Risk Mapping of Foot-and-Mouth Disease in Central Asia Region

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Rationale

- Within the PCP-FMD framework, seroprevalence data are important to assess risk and monitor control progress
  - *STAGE 0 – STAGE 1*
    Serological data enable a preliminary assessment of the FMD epidemiological status and the level of risk of FMD infection
- The establishment of Regional Roadmaps provides an opportunity for harmonising sero-survey and thus enhancing the precision of estimates at regional scale
- *GTFS/INT/907/ITA*
  - September 2010 – March 2012, country-wide survey in Central Asia

	2010	2011	2012
Afghanistan	1	1	1
Pakistan	1	1	1
Tajikistan	1	1	1
Turkmenistan	0	0	1
Uzbekistan	0	0	1

  - Harmonised cross-sectional surveys based on a two-stage cluster sampling design
  - Subsistence farming system (village level) – age-stratified (0-6m; 6-18m; >18m)
  - Diagnostic test by NSP-ELISA (*in-house* IZSLER Brescia, Italy)

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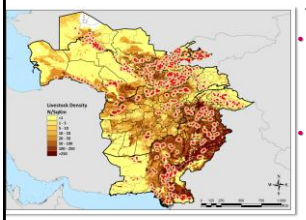
Survey Design



Two-Stage Cluster Sampling Design

- 1st Stage (PSU = Village), required No calculated by Intensity Sampling

$$N(PSU) = \frac{r}{Km^2} \qquad r = 25\text{km}$$

- 2nd Stage (SSU = Animal), required No calculated by Simple Random Sampling Formula for Binomial Data

$$N(SSU) = \frac{1.96^2 \cdot p \cdot q}{d^2}$$

p = event proportion (0.5)
q = non-event proportion (0.5)
d = SE (25%) at 95% CI

	Villages (PSU)	Samples (SSU)	Samples/Village
Afghanistan	196	3243	16.54
Pakistan	235	3761	16.00
Tajikistan	132	2112	16.00
Turkmenistan	61	976	16.00
Uzbekistan	110	1760	16.00
TOT	734	11852	16.15

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Statistical Analysis

- Prevalence analysis
  - Sample Base Weight and Finite Population Correction

$$BW_{ij} = \frac{1}{\left(\frac{z_j}{Z_j}\right)\cdot\left(\frac{k_{ij}}{K_{ij}}\right)} \qquad FPC_{ji} = \sqrt{\frac{N_{ji} - n_{ji}}{N_{ji} - 1}}$$

- Risk Analysis – Odds Ratio
  - Generalized Linear Model (Logit link) – categorical covariates
    - *Age* (0-6m, 6-12m, 12-18m, >18m)
    - *Vaccination distance* (VaccinationDATE – SamplingDATE)
    - *Susceptibility* (6monthDATE – VaccinationDATE)
    - *Species, Farm System, Origin* (data not shown)
  - Cubic Spline Logistic Regression (combining continuous+categorical)
- Risk Map
  - Mixed-Effect Model (via GLLAMM program – Stata 12.1 SE)
    - Probability $p(x)$ of FMD prevalence mapped in ArcGIS 10.1 using Kernel Smoothed Intensity map

$$p(x) = \frac{e^{g(x)}}{1 + e^{g(x)}}$$

  - Space-Time Permutation Model (via SaTScan 9.1.1)

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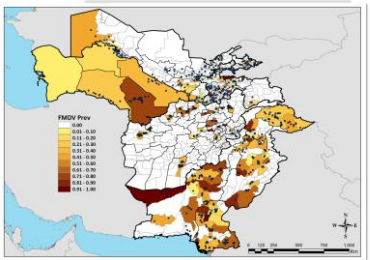
FMD Prevalence



	+ve/No Sampled	Observed [True] PREV*	95% CI	Within-District PREV	Within-Village PREV	DEFF [DEFT]
Afghanistan	1504/3243	46.81% [46.93%]	43.40% - 50.24%	6.25% - 63.85%	0% - 100%	1.309 [1.144]
Pakistan	1591/3761	39.73% [39.79%]	36.53% - 43.03%	0% - 94.20%	0% - 100%	0.436 [0.660]
Tajikistan	851/2112	47.83% [47.96%]	43.96% - 51.73%	0% - 93.75%	0% - 100%	3.237 [1.799]
Turkmenistan	465/976	41.93% [42.01%]	38.26% - 45.69%	0% - 100%	0% - 100%	0.392 [0.626]
Uzbekistan	281/1760	14.35% [14.18%]	11.49% - 17.78%	0% - 81.25%	0% - 82.00%	16.9 [4.111]
TOT	4692/11852	24.48% [24.40%]	22.24% - 26.87%	0% - 100%	0% - 100%	8.963 [2.994]

*Adj-Wald Test, F = 65.475 (d.f. 4, 11848) [p = 0.000]

