Spatial analyses of undervaccination patterns in early childhood in Montana

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AMERICAN IMMUNIZATION REGISTRY ASSOCIATION ANNUAL MEETING

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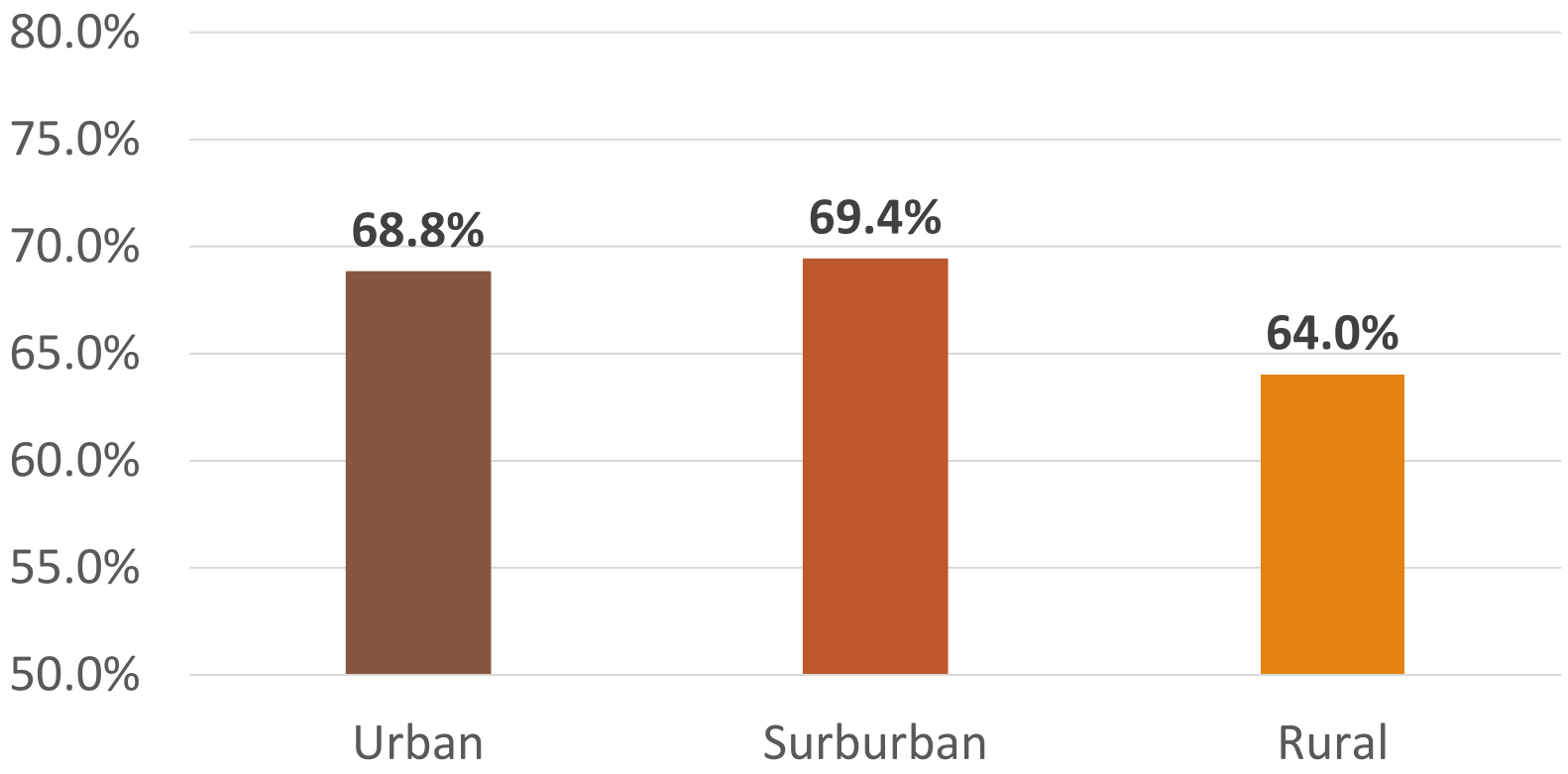
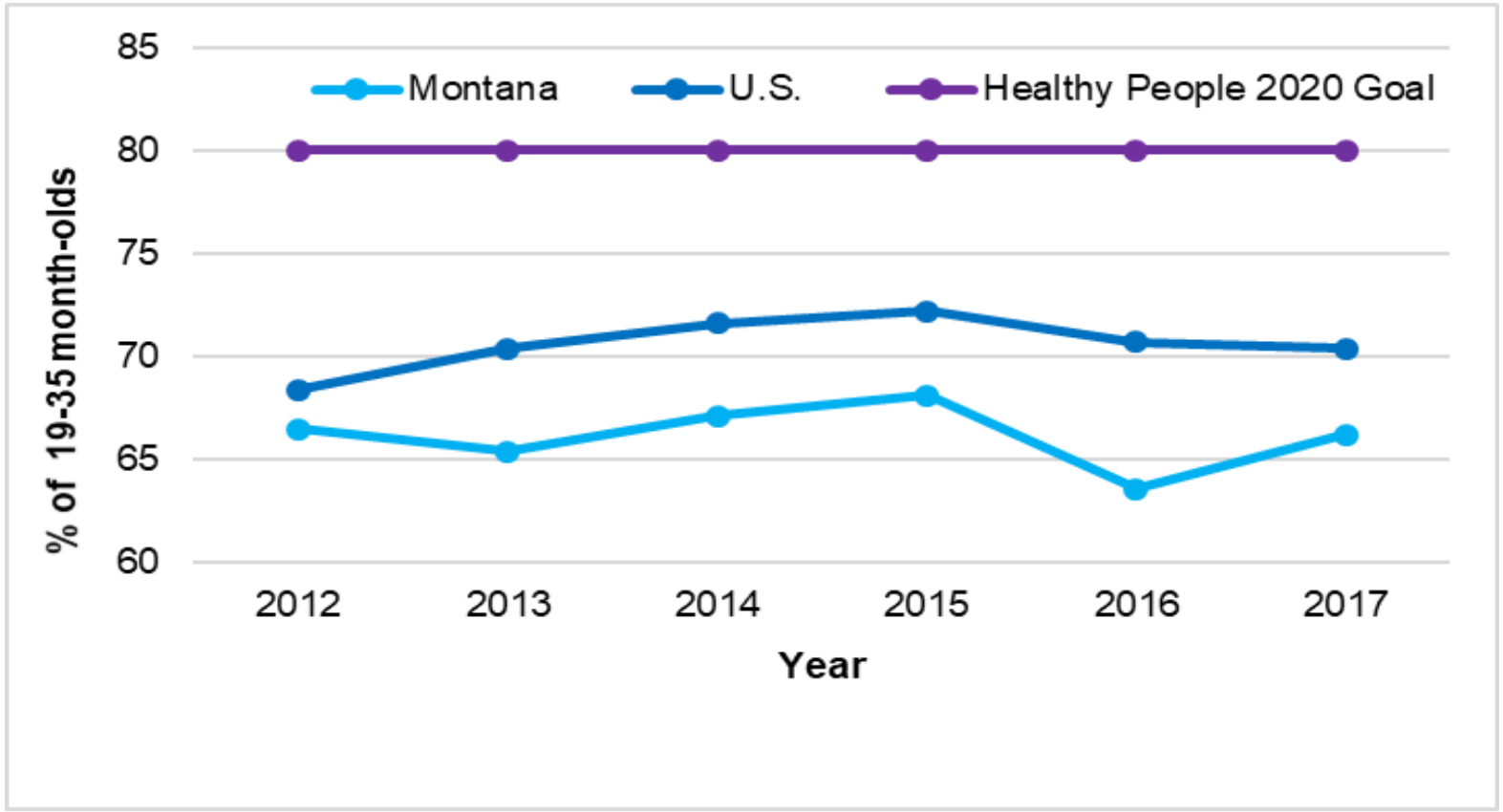
Completion of combined 7-vaccine series by age 24 months, U.S. children born 2015-2016



