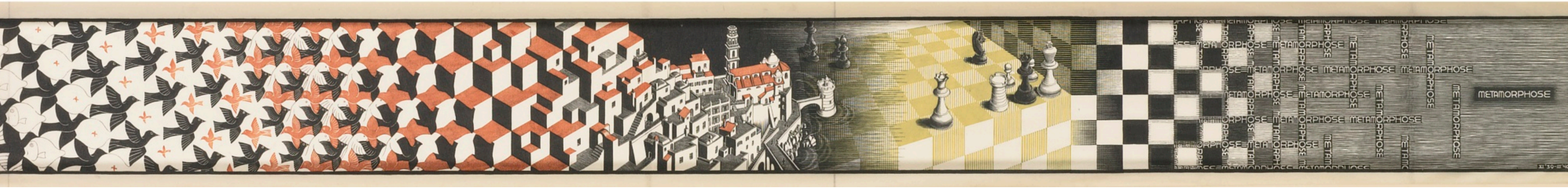
VECTOR-BORNE ZOONOSES
HOW DO WE PROTECT EUROPE?

M. C. Escher – Metamorphosis II, modified



SWISS TPH WINTER SYMPOSIUM 2018, Basel, Switzerland –7 December 2018

GIULIA PATERNOSTER –PhD Candidate in Epidemiology and Biostatistics

life science zurich Graduate School Universität Zürich ETH zürich

OUTLINE

1. **VECTOR-BORNE ZOONOSES**: an **opportunity** for **ONE HEALTH**

2. **ONE HEALTH IN PRACTICE**: the case of **West Nile virus (WNV) integrated surveillance** in Emilia-Romagna

3. **ECONOMIC EVALUATION** of **WNV integrated surveillance** in Emilia-Romagna

   ⟶ **ONE HEALTH** & **PROCESS EVALUATION** of WNV integrated surveillance in Northern Italy

4. **LESSON LEARNT** & **FUTURE PERSPECTIVES**

VECTOR-BORNE ZOONOSES

- **Human and animal illnesses** caused by parasites, viruses, and bacteria, **transmitted by vectors**
- Affect **hundreds of millions of people** and **animals globally**
- Highest **direct impact in tropical** and **subtropical areas**

  indirect economic impact on the **poorest populations through animal disease**
- Distribution determined by **complex interaction** of **demographic**, **environmental**, **social** and **economic factors**

Raku Inoue: Natura Insects

XU Zhen, The Last Few Mosquitoes (2005)

VECTOR-BORNE ZOONOSES

- Distribution determined by **complex interaction** of **demographic**, **environmental**, **social** and **economic factors** ⟶ "ideal case" for **ONE HEALTH approach in public health**

ONE HEALTH

- **Integration**
  ⟶ knowledge
  ⟶ perspectives

- **Transdisciplinarity**
  ⟶ society and science
  ⟶ health professionals as **agents of change**

Source: www.sustyvibes.com

Source: Brian Holly | LinkedIn

Source: Wikipedia

ONE HEALTH

Any **added value** in terms of human and animal lives saved, reduced cost and sustained social and environmental services that can be **achieved by a closer cooperation** of **human and animal health** and **other disciplines** which **could not be achieved** if the sectors worked **separately** [Zinsstag 2015]

NEED FOR POLICY EVALUATION

⟶ provides **accountability** for policy makers
⟶ should be a **change oriented** process

"evaluate **to evolve**"

Source: www.streetartbio.com/banksy

THE ADDED VALUE OF ONE HEALTH…
CAN WE MEASURE IT?

PLOS | ONE

2017

RESEARCH ARTICLE

Economics of One Health: Costs and benefits of integrated West Nile virus surveillance in Emilia-Romagna

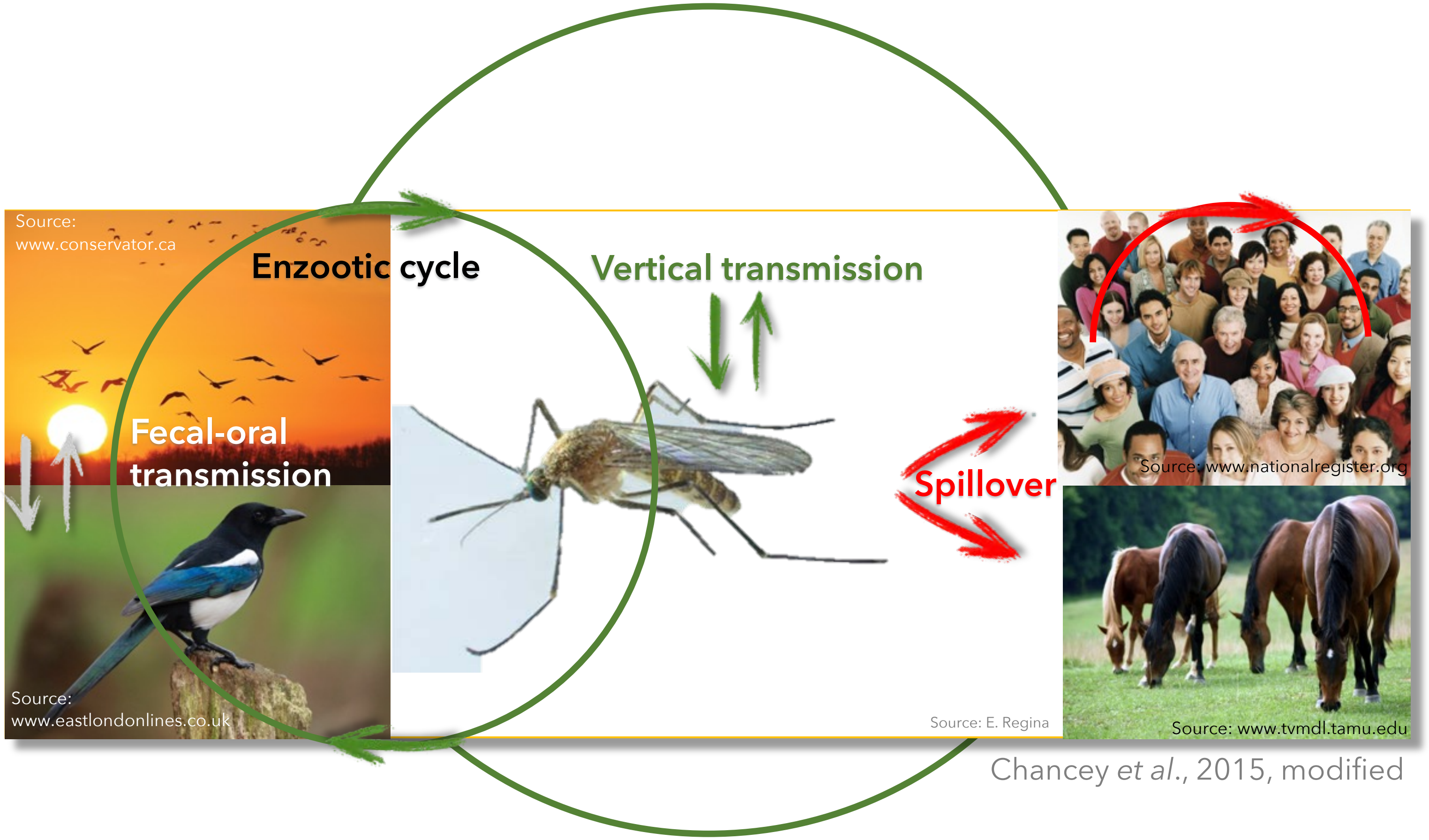
Giulia Paternoster[1¤]*, Sara Babo Martins[2,3], Andrea Mattivi[4], Roberto Cagarelli[4], Paola Angelini[4], Romeo Bellini[5], Annalisa Santi[1], Giorgio Galletti[1], Simonetta Pupella[6], Giuseppe Marano[6], Francesco Copello[7], Jonathan Rushton[8], Katharina D. C. Stärk[2,3], Marco Tamba[1]

