximum Number of Estimable Parameters	Parameters to be Estimated Under Conditional Dependence	Parameters to Be Estimated Under Conditional Independence
1	1	3	3
2	3	7	5
3	7	15	7
4	15	31	9
5	31	63	11
h	$2^h - 1$	$2^{h+1} - 1$	$2h + 1$

Berkvens D et al. (2006) Estimating Disease Prevalence in a Bayesian Framework Using Probabilistic Constraints.
doi: 10.1097/01.ede.0000198422.64801.8d

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prior beta distributions

prevalence	sensitivity	specificity
$\pi = P(D)$	$\eta_i = \mathrm{P}(+\|\mathrm{D}, T_i)$	$\theta_i = P(-\|\bar{D}, T_i)$
$\pi \sim Beta(a_\pi, b_\pi)$	$\eta_i \sim Beta(a_{\eta_i}, b_{\eta_i})$	$\theta_i \sim Beta(a_{\theta_i}, b_{\theta_i})$

$$Posterior \propto Likelihood * Prior$$

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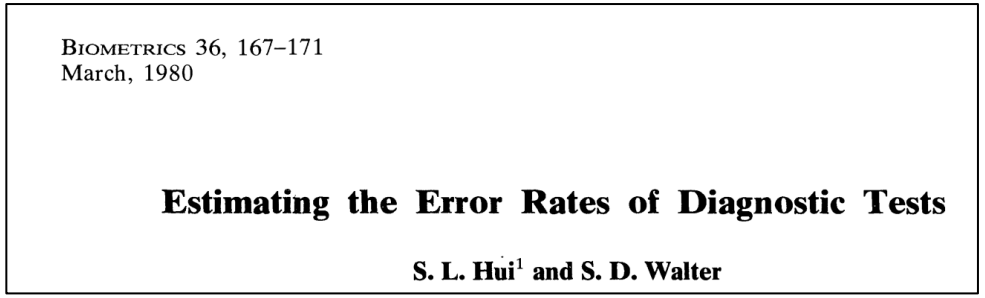

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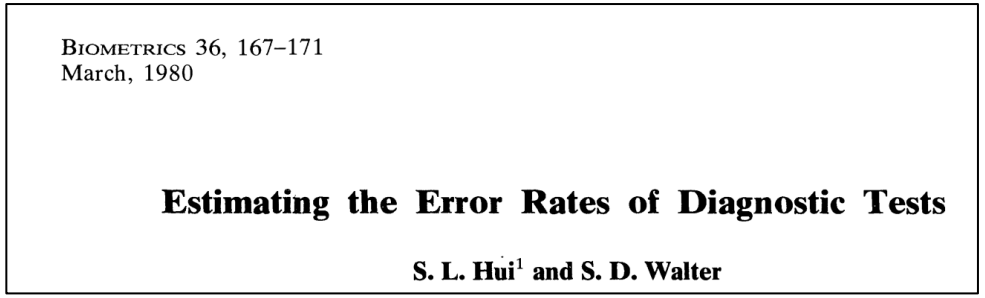

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OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals **endorsed BLCM** *(2016)*