Source: CDC, NCRID, National Immunization Survey - Child.

Completion of combined 7-vaccine series among children ages 19-35 months,



Source: CDC, NCRID, National Immunization Survey - Child.

Barriers to vaccination

PARENTAL HESITANCY

- Getting some vaccines but not others
- Spreading out vaccines
- Following distinct alternative schedules

STRUCTURAL BARRIERS

- Lack of immunization providers
- Distance to providers
- Financial barriers
- Multiple visits needed to complete series

Goals

- Quantify timeliness and prevalence of specific patterns of undervaccination among Montana children ages 0-24 months

- Identify whether there are spatial clusters of specific patterns of undervaccination in the state

Study Team

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Data Source & Study Population

- **Data source**
  - Montana's Immunization Information System, ImMTrax
  - Limited variables in dataset
    - Age in days at vaccination
    - Geomasked address
- **Study population**
  - Children born in Montana in 2015-2017
  - At least one vaccine record after 1st birthday

Geomasking

- Random perturbation of spatial locations; “blurring” a patient’s address
- Scale of “blurring” differs in rural vs. urban areas
- Each geomasked location is indistinguishable from the nearest 100 individuals

Analyses: Combined 7-vaccine series

- ✓ 4 doses of **diphtheria-tetanus-acellular pertussis** (DTaP)
- ✓ 3 doses of **poliovirus**
- ✓ 1 dose of **measles-mumps-rubella** (MMR)
- ✓ 3 doses of **Hepatitis B** (HepB)
- ✓ 3 or 4 doses of ***Haemophilus influenzae*** **type b** (Hib)
- ✓ 1 dose **varicella**
- ✓ 4 doses of **pneumoccocal conjugate**

Analyses, cont.