1 Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia-Romagna (IZSLER), Brescia, Italy, **2** Department of Production and Population Health, Royal Veterinary College, Hatfield, United Kingodm, **3** SAFOSO AG, Bern-Liebefeld, Switzerland, **4** Regional Health Authority of Emilia-Romagna, Bologna, Italy, **5** Centro Agricoltura Ambiente "G. Nicoli", Crevalcore, Italy, **6** National Blood Centre, National Institute of Health (Istituto Superiore di Sanità, ISS), Rome, Italy, **7** Occupational Medicine Unit, IRCCS AOU San Martino-IST teaching Hospital, Genoa, Italy, **8** Institute of Infection and Global Health, University of Liverpool, Liverpool, United Kingodm

OBRIGADA
GRAZIE
THANKS
DANKE

WEST NILE VIRUS (WNV)

- **Complex interactions** among **animals**, **humans** and their **overlapping/shared ecosystems**
- In humans: ~80% asymptomatic | ~20% West Nile fever (WNF) | <1% West Nile Neuroinvasive disease (**WNND**)



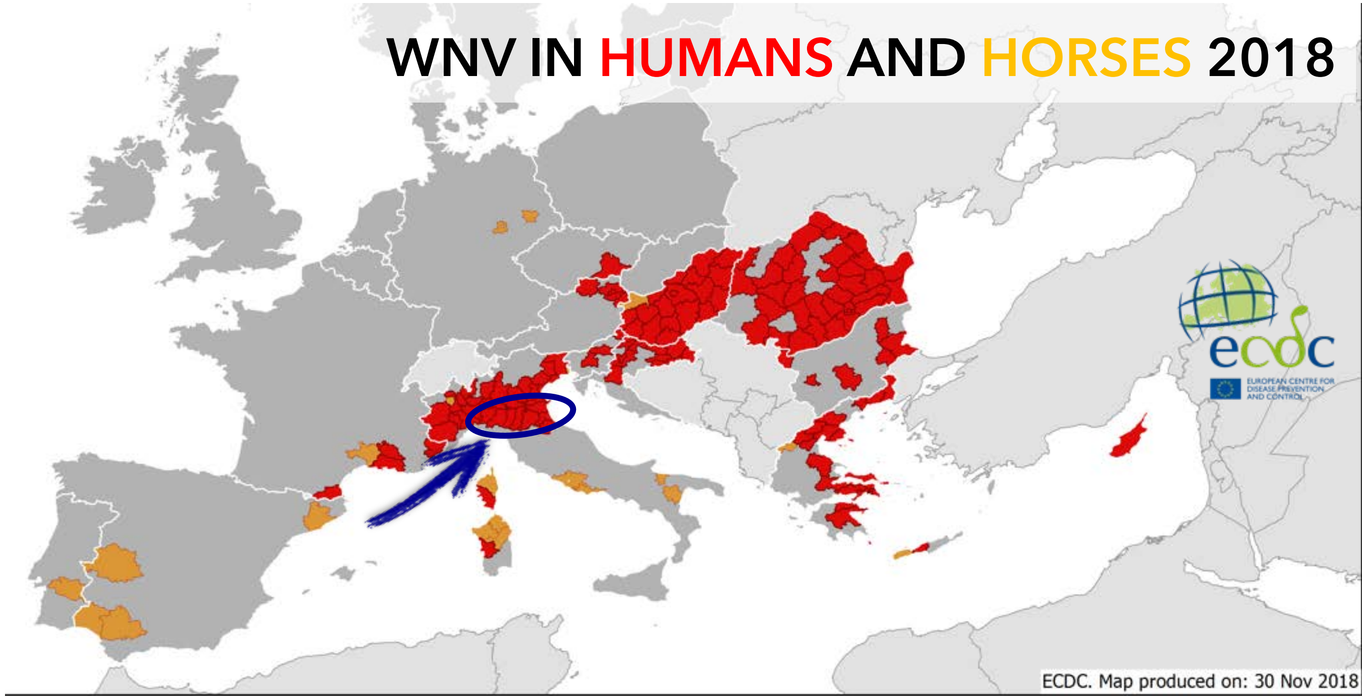
Chancey *et al.*, 2015, modified

- **Blood transfusion**
- Organ transplantation
- Breast feeding
- In utero

EMILIA-ROMAGNA (ER), ITALY

Population ~ 4.5 M. Surface ~ 22,000 km^2
Strong tradition of blood donation
1st WNV detection in 2008

