Bayesian inference in food chain risk modeling

Estimating the average CFU/g per serving and predicting the number of cases under intervention as compared to the default situation.

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28.6.-1.7.2004, Pamplona.

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- **Amount and quality of data: reflections on modeling.**

-A scientist aims to construct well posed questions and use good quality data in modeling.

-Models for aiding decision making are (?) required regardless of the amount or quality of data.

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-May lead to bad quality models reflecting only uncertain expert opinions...

-May lead to complex models of missing data.

Threat:
"Modeling opinions & guessing instead of modeling risks"?

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Example from salmonella RA:

-Assigned goal: quantitative risk assessment from "farm to fork", i.e. to model the whole production chain for broiler, pork and beef.

-Primary production models utilized data and expert knowledge using Bayesian inference and accounting for missing data.
-Processing models largely based on expert opinion and simplification.
-Consumption-dose-response model (very simplified) combined results from previous submodels with reported human case data (KTL) using Bayesian inference.

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- Problem with Monte Carlo 'forward' simulations: Lack of inference.

-In Bayesian inference, all unknown quantities are estimated jointly from the known data set.
-Data set can represent fragments of information from different parts of the food chain.

I.e. derive plausible values for missing data, 'hidden' variables, parameters, etc., given all observed data.

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- Simulations: what do we simulate?

-A target distribution is specified by the model.

-Many ways to simulate the same target distribution.

-What is a 'target' distribution?

$$P(\text{unknown quantities of interest} \mid \mathcal{B})$$

where: $\mathcal{B}$ = all known data & prior information within the specified model.

- **Bayesian inference**

X = set of all observations (data)
θ = set of all unobserved quantities (parameters, missing data)

Joint probability model of θ and X:

$$P(\theta, X)$$

What is uncertainty about X for a given θ?

$$P(X \mid \theta) \qquad \text{(use e.g. 'forward' Monte Carlo)}$$

What is uncertainty about θ after observing X?

$$P(\theta \mid X) = \frac{P(X \mid \theta)P(\theta)}{\int_\Theta P(X \mid \theta)P(\theta)d\theta} \qquad \text{(Bayes formula)}$$

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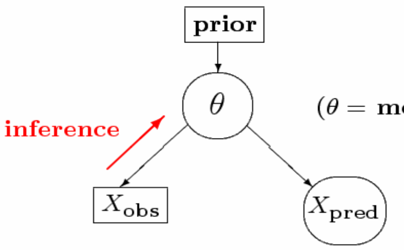
- **Conditional distributions as a graph:**



(θ = model parameters)

(X_{obs} = observations) (X_{pred} = future observations)

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Salmonella contamination puzzle with three pieces:

1• Number of contaminated servings entering retail from the industry (initial point).
2• Contamination level per such serving at the time of consumption (final point).
3• Resulting number of human cases of illness.

Assume: fixed dose-response model.

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Salmonella estimation and the puzzle:

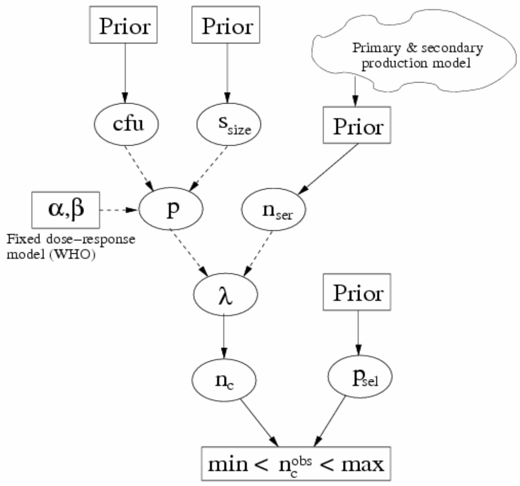
Whenever 1 & 2 are given, can simulate 3 ('forward' Monte Carlo).
If 3 (number of human cases) is given, can derive joint probability density of 1 & 2.

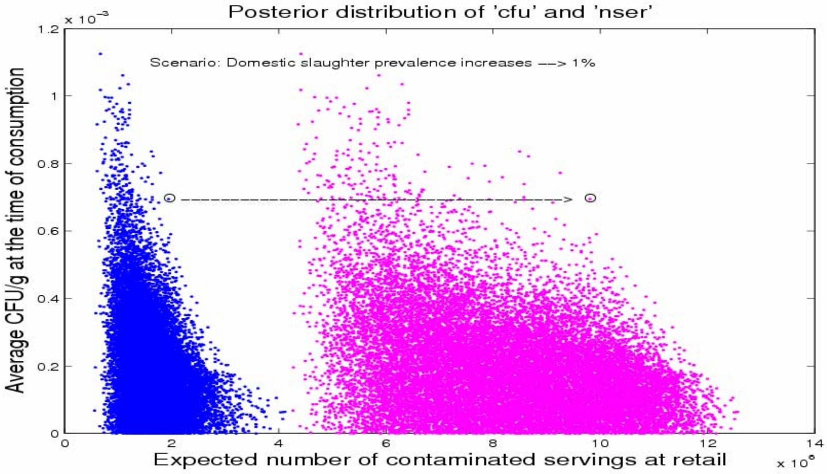
BUT:

- **Problem: only reported human cases are known.**
- **Solution: include a probability of becoming a reported case using expert opinion and literature on underreporting.**

BUT:

- **Problem: need to know number of beef/pork/broiler borne reported human cases.**
- **Solution: use phagetype information to derive a maximum number of reported cases, treat the true reported number as a *censored*, i.e. imprecise, observation.**

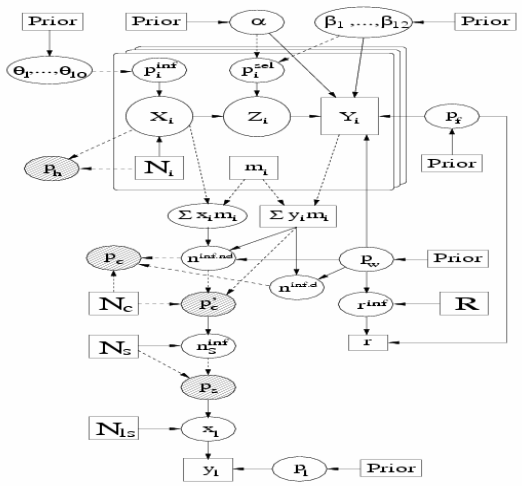




Computing scenario predictions:

- **Simulations of primary production with different scenarios provide alternative distributions for n_{ser}. Notice: no data available under hypothetical scenarios.**

- **Assumption: all other quantities remain as they were. Replace the marginal distribution of n_{ser} by the scenario distribution using stochastic point wise coupling.**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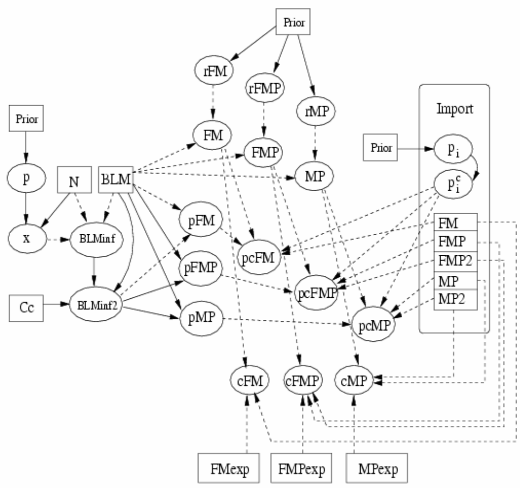
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