- Compared vaccine **coverage** in ImMTrax with National Immunization Survey-Child (NIS-Child)
- **Timeliness** of vaccine receipt
  - Days undervaccinated
- Undervaccination **pattern**

Undervaccination patterns

PARENTAL HESITANCY

- Vaccine-limiting
- Selective vaccination

STRUCTURAL BARRIERS

- Started all series, missing doses
- Received all doses, some or all late

Robison et al. *Pediatrics* 2012
Hargeaves et al. *Pediatrics* 2020
Daley et al. *Acad Ped* 2018

Spatial scan analyses

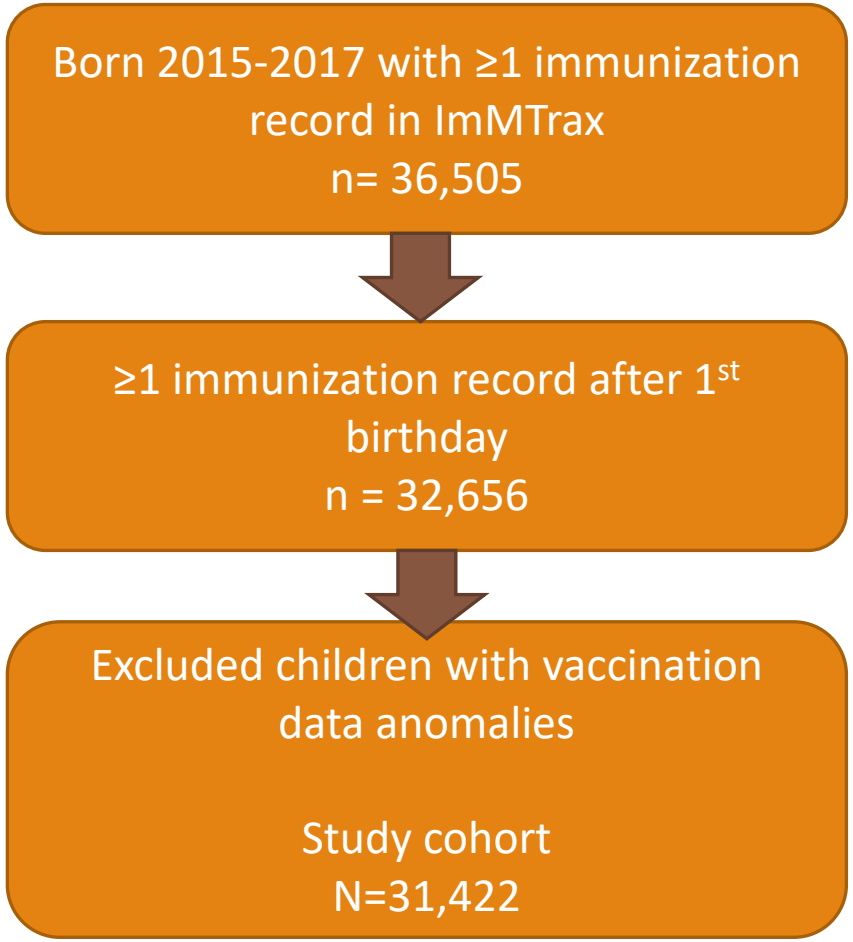
- Goal: identify geospatial clusters of >100 children who
  - Failed to complete combined 7-vaccine series by age 24 months
  - Had an undervaccination pattern consistent with vaccine hesitancy
  - Had an undervaccination pattern consistent with other structural barriers

Spatial scan analyses, cont.

- Scan circles of different sizes across a geographic area
- Compare the observed cases in the circle with the number of expected cases in the circle
- Calculate likelihood function
- Significance of cluster determined with Monte Carlo p-value

