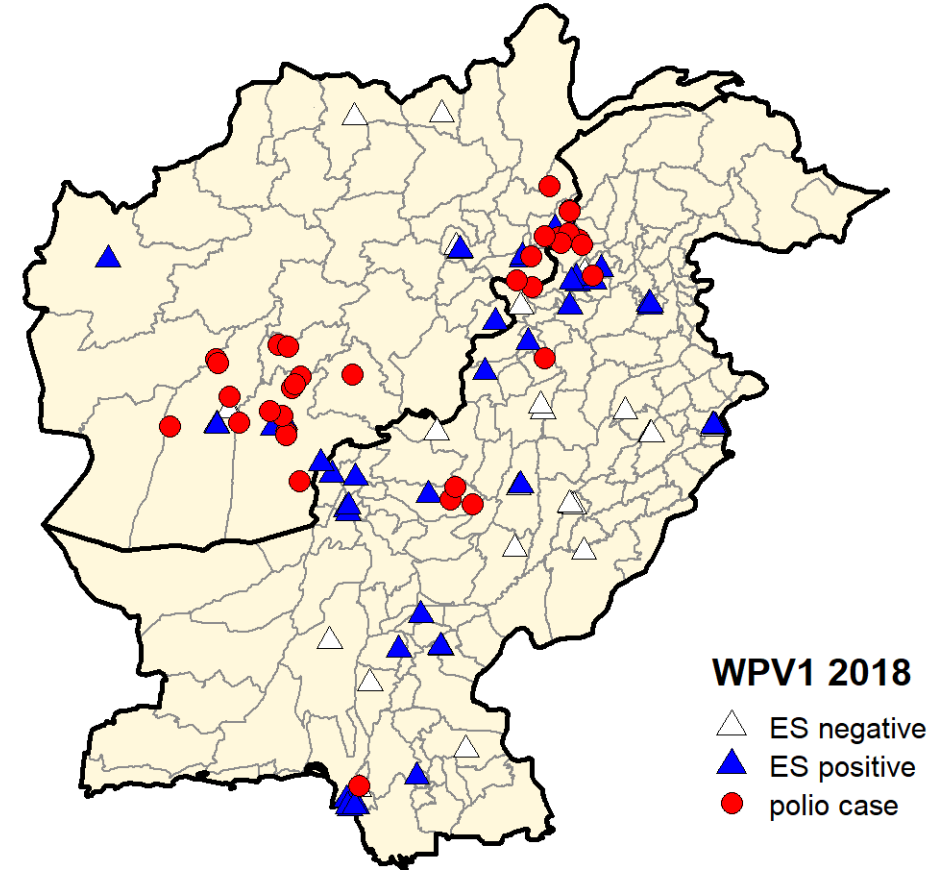# Risk factors and short-term projections for serotype-1 poliomyelitis incidence in Pakistan: A spatiotemporal analysis