- **WNV integrated surveillance** since 2009 targeting humans, horses, wild birds, mosquitoes
  - ⟶ **early detection** WNV circulation
  - ⟶ **prevention of WNV transmission via blood transfusion**



WNV INTEGRATED SURVEILLANCE

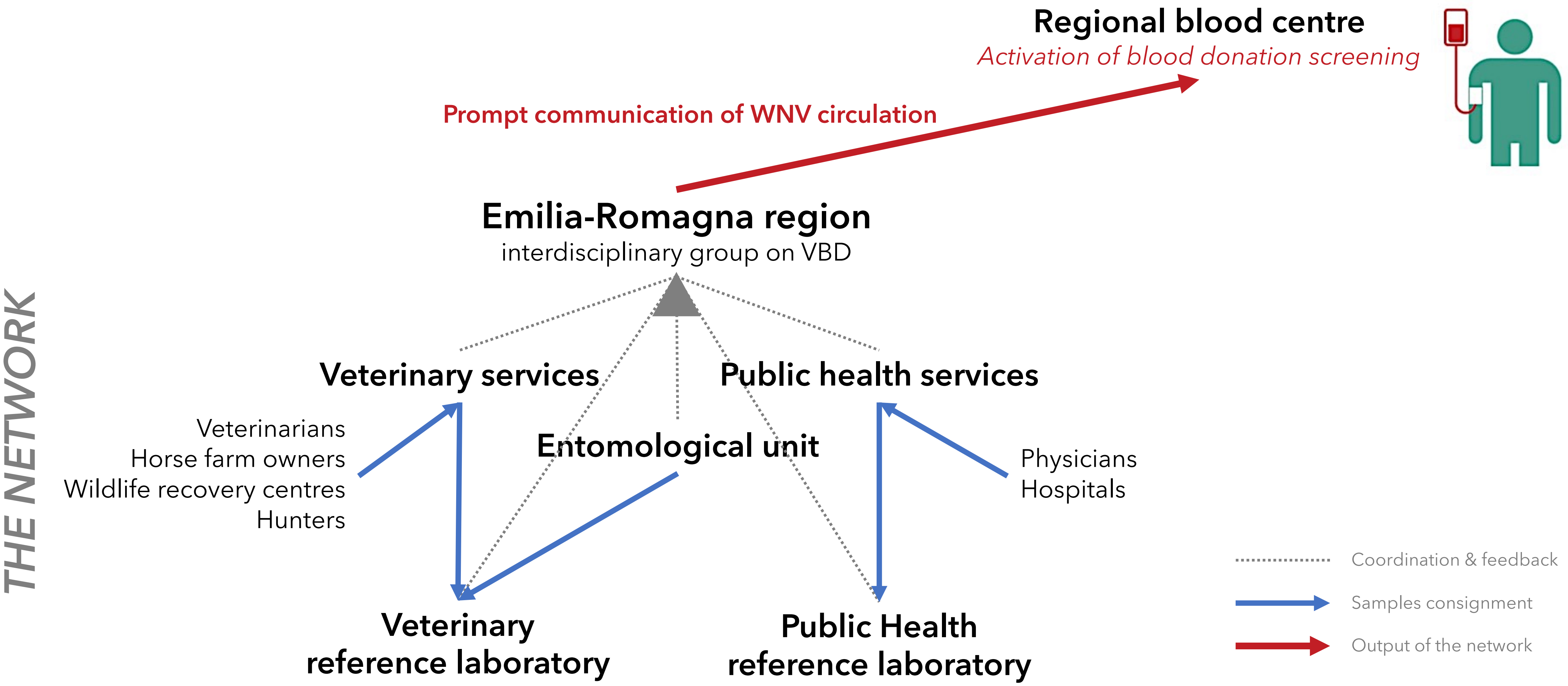
Prevention of WNV transmission via blood transfusion

Systematic WNV blood donation testing at the province level (adm2)

	Uni-sectoral approach National regulation	**One Health approach** ER blood safety policy
BASED ON	▪ Human surveillance	▪ Human surveillance ▪ Veterinary surveillance mosquitoes, wild birds, horses ▪ Sharing of information
WHEN	**CURRENT SEASON** **Notification of the 1st human case (WNND, WNF)** until Nov. 30 **&** **FOLLOWING SEASON** July 1 until Nov. 30	**CURRENT SEASON** **1st WNV detection in any *spp.* targeted by the SS** until Nov. 30

ONE HEALTH APPROACH

REGIONAL CROSS-SECTORAL NETWORK for the activation of preventative measures to mitigate the risk of WNV transmission via **blood transfusion** in ER



WNV INTEGRATED SURVEILLANCE

IDENTIFICATION OF COSTS & BENEFITS (ER, 2009-2015). Application of the conceptual framework developed by Babo Martins *et al.*, 2015

	Uni-sectoral approach National regulation	**One Health approach** ER blood safety policy
COSTS	**Surveillance** Human surveillance **Triggered actions** Blood testing Communication campaigns Vector control interventions	**Surveillance** Human surveillance Veterinary surveillance –mosquitoes, wild birds, horses Sharing of information **Triggered actions** Blood testing Communication campaigns Vector control interventions
BENEFITS		**Averted costs** of potential WNND cases associated to infected transfusions Short term cost of hospitalization Compensation for transfusion associated disease

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF COSTS (ER, 2009-2015)

