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**DYNAMICAL SYSTEMS APPLIED TO  
BIOLOGY AND NATURAL SCIENCES**  
**DSABNS 2020**  
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# USING DIGITAL METHODS IN EPIDEMIOLOGY TO ADDRESS DISEASE CONTROL IN SUB SAHARAN AFRICA: EXPERIENCES AND PERSPECTIVES OF DOCTORS WITH AFRICA CUAMM

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Planning and Operational Research

Doctors with Africa CUAMM



Dipartimento di  
Matematica



# WHO WE ARE: 70 years of work in Africa



## LA NOSTRA STORIA

Dal 1950 più di mille sono le persone che hanno prestato servizio con Medici con l'Africa Cuamm e hanno dato il loro personale contributo, professionale e umano, in una qualche parte del mondo povero.



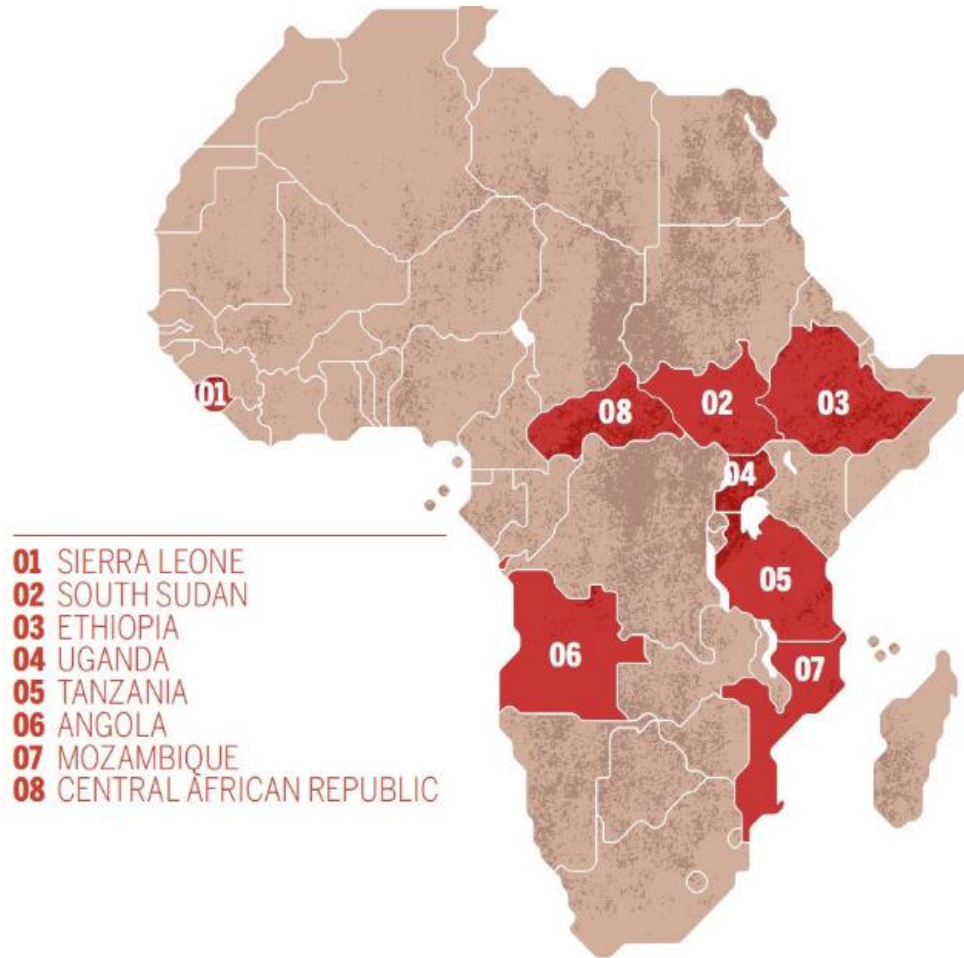
**Dott. A. Dal Lago, Kenya, 1955**



The first Italian organization to take care of health and development in Africa



# WHERE WE WORK



## Field research

Papers, abstracts  
and posters from  
cooperation activities  
in Africa - 2018



## Operational research



**2019**

**27** published researches  
36 Academic partners

**2018**

**23** published researches  
32 Academic Partners

**2017:**

**19** published researches  
38 academic partners

**2016:**

**19** published researches



<https://doctorswithafrica.org/en/fieldresearch/>

# The evaluation of control interventions of Ebola outbreak in Pujehun district Sierra Leone



# Ebola in Sierra Leone: do public health interventions work? the case of Pujehun District



370.000 inhabitants  
1 Hospital-77 health units  
Very High MMR and U5MR

2012 Doctors with Africa CUAMM  
intervention in Pujehun