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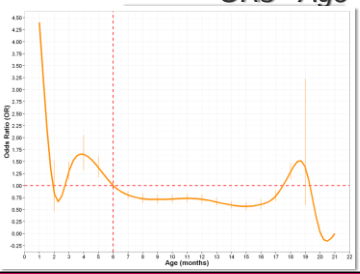
ORs - Age



Status	+ve/No Sampled	Observed [True] PREV*	95% CI	OR [95% CI]
0 – 6 months	1599/3702	33.41% [33.41%]	28.90% – 38.25%	1.690 [1.306 – 2.188]
6 – 12 months	902/2745	22.75% [22.65%]	19.06% – 26.91%	0.839 [0.645 – 1.092]
12 – 18 months	1090/2734	21.88% [21.78%]	18.50% – 25.69%	0.801 [0.616 – 1.041]
>18 months	3/10	8.03% [7.80%]	1.18% – 39.01%	0.269 [0.037 – 1.980]
TOT	3594/9191	24.09% [24.01%]	21.79% – 26.54%	0.773 [0.660 – 0.906]

*Adj-Wald Test, F = 7.3821 (d.f. 3, 9188) [p = 0.000]

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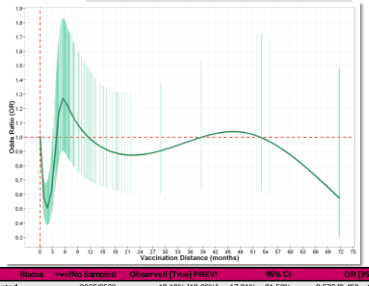
ORs - Vaccination



Status	+ve/No Sampled	Observed [True] PREV†	95% CI	OR [95% CI]
Vaccinated	2665/6526	19.19% [19.06%]	17.01% – 21.58%	0.572 [0.450 – 0.726]
0>mpv<6	839/2668	14.57% [14.40%]	12.20% – 17.31%	0.378 [0.292 – 0.491]
6>mpv<12	723/1590	44.02% [44.12%]	39.88% – 48.25%	2.571 [2.069 – 3.195]
>12mpv	184/513	39.48% [39.53%]	32.07% – 47.41%	2.052 [1.449 – 2.907]
Unvaccinated	2027/5326	29.35% [29.31%]	25.61% – 33.39%	1.749 [1.377 – 2.220]

†Adj-Wald Test, F = 19.1818 (df. 1, 11851) (p = 0.000)

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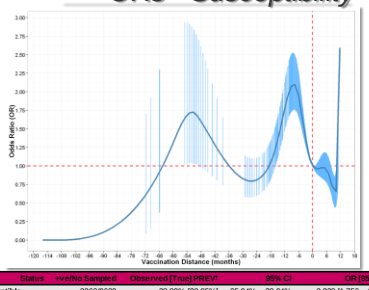
ORs - Susceptibility



Status	+ve/No Sampled	Observed [True] PREV†	95% CI	OR [95% CI]
Susceptible	3960/9689	28.89% [28.85%]	25.94% – 32.04%	2.339 [1.756 – 3.117]
6month age PV	1290/3147	27.45% [27.40%]	24.36% – 30.77%	1.206 [0.968 – 1.501]
Not Susceptible	732/2163	14.80% [14.63%]	11.96% – 18.17%	0.427 [0.321 – 0.569]
0>apv<6	280/1028	18.99% [18.86%]	14.64% – 24.27%	0.680 [0.484 – 0.957]
>6apv	176/596	8.65% [8.42%]	5.76% – 12.79%	0.256 [0.162 – 0.405]

†Adj-Wald Test, F = 20.3639 (df. 3, 8088) (p = 0.000)

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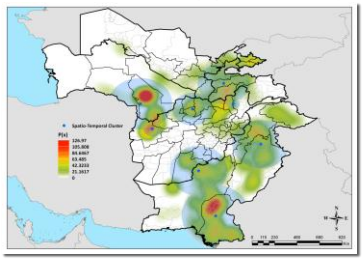
P(x) Risk Map



Country (Province)	Radius (Km)	Observed/Expected	P
Turkmenistan (Mary)	261.2	8.95	0.000
Tajikistan (Rep. Subordination)	207.93	5.2	0.000
Afghanistan (Herat)	75.7	5.76	0.000
Afghanistan (Sar-e-Pol)	166.42	3.91	0.000
Afghanistan (Takhar)	54.19	10.4	0.000
Pakistan (Balochistan)	254.2	3.88	0.000
Pakistan (Punjab)	245.3	10.69	0.000
Pakistan (Sindh)	314.2	6.69	0.000

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Discussion

- Validity of survey assumption and power of harmonised process
- Trend of FMD Prevalence Increasing with Distance from Vaccination
  - Age as a confounding factor
- Susceptibility Variable (naïve population) explains low Vaccination Effect
- High Risk probability of FMD Prevalence found in bordering area between:
  - Afghanistan – Pakistan (n = 2)
  - Afghanistan – Tajikistan
  - Afghanistan – Turkmenistan
- Identified FMD Risk Areas can be used as Target Points for improving:
  - FMD surveillance
  - Joint effort for FMD Control

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