# Bayesian latent class models for prevalence estimation and diagnostic test evaluation when there is no gold standard.
ISVEE pre-conference workshop
August 6-7$^{th}$
Halifax Hotel Marriott Harbourfront

**Instructors**
**Simon Dufour,** Professor, Université de Montréal,
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Simon completed a DVM degree at UdeM in 1998. Following 10 years of professional happiness as a dairy practitioner in Canada he finally saw the light and completed in 2011 a PhD in epidemiology at UdeM and then a post-doctoral fellowship in 2012 at the Atlantic Veterinary College. Since 2012, he is an epidemiology professor at UdeM. He led multiple research on validation of diagnostic tests and on estimation of diseases prevalence and incidence, or of associations with exposures, for diseases where a gold-standard diagnostic test is not available. Said differently, he is quite good at estimating the number of sardines in a can of sardines without opening it!

**Juan Carlos Arango Sabogal,** Professor, Université de Montréal,
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Juan completed a veterinary medicine degree at the Universidad de Antioquia, Colombia in 2006 and a PhD in veterinary sciences at the Université de Montréal, Canada in 2018. Motivated by his passion for epidemiology and diagnostic test validation, he completed two post-doctoral programs, one at the Faculty of Veterinary Medicine at UdeM, on Bayesian latent class models, and one at the Royal Veterinary College, UK, on the epidemiology of racehorses. Juan is currently a professor of biosecurity in dairy production at UdeM and has benefited from Bayesian latent class models to assess the accuracy of tests to diagnose animal health problems in different species such as dairy cows (Johne's disease, endometritis, and colostrum quality), mares (endometritis) and more recently camels (brucellosis).

## Course's objectives
Bayesian statistical methods have been widely applied in veterinary science and epidemiological research. In particular, Bayesian latent class variable models (LCM) have been shown to be useful for estimating disease prevalence or diagnostic test accuracy (sensitivity and specificity) in the absence of a perfect reference test (i.e. a gold standard). This 2-day workshop will introduce these methods and illustrate their application with concrete veterinary examples. The format of the workshop will include theoretical parts and laboratory sessions giving participants the opportunity to learn how to apply these methods using R and the R2OpenBUGS package. The material will be suitable for graduate students or professionals and researchers in veterinary science or epidemiology, or with an interest in applications of new statistical methods.

At the end of the workshop, participants will know how to estimate true disease prevalence and diagnostic test accuracy when gold standard tests are not available and for situations where:
- Two imperfect tests are applied to a single population;
- Diagnostic tests compared may be conditionally dependent;
- Two imperfect tests are applied to ≥ 2 populations;
- ≥ 3 diagnostic tests are applied to one or many populations;
- The test sensitivity and specificity vary as function of a covariate.

They will also be aware of some more advance modelling techniques such as hierarchical LCM and they will learn the best reporting practices for studies on diagnostic accuracy that uses Bayesian LCM.

**Required skills**
This course is intended for those with an interest in evaluating diagnostic tests or estimating the prevalence of a health condition in the absence of a perfect reference test. While most of the examples used in the workshop will be derived from animal health, the methods presented are directly applicable to human health. Prior experience with animal health is, therefore, not essential. Some basic epidemiological knowledge related to the attributes of diagnostic tests (e.g., gold standard, diagnostic sensitivity and specificity, prevalence of disease in a population) would be beneficial. The level of the course will be appropriate for graduate students who have already taken introductory courses in epidemiology and statistics and for professional epidemiologists. **Participants are not expected to have any previous Bayesian training**.

Participants will need to have **some very basic proficiency in R**. Guidance in developing this proficiency will be provided prior to the course. More3over, for the exercises, participants will use partially completed R scripts, will have access to completed scripts, and will work in small groups. Thus, participants with a limited R experience will be able to fully participate and benefit from the course.

**Previous workshop history**
This workshop was **previously offered four times** in English or French at Université de Montréal (Canada, 2017, 2019, 2020) and at UdeLiège (Belgium, 2018).

**Workshop specifications**
The workshop will be offered as a **pre-conference 2-days workshop**. We will **accommodate online participants**, though the priority will be given to in-person participants. **Non-ISVEE delegates are welcome to participate**.

The lectures will be given in English, but the instructors are fluent in **English, Spanish, and French**.

(The proposed schedule is presented on the following page)

**Proposed schedule**

| Day | Time | Activity/Contents | Details |
|---|---|---|---|
| 1 | 8h30 – 9h00 | Presentation / logistics | |
| | 9h00-10h00 | -Key parameters for diagnostic test accuracy<br>-The issue when there is no gold standard test<br>-Intro to latent class models | Lecture |
| | 10h00-10h30 | Break | |
| | 10h30-12h00 | -Intro to Bayesian analyses | Lecture |
| | 12h00-13h00 | Lunch | |
| | 13h00-14h00 | -Intro to the R2OpenBUGS package | Lecture |
| | 14h00-15h00 | -Using R2OpenBUGS to estimate a proportion and to compare two proportions | Lab and discussion |
| | 14h45-15h15 | Break | |
| | 15h15-16h00 | -Estimating prevalence, Se and Sp with 2 imperfect tests applied to one single population<br>-The issue of mirror solutions<br>-Modeling conditional dependency between tests | Lecture |
| | 16h00-17h00 | -Using R2OpenBUGS to estimate accuracy parameters of two imperfect tests and one single population<br>-Modeling conditional dependency between tests | Lab and discussion |
| 2 | 8h30-9h15 | -LCM for diagnostic validation studies with ≥ 2 populations<br>-Hierarchical model with hyperpriors | Lecture |
| | 9h15-10h15 | -Using R2OpenBUGS to estimate accuracy parameters of two imperfect tests applied to ≥ 2 populations | Lab and discussion |
| | 10h15-10h45 | Break | |
| | 10h45-11h45 | -LCM for studies ≥3 Dx tests<br>-LCM when test(s) Se and Sp vary as function of a covariate | Lecture |
| | 11h45-13h00 | Lunch | |
| | 13h00-14h00 | -Using R2OpenBUGS to estimate accuracy parameters when:<br> - ≥3 imperfect tests<br> - Test(s) Se and Sp vary as function of a covariate | Lab and discussion |
| | 14h00-14h30 | Break | |
| | 14h30-16h00 | -Standards for the Reporting of Diagnostic accuracy studies that use Bayesian Latent Class Models (STARD-BLCM)<br>-Other advanced LCM topics | Lecture and discussion |