# Ebola in Pujehun District, July-November 2014



- A total of **49 patients**, consisting of 31 confirmed and 18 probable cases, were registered between July 2014 and November 2014 in Pujehun District



## Ethical dilemmas: stay or leave? Tackling Ebola and maintaining routine care for mother and children?



Maria Bonino, CUAMM's pediatrician.  
She died on 24th March 2005 for EVF Marburg in  
Angola after serving in Uige Hospital.  
She is buried in Luanda as per her wishes





MINISTRY OF HEALTH  
AND SANITATION  
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## Isolation units: Ebola Holding Center



20 beds in the two EHCs

89%: Hospitalisation rate (52% in WA)

4.5 days: The mean time from the onset of symptoms to hospitalization







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# Contact tracing



250 contact tracers trained

25 the mean number of contacts investigated per EVD case



# Transport and safe burial



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Ebola Ambulance, Pujehun Hospital

50-60 safe burials on a weekly basis





# Community mobilisation



Meeting elders and local chief in Zimmi

Meeting young people in the  
market of Pujehun







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# 10th January 2015: a good news!!!

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## Ebola

The Observer

# Sierra Leone declares first Ebola-free district

Pujehun, in the south east, has had no cases for 42 days after early decision to clamp down on public gatherings

Lisa O'Carroll

[@lisaocarroll](#)

Saturday 10 January 2015 22:39 GMT

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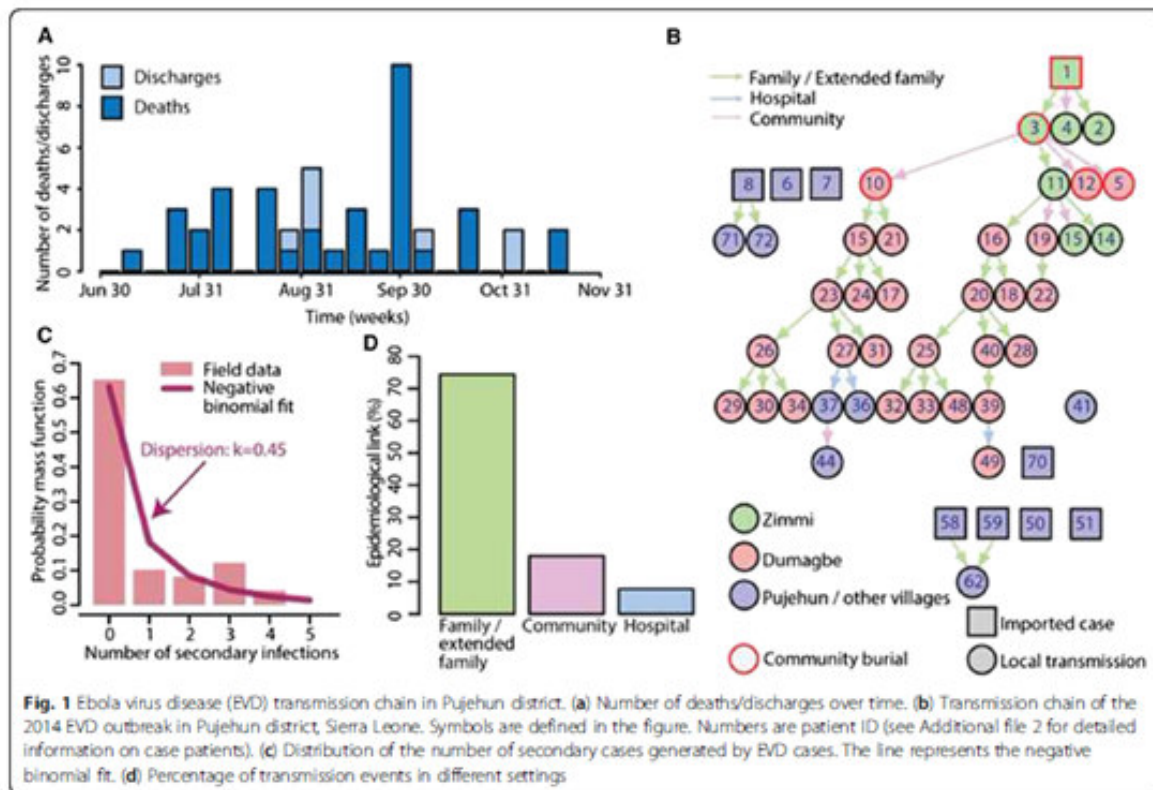
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# What really happened in Pujehun District?