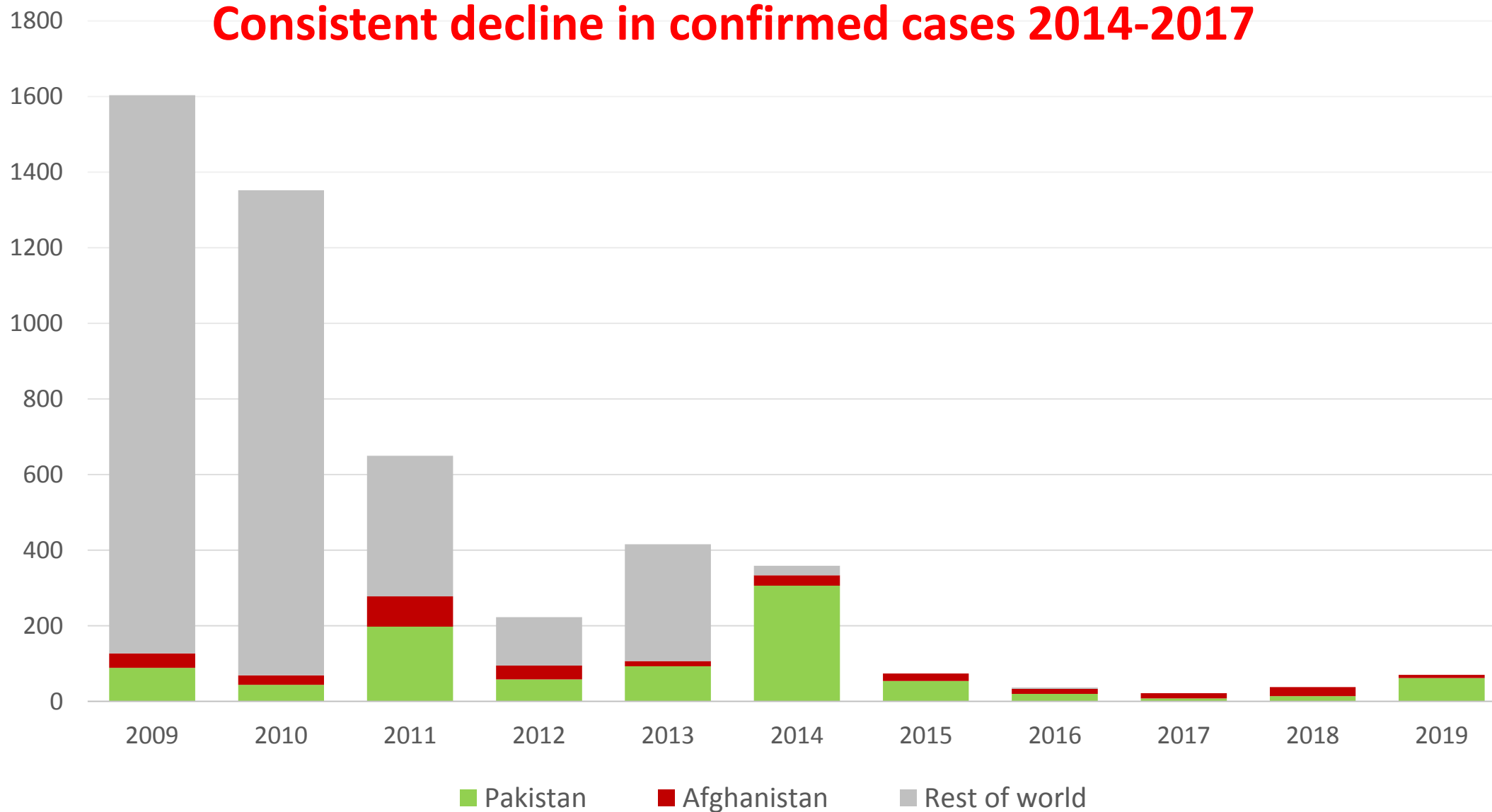*Molodecky et al. 2017 Plos. Med.*

# Background

- Pakistan and Afghanistan represent the last remaining cluster of wild poliovirus transmission globally. No cases have been seen in Nigeria since 2016

- RI and SIAs are the key interventions in Pakistan to interrupt transmission

- Accessibility issues are known – estimating risk in inaccessible areas is hard but they also represent risk of transmission to surrounding areas

- OPV immunogenicity poorer in Pakistan – multiple doses needed

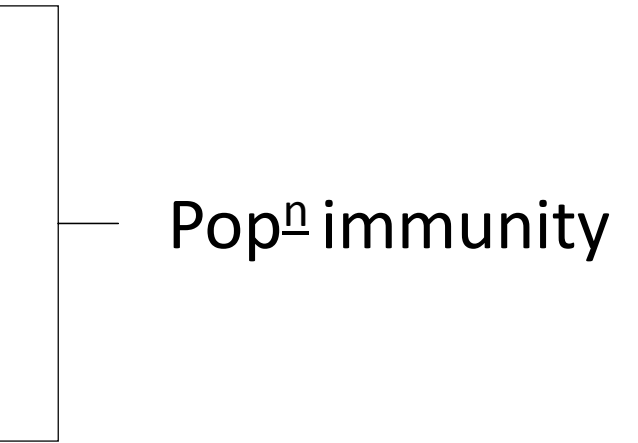- Targeting interventions important to maximise utility of doses