Kulldorff and Nagarwalla *Stat Med* 1995
Lieu et al. *Pediatrics* 2015

Results – Study cohort



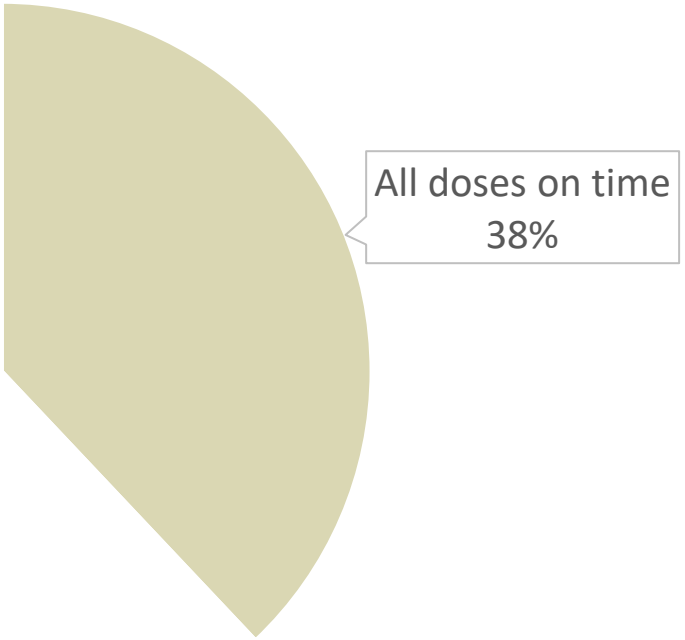
Newcomer et al. *Amer J Prev Med* 2021

Results – Vaccine coverage

Vaccine	Vaccine coverage by age 24 months in ImMTrax, children born 2015-2017 n=31,422	Vaccine coverage by age 24 months in National Immunization Survey-Child, Montana, children born 2015-2016[a] n=418
	% (95% CI)	**% (95% CI)**
Diphtheria-tetanus-acellular pertussis (DTaP), 4 doses	75.7% (75.2% - 76.2%)	73.0% (68.0% - 78.0%)
Poliovirus, 3 doses	89.8% (89.5% - 90.2%)	89.5% (85.2% - 93.8%)
Measles-mumps-rubella (MMR), 1 dose	91.1% (90.8% - 91.4%)	85.3% (80.3% - 90.3%)
Haemophilus Influenzae type b (Hib), 3 or 4 doses	76.6% (76.1% - 77.0%)	74.7% (69.0% - 80.4%)
Hepatitis B, 3 doses	90.3% (90.0% - 90.6%)	89.9% (85.6% - 94.2%)
Varicella, 1 dose	89.0% (88.6% - 89.3%)	84.9% (80.1% - 89.7%)
Pneumococcal conjugate, 4 doses	77.0% (76.5% - 77.5%)	78.0% (72.3% - 83.7%)
Combined 7-vaccine series	**62.3% (61.8% - 62.8%)**	**61.7% (55.2% - 68.2%)**

Newcomer et al. *Amer J Prev Med* 2021

Patterns of undervaccination



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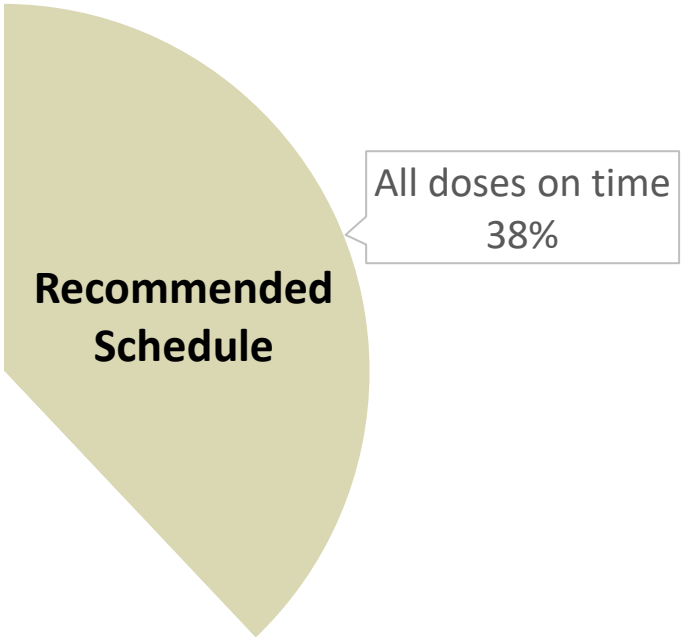

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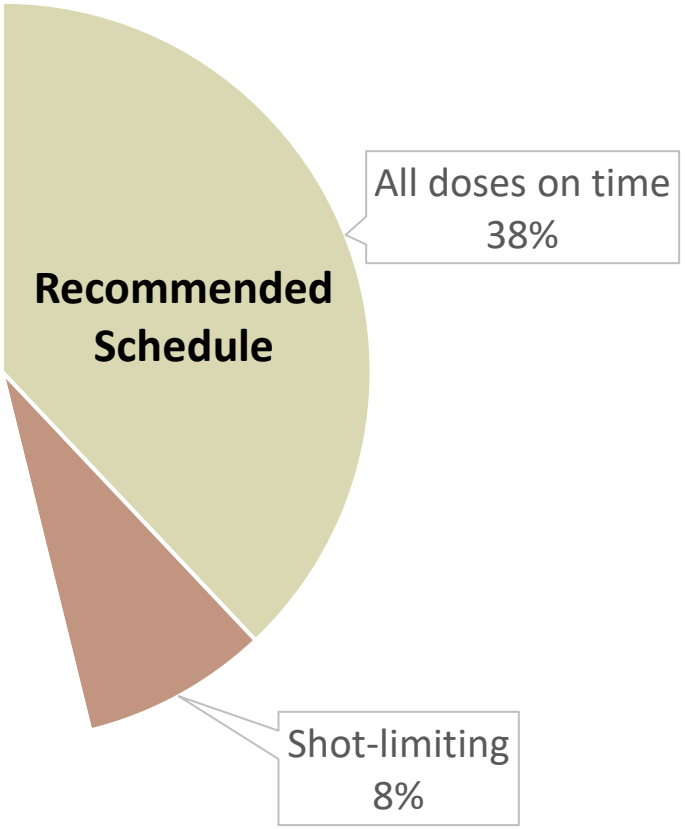