## Method:

- By integrating hospital registers and contact tracing form data with healthcare worker and local population interviews, we reconstructed the transmission chain and investigated the key time periods of EVD transmission.
- The impact of intervention measures has been assessed using a microsimulation transmission model calibrated with the collected data.

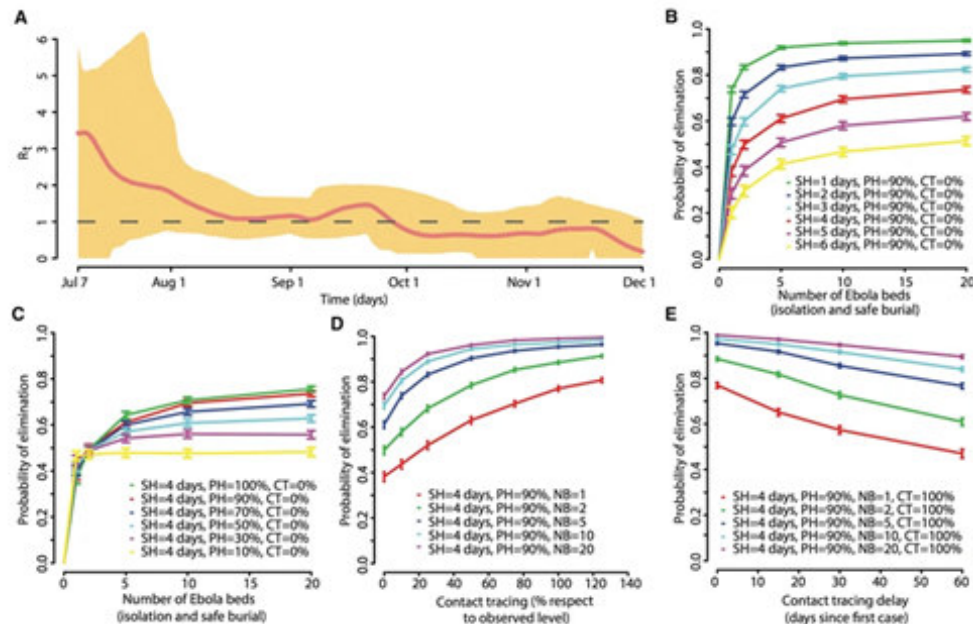
## RESEARCH ARTICLE

## Open Access

## The 2014 Ebola virus disease outbreak in Pujehun, Sierra Leone: epidemiology and impact of interventions

Marco Ajelli<sup>1</sup>, Stefano Parlamento<sup>1</sup>, David Borne<sup>2</sup>, Atiba Kebbi<sup>3</sup>, Andrea Atzori<sup>4</sup>, Clara Frasson<sup>4</sup>, Giovanni Putoto<sup>4</sup>, Dante Carraro<sup>4</sup> and Stefano Merler<sup>1\*</sup>