	Uni-sectoral approach National regulation	**One Health approach** ER blood safety policy
COSTS	**Surveillance** Human surveillance **Triggered actions** Blood testing Communication campaigns Vector control interventions	**Surveillance** Human surveillance Veterinary surveillance –mosquitoes, wild birds, horses Sharing of information **Triggered actions** **Blood testing** **~1.2 M EUR savings** Communication campaigns Vector control interventions
EUR	**5,075,906**	**4,914,985**

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF BENEFITS (ER, 2009-2015)

Potential WNND cases associated to 18 **infected blood components transfusions**

		One Health approach ER blood safety policy		
	p of WNND after infected blood transfusion	0.66 % BEST CASE SCENARIO (EUR) **0 cases**	10% INTERMEDIATE SCENARIO (EUR) **2 cases**	100% WORST CASE SCENARIO (EUR) **18 cases**
BENEFITS	**Avoided** short term cost of **hospitalization**	0	30,792	277,128
	Avoided compensation for transfusion associated disease	0	300,000	2,700,000
	EUR	**0**	**330,792**	**2,977,128**

OH IN PRACTICE

- **OH approach to WNV surveillance** can lead to accelerated viral detection and prevention of human infections
- Is **cost saving** and has **potentially additional economic benefits** due to **early warning in endemic ER region** (evaluation results are **context specific!**)
- Allows **the collection of data that are useful to understand the epidemiology of WNV infection**

EVIDENCE ON THE ECONOMIC RETURN OF CROSS-SECTORAL COOPERATION FOR VBZ MITIGATION IN EUROPE, BUT…

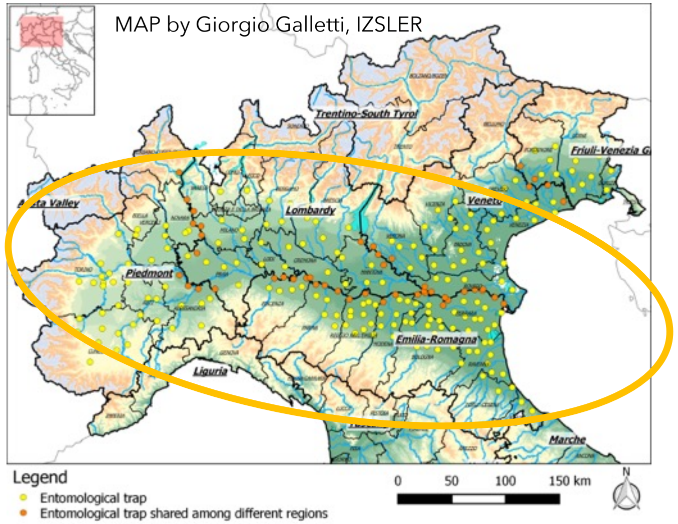
Further evaluations including intangible costs, social, and ecological dimensions, would allow a deeper understanding of the economic context of the disease and its mitigation, allowing to better inform public health decision makers.

VBZ WITHOUT BORDERS

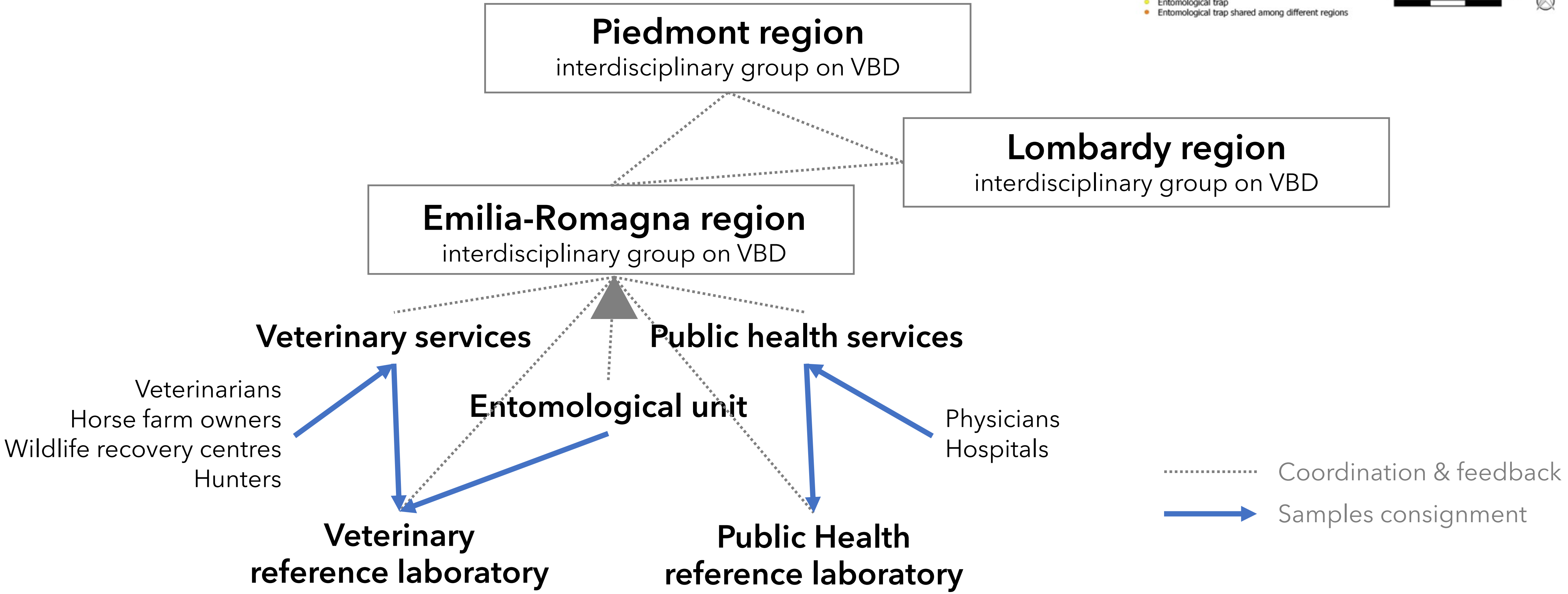
WNV integrated surveillance is an **inter-regional challenge**