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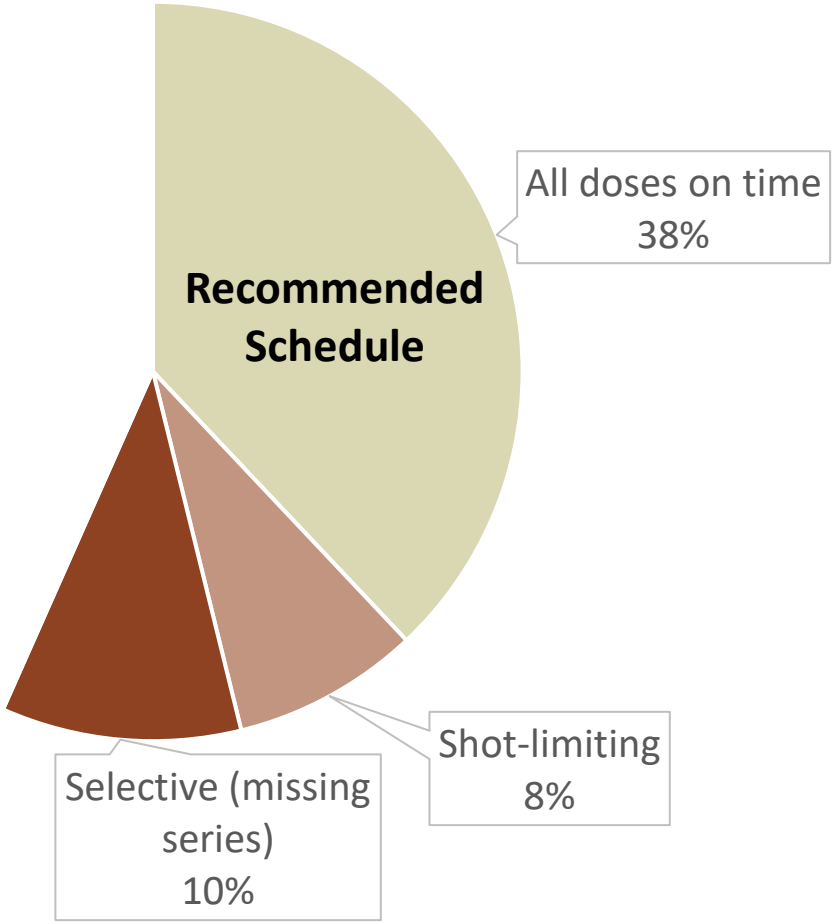

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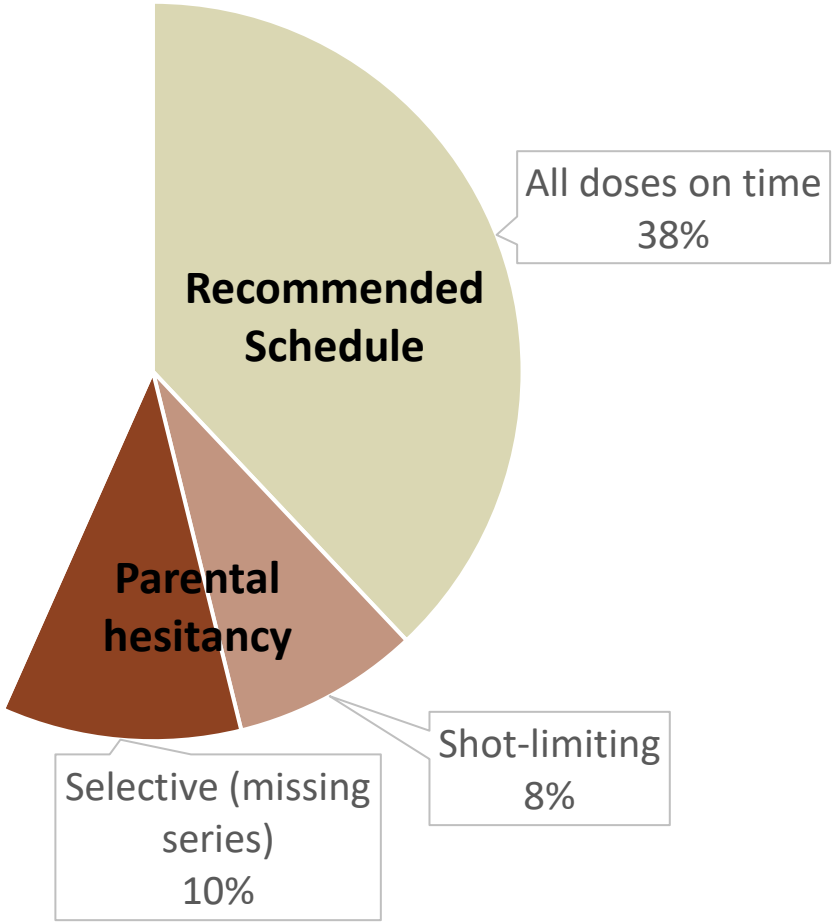