# What was the impact of the adopted control measures?



- Isolation centres, aggressive contact tracing and safe burial (prepariness) with their relative weight, **have been effective measures for the epidemic control at the source.**

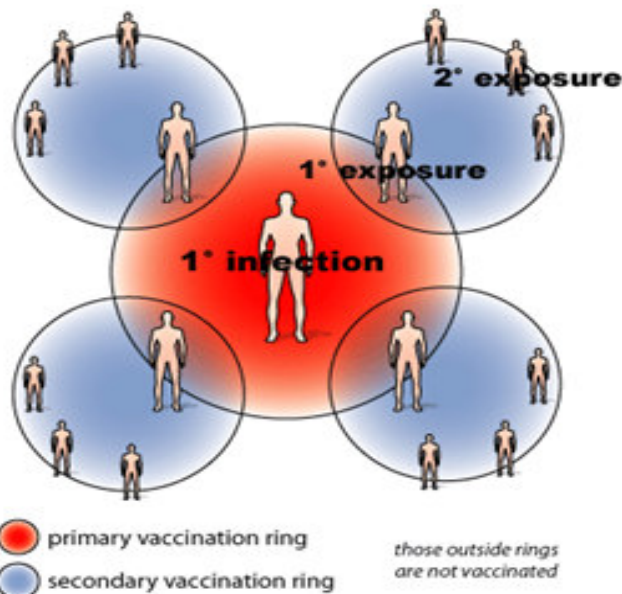
Ajelli et al. *BMC Medicine* (2015) 13:281  
DOI 10.1186/s12916-015-0524-z



\* **For the microsimulation model** refers to Merler S, Ajelli M, Fumanelli L, Gomes MFC, Piotti APY, Rossi L, et al. Spatiotemporal spread of the 2014 outbreak of Ebola virus disease in Liberia and the effectiveness of non-pharmaceutical interventions: a computational modelling analysis. *Lancet Infect Dis.* 2015;15(2):204–11.



# What if: containing Ebola at the source with Ring Vaccination



- Ring vaccination is effective if the  $R_0$  is up to 1,6
- If combined with other PH measures, the effectiveness increases up to the  $R_0$  is 2,6

 **PLOS** | NEGLECTED TROPICAL DISEASES

RESEARCH ARTICLE

## Containing Ebola at the Source with Ring Vaccination

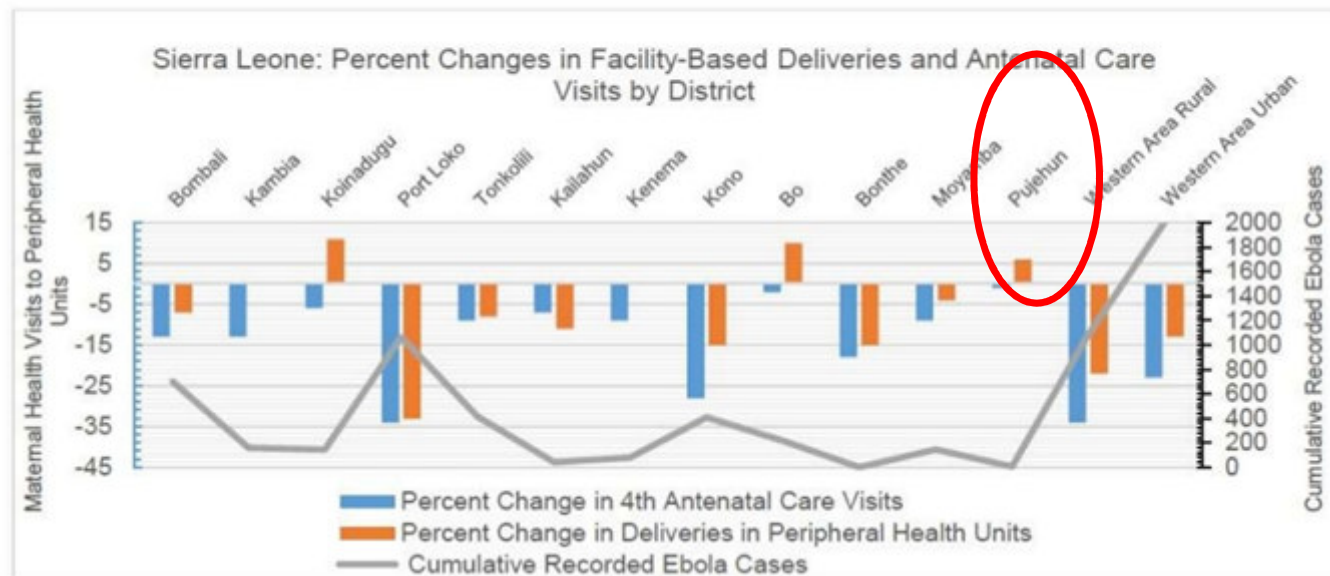
Stefano Merler<sup>1</sup>, Marco Ajelli<sup>1</sup>, Laura Fumanelli<sup>1</sup>, Stefano Parlamento<sup>1</sup>, Ana Pastore y Piontti<sup>2</sup>, Natalie E. Dean<sup>3</sup>, Giovanni Putoto<sup>4</sup>, Dante Carraro<sup>4</sup>, Ira M. Longini, Jr.<sup>3</sup>, M. Elizabeth Halloran<sup>5,6</sup>, Alessandro Vespignani<sup>2,7,8\*</sup>