Case study in three regions of the Po Valley: Emilia-Romagna, Lombardy, Piedmont

Legal framework



INSTITUTIONAL NETWORK



EVALUATIONS

System definition and **description of the initiative followed by the evauation of**

1. KNOWLEDGE INTEGRATION

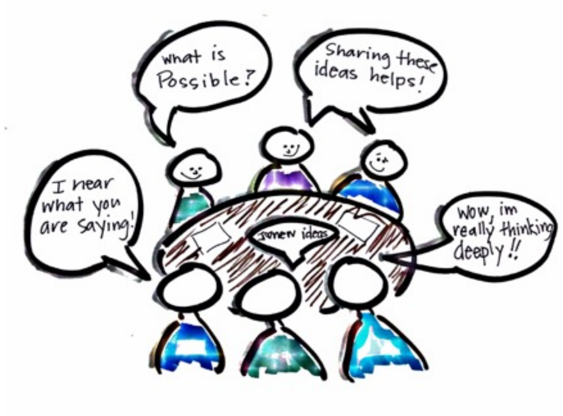
DEGREE OF OH IMPLEMENTATION

Network for Evaluation of One Health

free PDF & worksheets

One Health Index

2. PROCESS



Focus groups

- ⟶ One for each region
- ⟶ Max 8 participants, 90′
- ⟶ “Privileged observers”
- ⟶ Final focus group with participants from all regions

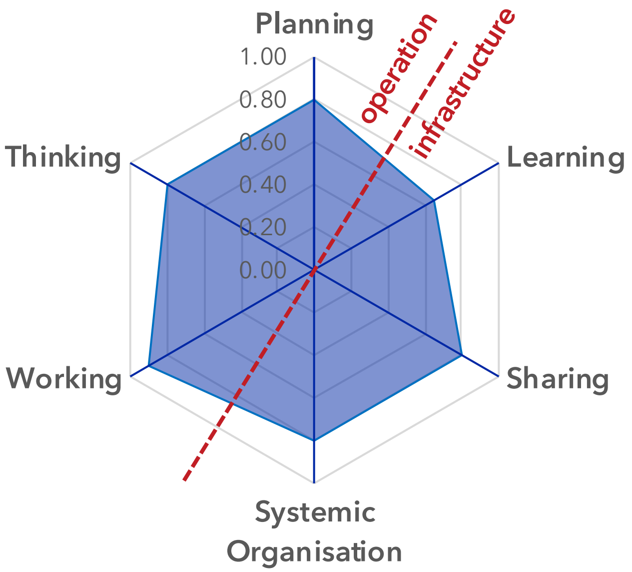
Process evaluation results

EVALUATIONS RESULTS

1. KNOWLEDGE INTEGRATION

Critical points

- communication
- learning



The degree of One Health implementation in West Nile virus integrated surveillance in northern Italy, 2016

Giulia Paternoster[1,2†], Laura Tomassone[3*†], Marco Tamba[1], Mario Chiari[1], Antonio Lavazza[1], Mauro Piazzi[4], Anna R. Favretto[5], Giacomo Balduzzi[6], Alessandra Pautasso[7] and Barbara R. Vogler[8]*

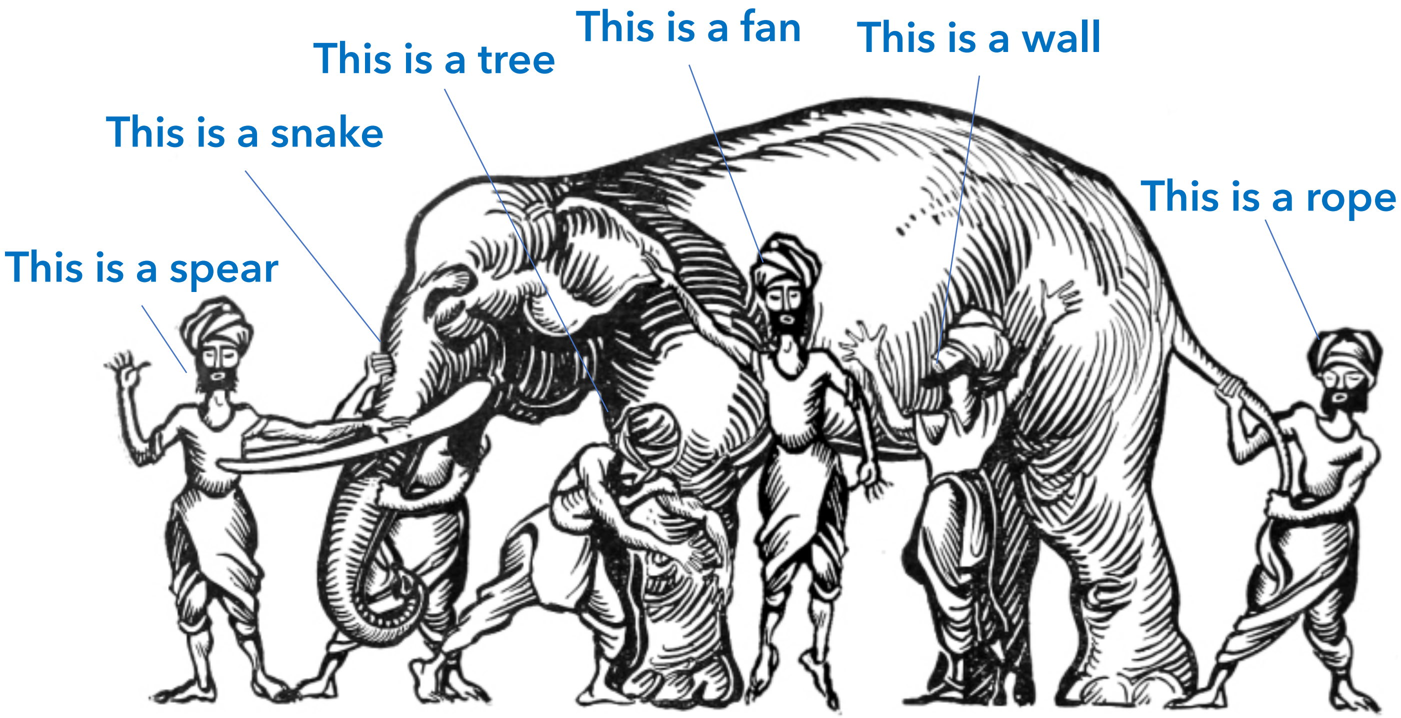
frontiers in Public Health

GRAZIE
THANKS
DANKE!

