State of the art of modelling approaches for assessing vector control strategies to contain human West Nile fever in Europe*

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Introduction

West Nile virus is an arbovirus maintained in an enzootic bird-mosquito cycle and transmitted to equids and humans. Since 2010, the number of European countries reporting human cases of West Nile fever (WNF) has increased. As no vaccine or specific treatment is available, prevention and control of infections rely on early detection of active transmission and mosquito abatement. To optimize resources allocation and vector control effectiveness, a comprehensive overview of modelling approaches developed for WNF has been undertaken with the aim of using the obtained results to helping in designing and developing a model to assess the vector control strategies.

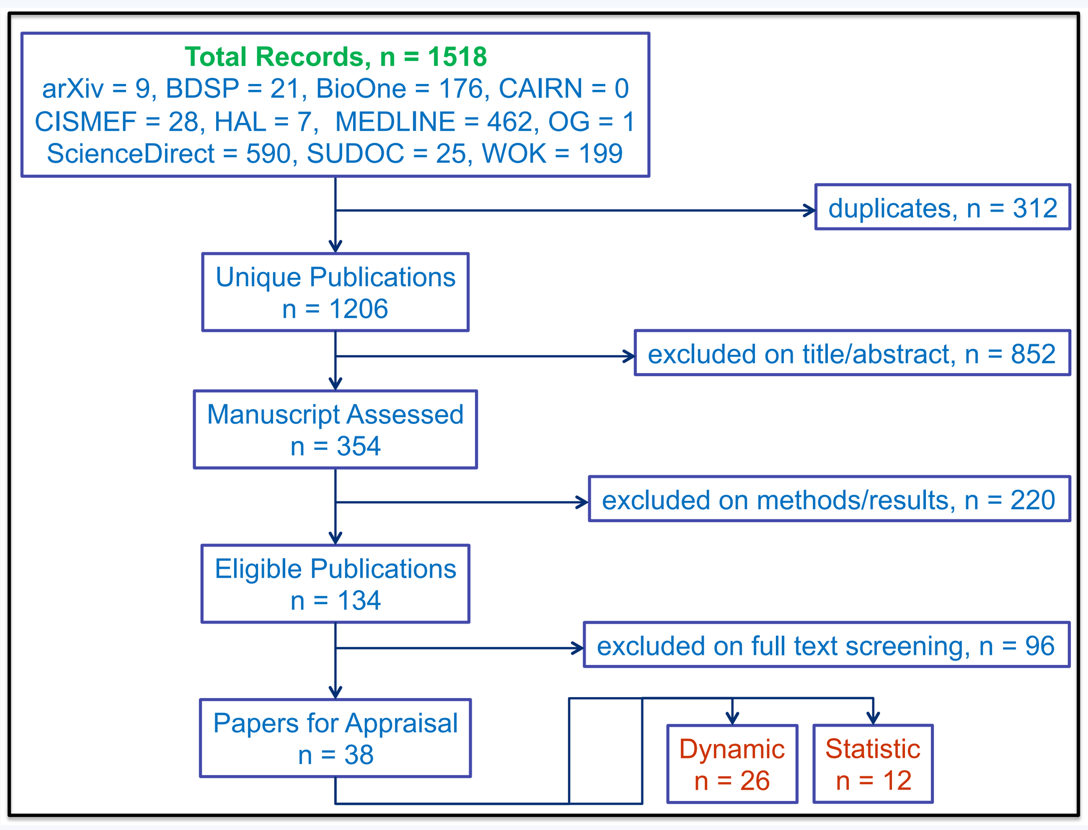
Methods

The systematic review was performed by a librarian and two experts, following the PRISMA Statement, from the earliest dates to October 22nd, 2012 via a total of 11 peer-reviewed (arXiv, BDSP, BioOne, CAIRN, CISMEF, MEDLINE, Science direct, Web of Knowledge) and grey (arXiv, HAL, OpenGrey, SUDOC) literature sources. Keywords consisted in a combination of "*West Nile Fever*" and method keywords ("*mathematical, statistical, spatial, SIR or SEIR, Simulations, ...*"). Retrieved studies were reviewed using predefined inclusion criteria for the quality of modelling and for suitability to address vector control issue.

Objective: to perform a review and appraisal of modelling approaches and models developed so far for West Nile fever