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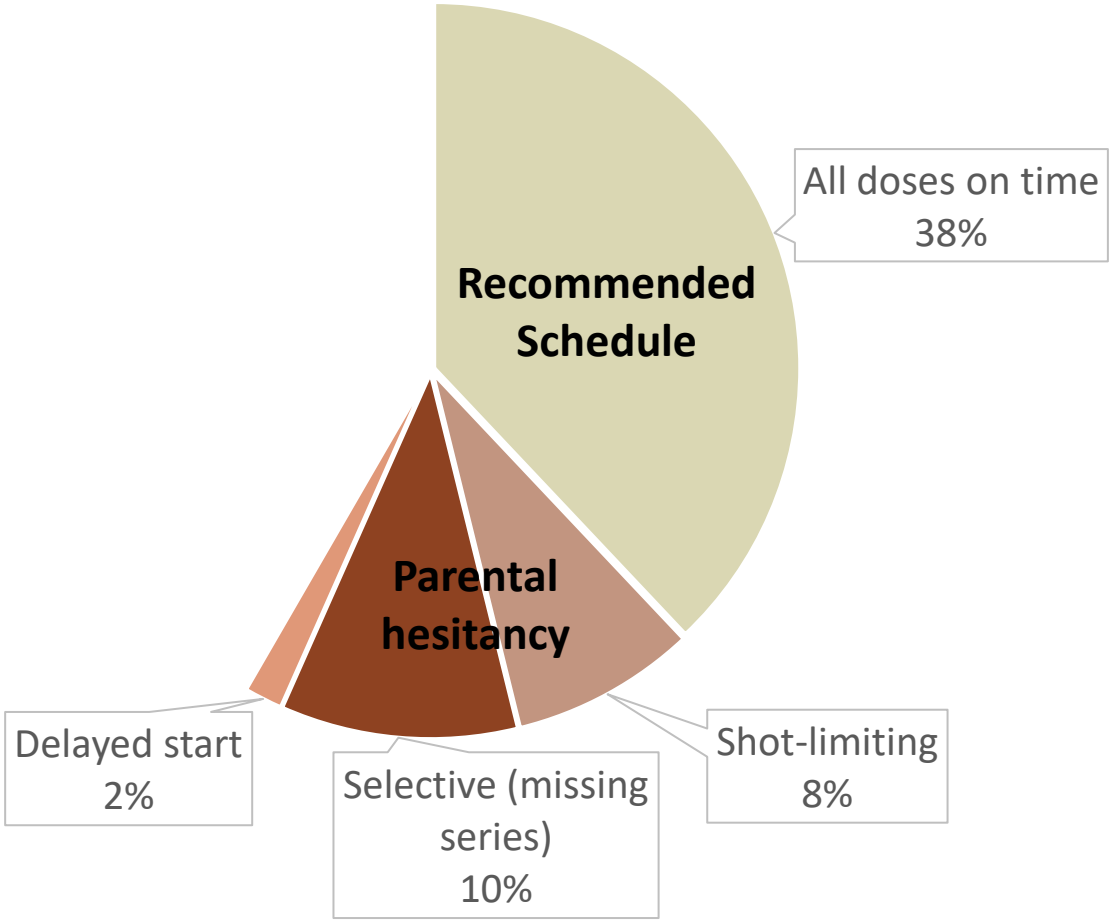