2. PROCESS

Critical points

- communication
- funding



The parable of the "Blind men and an elephant". Illustrated by Robert W. Williams, 2017, modified

VECTOR-BORNE ZOONOSES & OH
LESSON LEARNT, FUTURE PERSPECTIVES

FOSTER DIVERSITY

- **Ideas**
- **Disciplines**: TRANSDISCIPLINARITY (beyond MD-DVM collaboration)
- **Biological organisms:** BIODIVERSITY
- **Gender**
- **Perspectives** (stakeholders)
  - ⟶ Local knowledge
  - ⟶ Citizen science, co-production of knowledge

COMMUNICATION, COLLABORATION

- Interregional coordination
- Legal systems & infrastructures

(MOBILE) TECHNOLOGIES

- Social media
- Infodemiology

EDUCATION, RESILIENCE

nature COMMUNICATIONS

Article | OPEN | Published: 24 October 2017

Citizen science provides a reliable and scalable tool to track disease-carrying mosquitoes

John R. B. Palmer, Aitana Oltra, Francisco Collantes, Juan Antonio Delgado, Javier Lucientes, Sarah Delacour, Mikel Bengoa, Roger Eritja & Frederic Bartumeus

Lose biodiversity, gain disease

Hamish Ian McCallum[1]
Environmental Futures Research Institute, Griffith University, Brisbane, QLD 4111, Australia

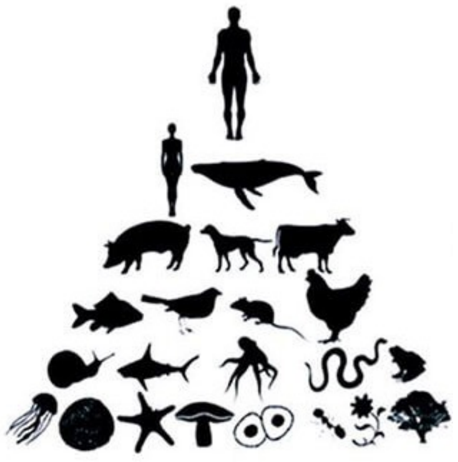
Lyme Disease

Much of Ostfeld and Keesing's (6, 7) work is based on a single, albeit important case study: Lyme disease in the northeast of the United States. Lyme disease in humans is a debilitating illness caused by the spirochete *Borrelia burgdorferi*, which is transmitted to humans via ticks, primarily the nymphal stage of *Ixodes* spp. (7). The nymphal ticks are host generalists, feeding on a variety of mammal species. One, the white-footed mouse *Peromyscus leucopus*, is a particularly competent host for the spirochete and as a small-bodied habitat generalist, persists in the smallest habitat patches (7). Where a high diversity of alternative hosts is present, many ticks will feed on these species, most of which are less-competent reservoirs for *Borrelia*, reducing the likelihood that nymphal ticks will transmit the infection to humans.

VECTOR-BORNE ZOONOSES
HOW DO WE PROTECT EUROPE?

Authoritarian
Dualistic
Unsustainable
Delusional
Mechanistic
Self-destructive
Unwise
Imbalanced
Power Seeking

EGO-LOGICAL



ECO-LOGICAL

Democratic
Holistic
Sustainable
Compassionate
Natural
Regenerative
Wise
Balanced
Interdependent

Christopher Chase-Dunn, sociologist, world-systems theory

TOGETHER, FOSTERING DIVERSITY, COLLABORATION, RESILIENCE

Foster an informal, safe, sandbox space

Be inclusive, representative, collaborative

Ensure easy & accessible participation

Encourage creative & dynamic approaches

Empower, support & unite members

Network for Evaluation of One Health

NETWORK FOR ECOHEALTH & ONE HEALTH

EUROPEAN CHAPTER OF ECOHEALTH INTERNATIONAL

Please join us in NEOH by:

1. Becoming a member of ECOHEALTH INTERNATIONAL www.ecohealthinternational.org

2. Writing an email to Sara Savic sara@niv.ns.ac.rs letting her know that you have joined so that we can contact you for our first online meeting

THANK YOU FOR YOUR ATTENTION

THANKS TO ALL COAUTHORS & TO MY TEAM @ UZH:

Paul Torgerson, Simon Rüegg, Sonja Hartnack, Duriya Charypkhan, & Anou Dreifuss
(previous members included!)

Maria Sibylla Merian (1647–1717) entomologist, naturalist, scientific illustrator. ***Metamorphosis insectorum Surinamensium***

giulia.paternoster@uzh.ch

life science zurich Graduate School · Universität Zürich · ETH zürich

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF COSTS (ER, 2009-2015)

Table 6. Overall costs of the One Health and uni-sectoral scenarios, Emilia-Romagna, Italy, 2009–2015.

	One Health scenario cost (Euro)	Uni-sectoral scenario cost (Euro)
Surveillance activities		
Human surveillance	71,188	71,188
Entomological surveillance	646,505	0
Wild birds surveillance	245,320	0
Horse surveillance	2340	0
Sharing of information	156,800	0
Triggered interventions		
Blood testing	3,276,352	4,488,238
Communication campaigns	105,000	105,000
Vector control interventions	411,480	411,480
	4,914,985	**5,075,906**

https://doi.org/10.1371/journal.pone.0188156.t006

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF COSTS (ER, 2009-2015)

Table 4. Cost evaluation for the One Health scenario—regional integrated West Nile virus (WNV) surveillance system, Emilia-Romagna, Italy, 2009–2015.