**WPV1 2018**

△ ES negative
▲ ES positive
● polio case

Global WPV1 Cases, 2009–2019*

Consistent decline in confirmed cases 2014-2017

Legend: Pakistan, Afghanistan, Rest of world

Updated from presentation by Natalia Molodecky, WHO

# Model aim

- This work aimed to include movement data in polio risk models to see if polio spread could be better estimated.

- Risk models are used to plan SIAs so accuracy is important to the interruption of WPV transmission.

# Basic parameters

- Vaccination history of AFP cases – reported vaccine doses of non-polio AFP cases divided by number of SIA campaigns in their district between birth and paralysis
- RI coverage - % of children receiving 3 RI doses of OPV

$Pop^{n}$ immunity

- Non-polio AFP rate – marker of surveillance intensity
- Cases in the same spatial unit
- Population and density of each spatial unit – number of individuals important to risk of spread
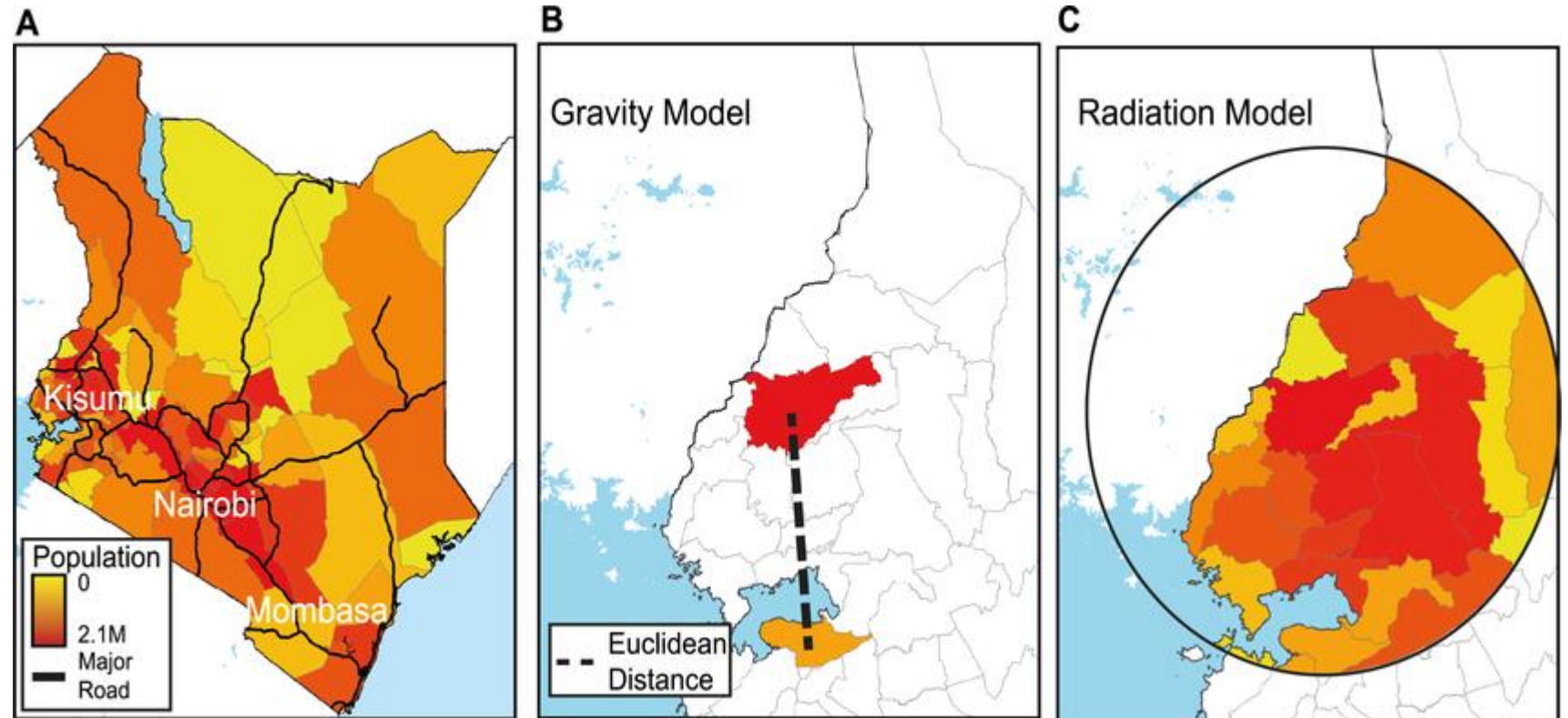- Population living in poverty
- Precipitation