# What was the impact of the disease on routine care for mothers and children?



 **+ 6,5%** a Pujehun District  
 **- 23%**, in media, in Sierra Leone



## Maintaining Maternal and Child Health Services During the Ebola Outbreak: Experience from Pujehun, Sierra Leone

JUNE 2, 2016 · RESEARCH ARTICLE

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Open access

Research

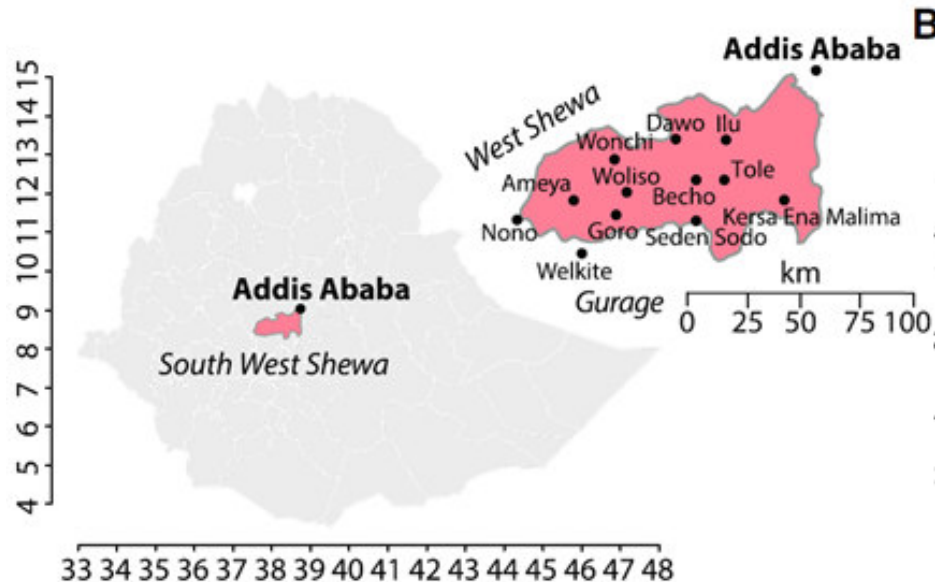
## BMJ Open Impact of Ebola outbreak on reproductive health services in a rural district of Sierra Leone: a prospective observational study