Year	Cost of surveillance activities							Cost of triggered public health interventions					Overall surveillance cost (Euro)
	Human surveillance	Horse surveillance	Entomological surveillance		Ornithological surveillance		Sharing of information	Communication campaigns	Vector control	Blood screening			
	Cost of diagnosis of suspect WNND cases (Euro)	Cost of diagnosis of suspect WNV neurologic disease cases (Euro)	Mosquito collection cost (Euro)	Mosquito screening cost (Euro)	Bird collection cost (Euro)	Bird screening cost (Euro)	Meetings cost (Euro)	Communication cost (Euro)	Vector control intervention cost (Euro)	No. of blood units tested	No. of positive blood units detected	Blood screening cost (Euro)	
2009 [ab]	5772	1100	50,000	28,380	16,900	16,065	22,400	15,000	102,870	44,295	0	531,540	790,027
2010 [ab]	8362	240	50,000	34,770	11,550	12,180	22,400	15,000	0	11,679	0	140,148	294,650
2011 [a]	4884	80	50,000	23,325	14,650	12,810	22,400	15,000	0	0	0	0	143,149
2012 [a]	5476	220	50,000	28,815	15,500	18,480	22,400	15,000	0	0	0	0	155,891
2013 [c]	14,726	270	60,000	39,510	18,400	29,880	22,400	15,000	102,870	74,242	12	840,419	1,143,475
2014 [c]	16,798	230	75,000	49,455	15,600	24,990	22,400	15,000	102,870	83,794	2	948,548	1,270,891
2015 [c]	15,170	200	75,000	32,250	15,800	22,515	22,400	15,000	102,870	72,058	6	815,697	1,116,902
Total	**71,188**	**2340**	**410,000**	**236,505**	**108,400**	**136,920**	**156,800**	**105,000**	**411,480**	**286,068**	**20**	**3,276,352**	**4,914,985**

WNV: West Nile virus; WNND: West Nile neurinvasive disease

Costs of entomological and ornithological surveillance, and blood screening activities for the years 2009–2013 are from Table 5 of Bellini *et al.* [3].

Blood screening activities

The integrated WNV surveillance system has been implemented during the whole study period in the Emilia-Romagna region. However, only the results of human surveillance were taken into account to trigger blood screening activities until 2013, following the national regulation (uni-sectoral scenario). In 2013, according to the regional surveillance system, WNV nucleic acid testing (NAT) screening is applied to all blood donors in a province after reports of at least two positive mosquito pools or one positive bird by the entomological or ornithological surveillance, within the limits of that province [3]. In 2014 and 2015 NAT screening at the province level is started after the confirmation of WNV in any species targeted by the surveillance system in that province. Therefore, for this scenario, blood screening data are estimated for 2009–2012, and real data for 2013–2015, based on the actual number of blood units tested and detected as positive.

[a] In this year, blood screening surveillance in Emilia-Romagna does not follow the regional integrated WNV SS, but the national WNV surveillance plan. However, based on surveillance results, it is possible to predict how many blood units would have been screened should the ER surveillance system (OH scenario) have been followed. Costs were derived accordingly.

[b] In this year, the blood units that would have been screened by the integrated WNV regional surveillance system happened to have been screened according to the national surveillance plan, so the number of positive blood units that would have been detected via the integrated WNV regional surveillance system is known.

[C] In this year, blood screening activities are based on the results of the integrated SS. Blood screening data are based on the actual number of blood units tested and detected as positive.

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF BENEFITS (ER, 2009-2015)

Table 2. Items included in the calculation of avoided short term cost of hospitalization and avoided compensation for transfusion-associated disease for the estimation of benefits, West Nile virus (WNV) integrated surveillance system in Emilia-Romagna, 2009–2015.

Item	Description	Value	Unit	Details	Source
Mean short term cost of hospitalization of WNV neuroinvasive disease (WNND)					
Hospitalization data	Date of admission and discharge to and from each hospital ward	Variable	Date		Hospital discharge form (HDF) database
	Hospital ward type	Description	NA	Intensive therapy, neurology, infectious and tropical diseases, haematology, neurology-rehabilitation etc.	
	Duration of hospitalization in each hospital ward	Table 3	Days		
	Primary and secondary diagnosis during hospitalization	Description	NA		
Hospitalization cost[a]	Daily cost of intensive therapy ward	1450	Euro/day	Direct costs: 1100 EUR/day Indirect costs: 350 EUR/day	Francesco Copello, personal communication, March 2016
	Daily cost of other hospital wards	450	Euro/day	Direct costs: 350 EUR/day Indirect costs: 100 EUR/day	
Mean compensation for transfusion-associated disease					
Anamnestic data of WNND notified cases	Sex and profession, thirty-day follow up status, local health unit (LHU) of notification	Description	NA		Surveillance form for infectious diseases (SMI) database
	Symptoms onset date, date of notification	Variable	Date		
	Age at symptoms onset date	Variable	Years		
Compensation for TAD	Compensation for TAD according to the subject's income class	Variable[b]	Euro/year for 15 years		[20,21]

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF BENEFITS (ER, 2009-2015)

Table 3. Duration (days) of hospitalization of 52 West Nile virus neuroinvasive disease cases occurred in Emilia-Romagna, 2009–2015.

Type of hospital ward	No. of WNND cases	Mean duration of hospitalization (days)	Range (days)
Intensive care	4	32.8	7–73
Infectious and tropical diseases	29	13.2	2–55
Other hospital wards	33	29.5	1–184
Total	**52**	**28.6**	**3–215**

WNND: West Nile virus neuroinvasive disease

https://doi.org/10.1371/journal.pone.0188156.t003

Parameter description	Value	Unit
Number of infected blood units intercepted in the One Health scenario only	6	Number
Number of assumed WNND cases avoided in the One Health scenario only	Table 8	Number
Number of confirmed WNND cases notified in Emilia-Romagna in 2009–2015	53	Number
Number of confirmed WNND cases in Emilia-Romagna in the study period with hospitalization records	52	Number
Number of hospitalization records considered in the estimation	76	Number
Mean hospitalization length of a WNND case	28.6	Days
Mean short term cost of hospitalization of a WNND case	15,396	Euro
Mean compensation for transfusion-associated disease per subject	150,000[a]	Euro

WNND: West Nile virus neuroinvasive disease

[a] Compensation in fifteen years.