# Movement models

**First order adjacency**

**Gravity and radiation models**
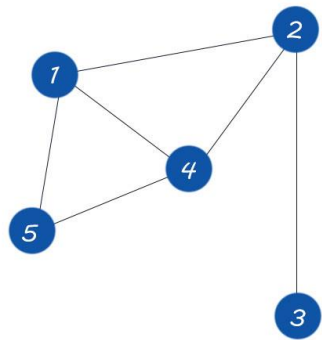


$$A = \begin{matrix} & 1 & 2 & 3 & 4 & 5 \\ 1 & 0 & 1 & 0 & 1 & 1 \\ 2 & 1 & 0 & 1 & 1 & 0 \\ 3 & 0 & 1 & 0 & 0 & 0 \\ 4 & 1 & 1 & 0 & 0 & 1 \\ 5 & 1 & 0 & 0 & 1 & 0 \end{matrix}$$

Wesolowski et al. Plos Comp. Biol. 2015

# Movement models

Extensions to these movement models incorporated:

- Population density in the radiation model – a small district with high population density is more likely to attract a migrant than a large district with the same population.

- Travel time in the radiation model – rather than direct distance we can use road network maps etc to estimate real world travel time.

- Mobile phone data in the gravity model – mobile phone data gives an indication of  where people are travelling in reality to fit the model to.