Gianluca Quaglio,<sup>1,2,3</sup> Francesca Tognon,<sup>4</sup> Livio Finos,<sup>5</sup> David Borne,<sup>6</sup> Santigie Sesay,<sup>6</sup> Atiba Kebbie,<sup>7</sup> Francesco Di Gennaro,<sup>8</sup> Bienvenu Salim Camara,<sup>9</sup> Claudia Marotta,<sup>10</sup> Vincenzo Pisani,<sup>7</sup> Zainab Bangura,<sup>7</sup> Damiano Pizzol,<sup>3</sup> Annalisa Saracino,<sup>8</sup> Walter Mazzucco,<sup>10</sup> Susan Jones,<sup>11</sup> Giovanni Putoto<sup>3</sup>

BMJ Open 2019;9:e029093. doi:10.1136

# What happens outside the hospital? From passive to active surveillance: the case of measles in Ethiopia

# The hidden burden of measles in Ethiopia



St. Luke Hospital, Woliso, South West Zone

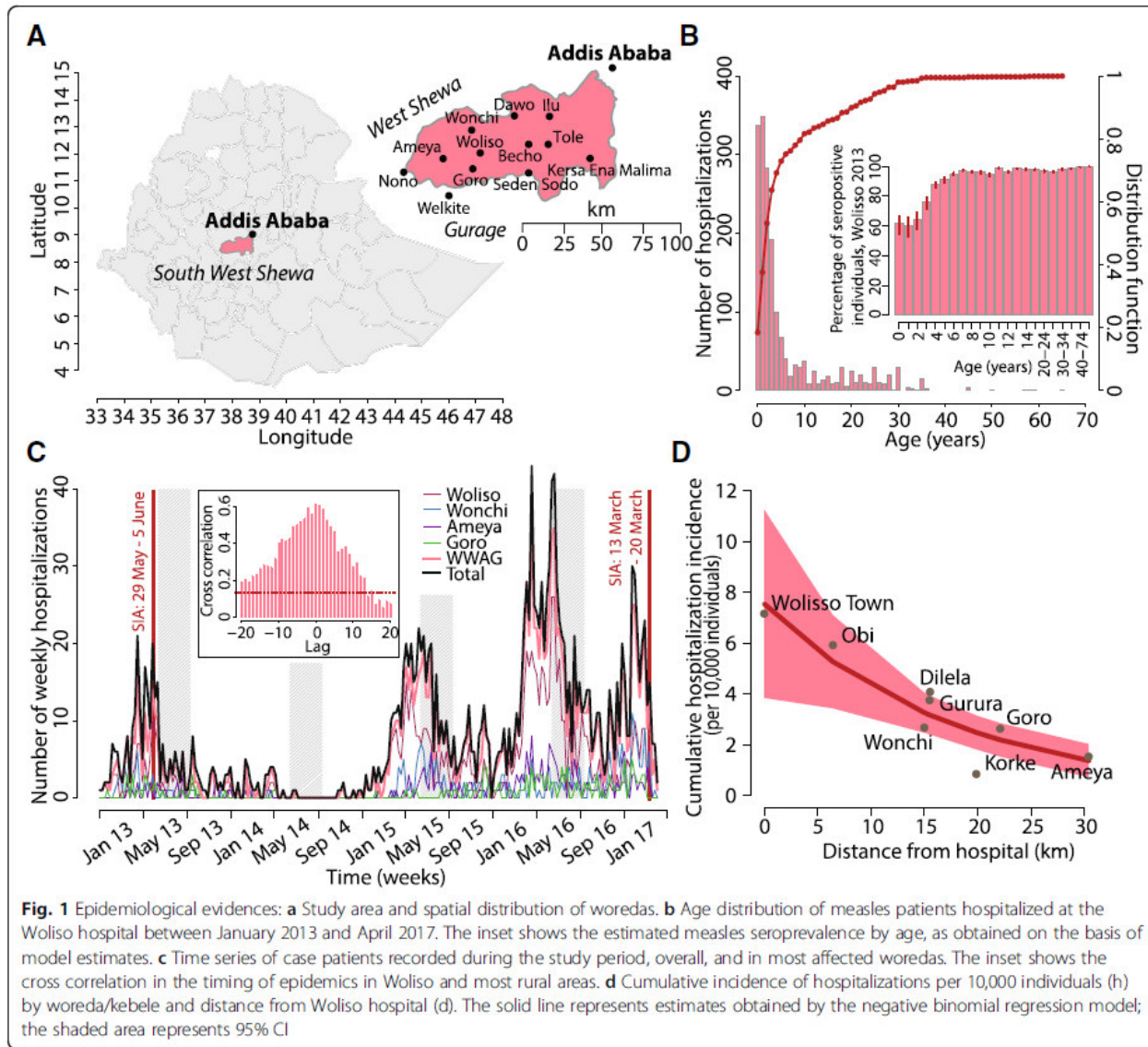
- **The issue:** A sequence of annual measles epidemics has been observed from January 2013 to April 2017 in the South West Shoa Zone of the Oromia Region, Ethiopia
- **The aim:** estimating the burden of disease in the affected area, taking into account inequalities in access to health care due to travel distances from the Wolisso Hospital
- **The method:** dynamic transmission model calibrated on the time series of hospitalized measles cases