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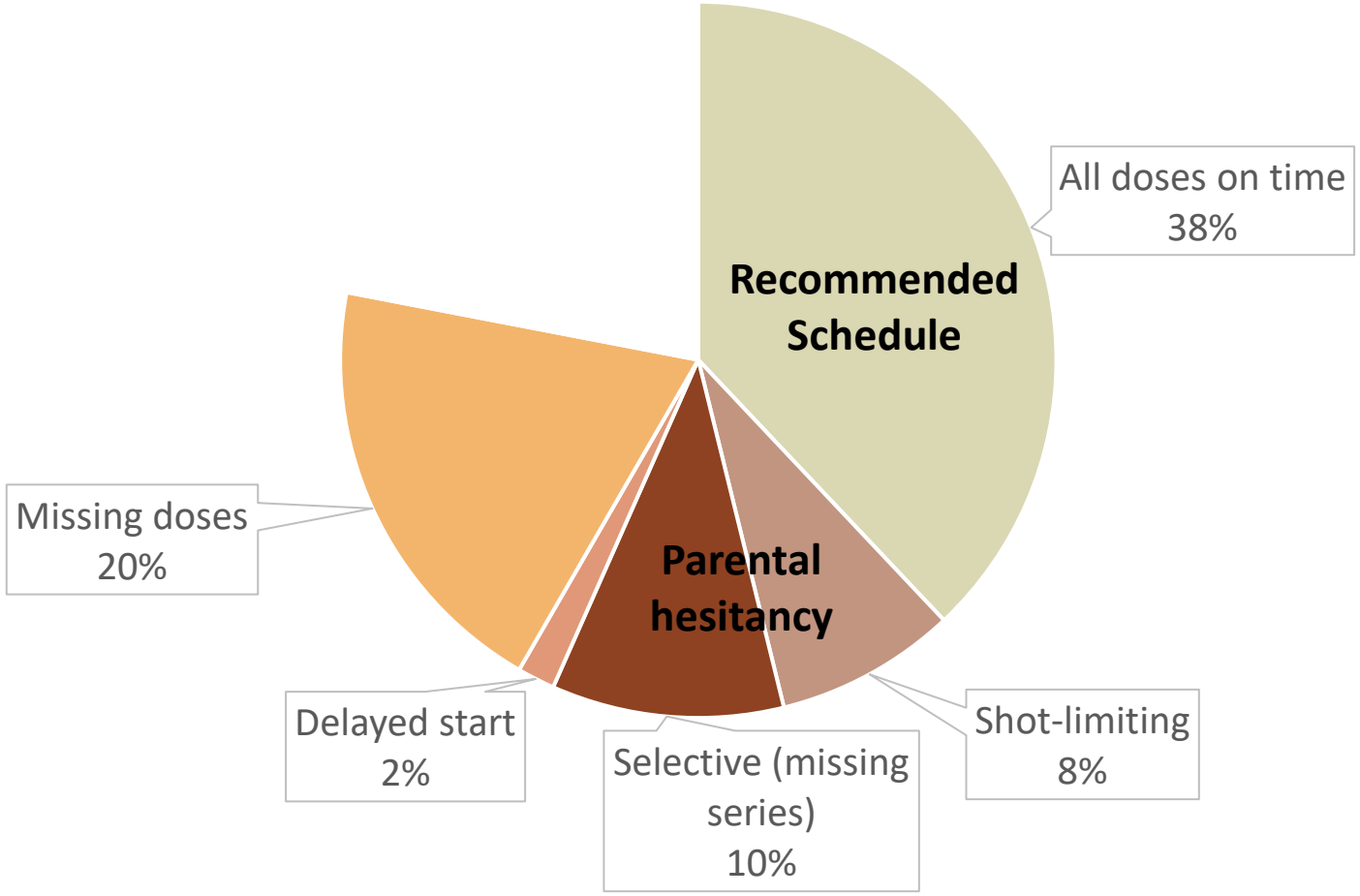

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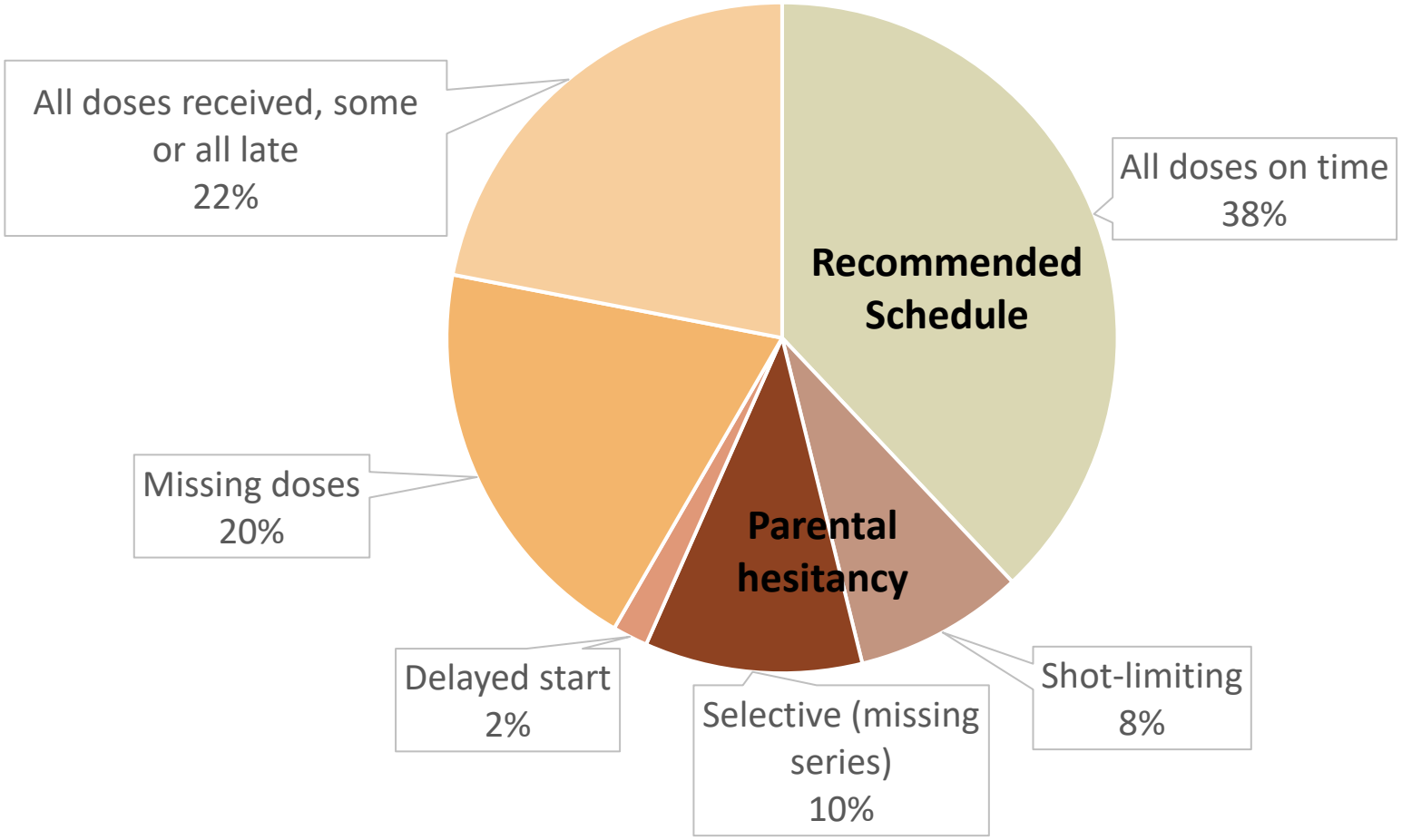