WNV INTEGRATED SURVEILLANCE

ESTIMATION OF BENEFITS (ER, 2009-2015)

Table 8. Benefits of the One Health scenario quantified as averted costs of potential human cases of West Nile virus neuroinvasive disease (WNND) associated to infected blood component transfusion. Best-case, intermediate, and worst-case scenario according to the probability of WNND transfusion associated transmission. Emilia-Romagna, Italy, 2009–2015.

	Best-case scenario	Intermediate scenario	Worst-case scenario
Short term cost of hospitalization avoided (Euro)	0	30,792	277,128
Compensation for transfusion-associated disease avoided (Euro)	0	300,000	2,700,000
Total benefit of the One Health scenario (Euro)	**0**	**330,792**	**2,977,128**

WNND: West Nile virus neuroinvasive disease

Benefits of the One Health scenario are estimated as potential transfusion associated West Nile virus neuroinvasive disease (WNND) cases avoided. Three scenarios are considered based on the assumed probability of developing WNND after receiving an infected blood transfusion. This probability was assumed to be 0%, 10%, and 100% in the best-case, intermediate, and worst-case scenario, resulting in 0, 2, and 18 potential WNND cases avoided, respectively.

https://doi.org/10.1371/journal.pone.0188156.t008

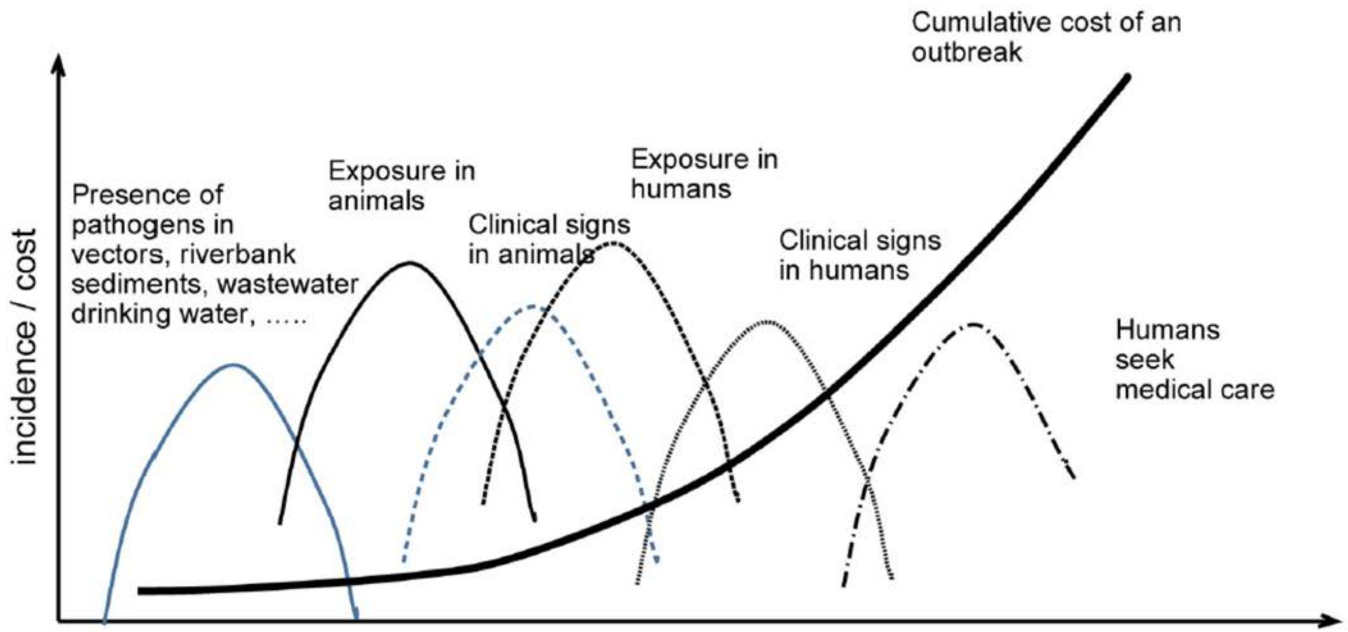


Figure 2. Schematic relationship of time to detection of an emerging pathogen and its cumulative cost of control. (Adapted and expanded from World-Bank 2012.)

Zinsstag et al., 2018

Integrated human and animal surveillance and response systems (iSRS) are one of the most important contributions of a One Health approach to mitigate effects of climate change. While public health surveillance is restricted to humans, understanding vector-borne diseases and climate change per se call for an integrated One Health approach (Semenza and Zeller 2014; Elbers, Koenraadt and Meiswinkel 2015). The above-mentioned example of integrated WNV surveillance in mosquitos, birds, horses and humans is a case in point (Paternoster et al. 2017). TheWorld Bank makes a compelling case for integrated human and animal surveillance (Fig. 2), emphasizing that if emerging diseases can already be detected in vectors, livestock or wildlife, prior to detection in humans, very large costs could be averted (World-Bank 2012; Heymann and Dixon 2013)

Food for thought

- https://crowdfunding.wur.nl/project/muggenradar-app?locale=en
- https://www.google.com/search?q=rame+filo&client=safari&rls=en&source=lnms&tbm=isch&sa=X&ved=0ahUKEwipspSc5f_eAhUEXiwKHW2nCo4Q_AUIDigB&biw=1246&bih=727
- Sabbia
- https://www.nytimes.com/2005/04/07/world/africa/flower-of-africa-a-curse-thats-blowing-in-the-wind.html
- Plastic bags breeding for malaria
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5655677/

Wangari Maathai, the assistant environmental minister in Kenya and 2004 Nobel Peace Prize winner

Action facilitating **exchange and collaboration between disciplines and between science and society.**