## RESEARCH ARTICLE

Open Access

The hidden burden of measles in Ethiopia: how distance to hospital shapes the disease mortality rate

Piero Poletti<sup>1\*</sup>, Stefano Parlamento<sup>1</sup>, Tafarrah Fayyisaa<sup>2</sup>, Rattaa Feyyiss<sup>2</sup>, Marta Lusiani<sup>3</sup>, Ademe Tsegaye<sup>3</sup>, Giulia Segafredo<sup>4</sup>, Giovanni Putoto<sup>4</sup>, Fabio Manenti<sup>1</sup> and Stefano Merler<sup>1</sup>



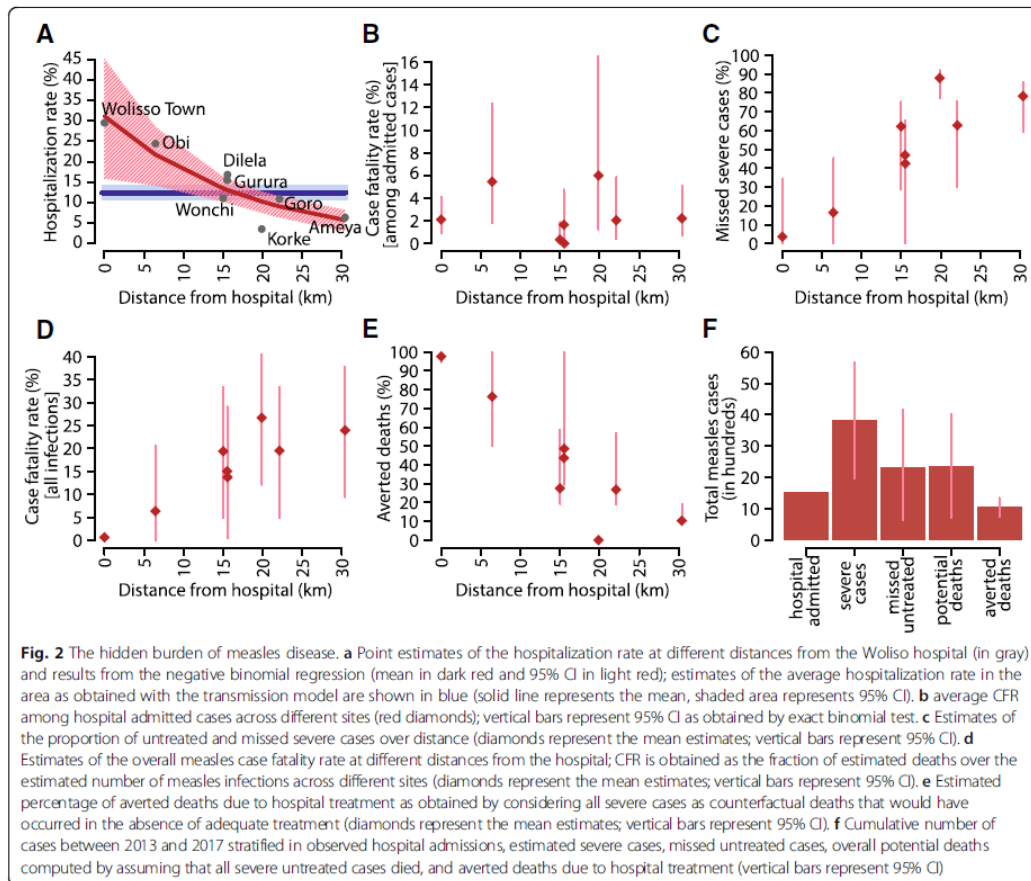
Epidemiological transitions are described by the following system of ordinary differential equations (don't ask me more than that!)