# FOI
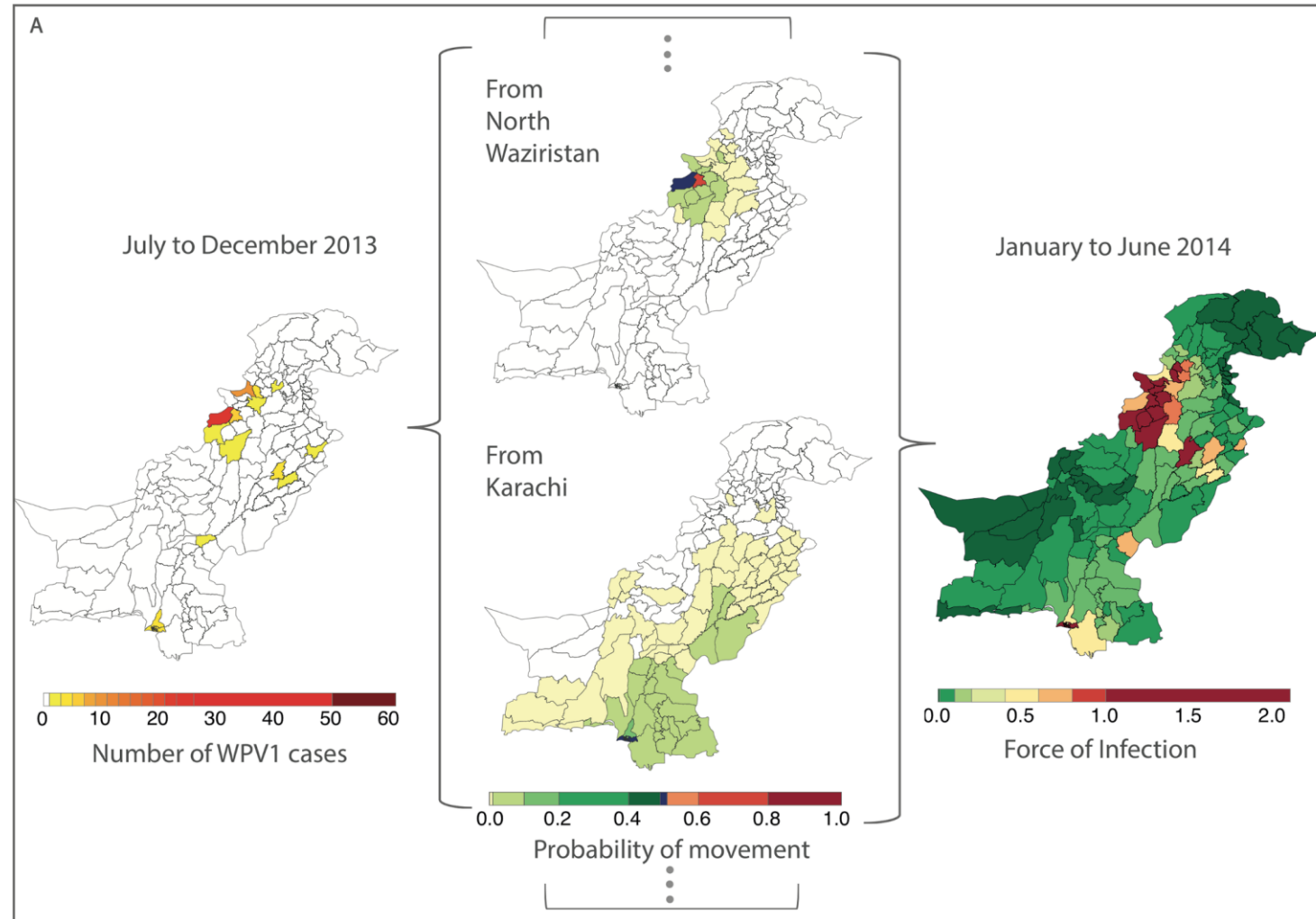
# Results

**Table 1. Risk factors associated with the incidence of wild poliovirus type 1 (WPV1) cases based on the best-fitting multivariable mixed-effects lagged regression model for January–June 2010 through July–December 2016.** The odds ratio (OR) and the 95% confidence interval (CI) for routine immunization and supplementary immunization activity (SIA) coverage are for an absolute 10% increase in these variables and a 1-unit increase for all other variables. Non-polio acute flaccid paralysis (AFP) rate is per 100,000 persons aged <15 years.

| Variable (fixed effects) | OR (95% CI) | P value |
|---|---|---|
| Routine immunization coverage (previous 6 months) | 0.75 (0.67–0.84) | <0.001 |
| SIA coverage (previous 6 months) | 0.75 (0.66–0.85) | <0.001 |
| Non-polio AFP rate (previous 6 months) | 1.13 (1.02–1.26) | 0.025 |
| Log (population size) | 2.62 (1.94–3.55) | <0.001 |
| Cases in the same district (previous 6 months) | 1.16 (1.04–1.28) | 0.006 |
| Cases in all other districts, weighted by probability of movement (previous 6 months; radiation model) | 1.14 (1.02–1.27) | 0.021 |
| **Variable (random intercepts)** | **Variance** | **Standard Deviation** |
| Province | 0.393 | 0.627 |
| Year (6-month interval) | 0.838 | 0.915 |