Results

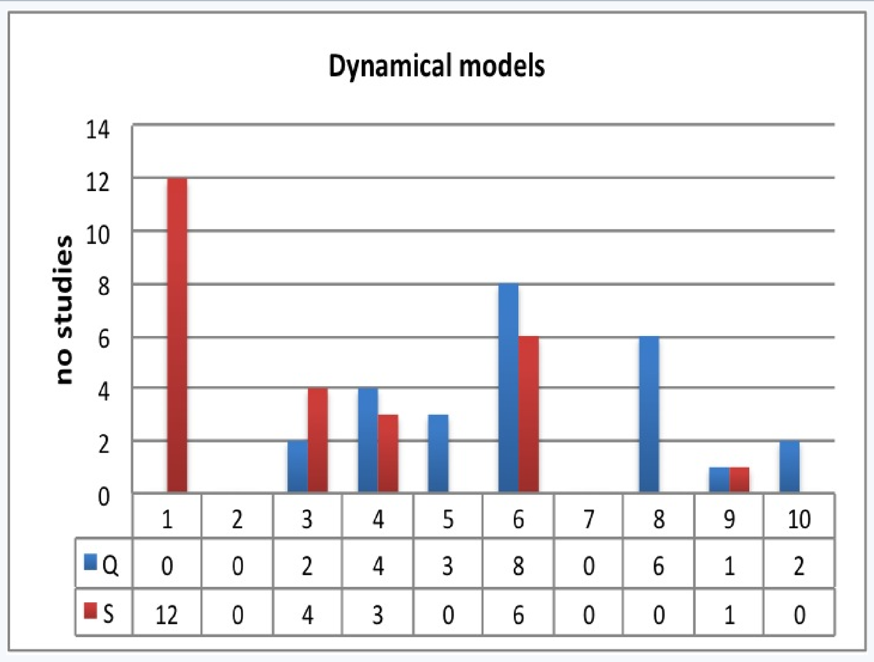
Summary of Results



	dynamical	statistical	dynamical	statistical
	$S \geq 5$		$S < 5$	
	A = most relevant		Q - relevant	
$Q \geq 5$	7	4	13	8
	S - relevant		less relevant	
$Q < 5$	0	0	6	0

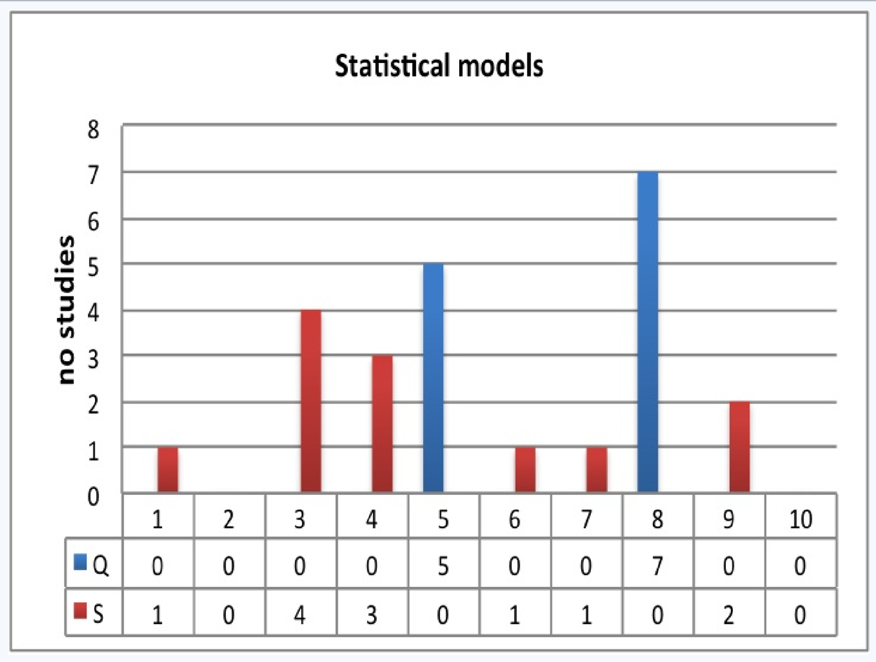
- **index Q** ($0 \leq Q \leq 10$): quality assessment of the modelling approach for WNF
- **index S** ($0 \leq S \leq 10$): suitability assessment of the model for addressing the vector control issue.

Dynamical models



- *ODE models* ([1, 2, 3, 4, 5] $\in A$): ordinary differential equations for the compartmental SIR - like models for WNV transmission dynamics (enzootic bird-mosquito or bird-mosquito–mammal cycles)
- *PDE models* ([6] $\in A$): extension of ODE models to partial differential reaction-diffusion equations to include spatial diffusion of both birds and mosquitoes
- *Multi-agents models* ([7] $\in A$): simulates in a virtual cartographic territory the behaviors and interactions of birds and mosquitoes involved in the WNV transmission and propagation

Statistical models



- *Logistic regression (LG)* ([8] $\in A$): case-control approach to explore associations between the risk of WNF human cases and environmental and socioeconomical variables. Next, these variables are used as predictors in a logistic model for risk map construction
- *GIS-based model (GIS)* ([9] $\in A$): weighted linear combination of maps on equid density, bird species and *Culex pipiens* abundances during suitable months to construct risk maps
- *Risk analysis approaches (RA)* ([10,11] $\in A$): combines modelling and ancillary data within a GIS to generate risk maps.

A - most relevant models

[1] - Balenghien, 2006
[2] - Bowman et al., 2005
[3] - Laperriere et al., 2011
[4] - Lord & Day, 2001
[5] - Wonham et al., 2004
[6] - Maidana & Yang, 2009
[7] - Bouden et al., 2008
[8] - Rochlin et al., 2011
[9] - Rodríguez-Prieto et al., 2012
[10] - Doctrinal et al., 2005
[11] - Tachiiri et al., 2006

Concluding Remarks

	Dynamical models (68%)	Statistical models (32%)
Description	Are based on and provide mechanistic representation for the transmission dynamics of WNV; use differential equations	Synthetize relevant factors or variables associated with WNF risk; use statistical and GIS-based methods
Use	Predict the incidence and prevalence of WNF; allow studying the impact of control strategies	Explore associations between WNF cases and relevant variables like environmental factors; allow developing risk analysis
Strengths	Adaptable, make explicit assumptions; allow predictions and sensitivity analysis	Flexible approach; allow few assumptions; allow predictions and sensitivity analysis
Weaknesses	Require a good understanding of the transmission mechanism; can be rich in parameter data	Only provide the description of associations not how the system works; site dependent; require field and/or ancillary data

Both the dynamical and statistical models appeared quite complementary for modelling transmission dynamics of WNF

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