$$\begin{cases}
 M_a'(t) &= bN(t) - \mu M_a(t) - (\varepsilon_R c_R(t, a) + \varepsilon_S c_S(t, a)) M_a(t) - d(t, a) M_a(t) \\
 S_a'(t) &= \mu M_a(t) - (\varepsilon_R c_R(t, a) + \varepsilon_S c_S(t, a)) S_a(t) - \beta(t) S_a(t) I(t) / N(t) - d(t, a) S_a(t) \\
 E_a'(t) &= \beta(t) S_a(t) I(t) / N(t) - \omega E_a(t) - d(t, a) E_a(t) \\
 I_a'(t) &= \omega E_a(t) - \gamma I_a(t) - d(t, a) I_a(t) \\
 R_a'(t) &= \gamma I_a(t) + (\varepsilon_R c_R(t, a) + \varepsilon_S c_S(t, a)) (S_a(t) + M_a(t)) - d(t, a) R_a(t) \\
 H_a'(t) &= p_R \omega E_a(t) \\
 I(t) &= \sum_{a=0}^{85} I_a(t) \\
 H(t) &= \sum_{a=0}^{85} H_a(t) \\
 N(t) &= \sum_{a=0}^{85} [M_a(t) + S_a(t) + E_a(t) + I_a(t) + R_a(t)]
 \end{cases}$$



# Results:

## substantial burden of Measles despite 84% of reported coverage



- **A total of 1819 case patients and 36 deaths were recorded at the hospital.** The mean age was 6.0 years (range, 0–65).
- **The estimated reproduction number was 16.5** (95% credible interval (CI) 14.5–18.3)
- **Cumulative disease incidence of 2.34%** (95% CI 2.06–2.66).
- **Measles severe cases: 3.821** (95% CI 1969–5671)  
**Measles related deaths 2.337** (95% CI 716–4009) estimated in the Wolisso hospital's [catchment area](#) (521,771 inhabitants).
- **The case fatality rate was found to remarkably increase with travel distance from the nearest hospital: ranging from 0.6% to more than 19% at 20 km.**
- **Accordingly, hospital treatment prevented 1049** (95% CI 757–1342) deaths in the area.

# Public health implications: SURVETHI

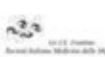


- Project to strengthen local capacity to improve epidemic surveillance and control of communicable diseases
- Training
- Operational Research
- Networking with local health authorities, professionals and communities

Con il patrocinio di



Evento co-finanziato dall'Agenzia Italiana per la Cooperazione allo Sviluppo



# Take home messages

## CONCLUSION

- **Epidemiological modelling** is important IF it is linked to field work (health system approach)
- **Epidemiological modelling** provides key info to evaluate effectiveness of health interventions in epidemics
- **Epidemiological modelling** helps to collect and use good data locally.

## WAY FORWARD

- **Ready** to joint hands with NGOs, local community and governments to improve African public health surveillance system?
- **Ready** to address new areas such as
  - *Climate changes and vectors control?*
  - *One health?*
  - *Antibiotic resistance?*
  - *Fragile countries?*
- **Ready** to work in interdisciplinary team?

THANKS!!!