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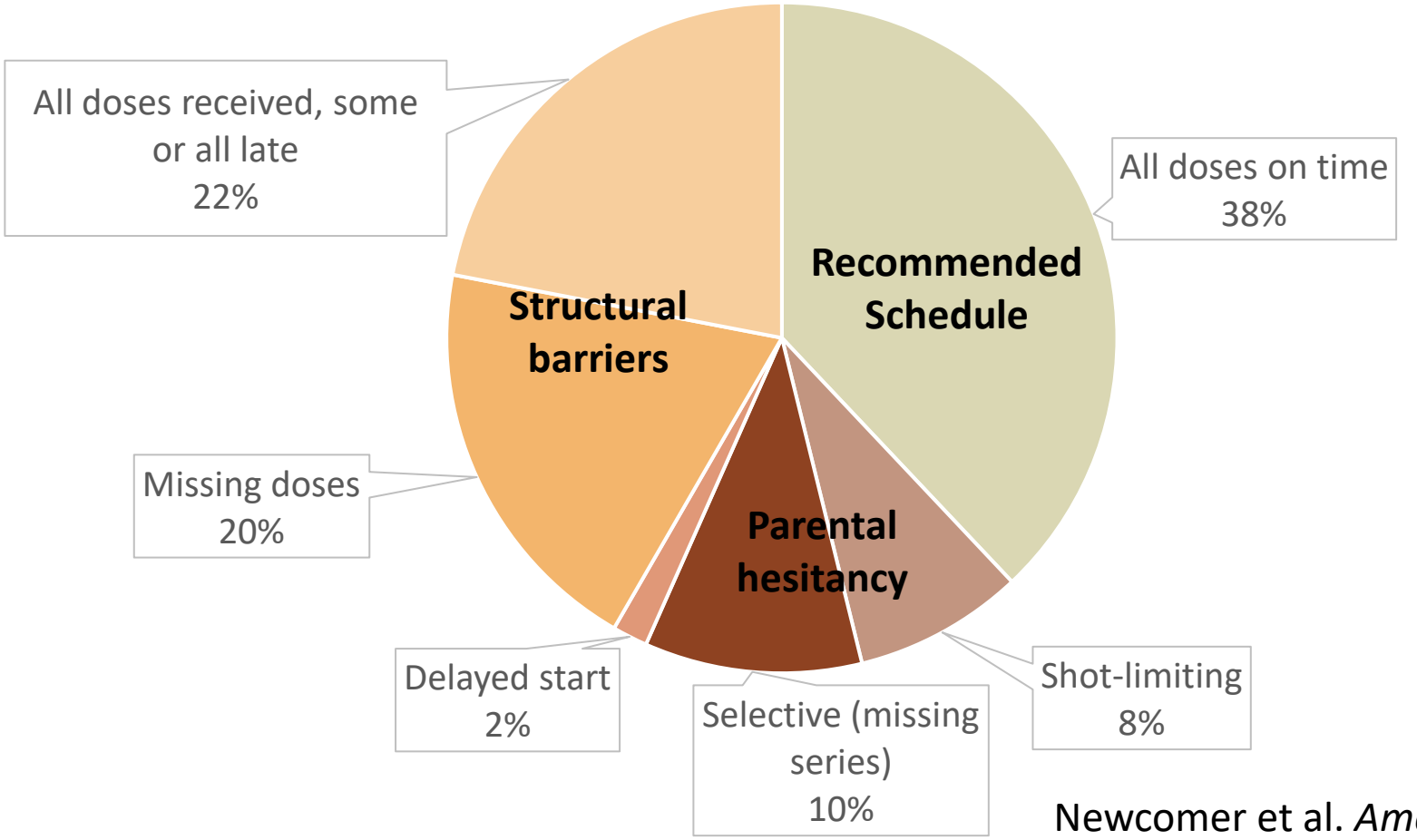

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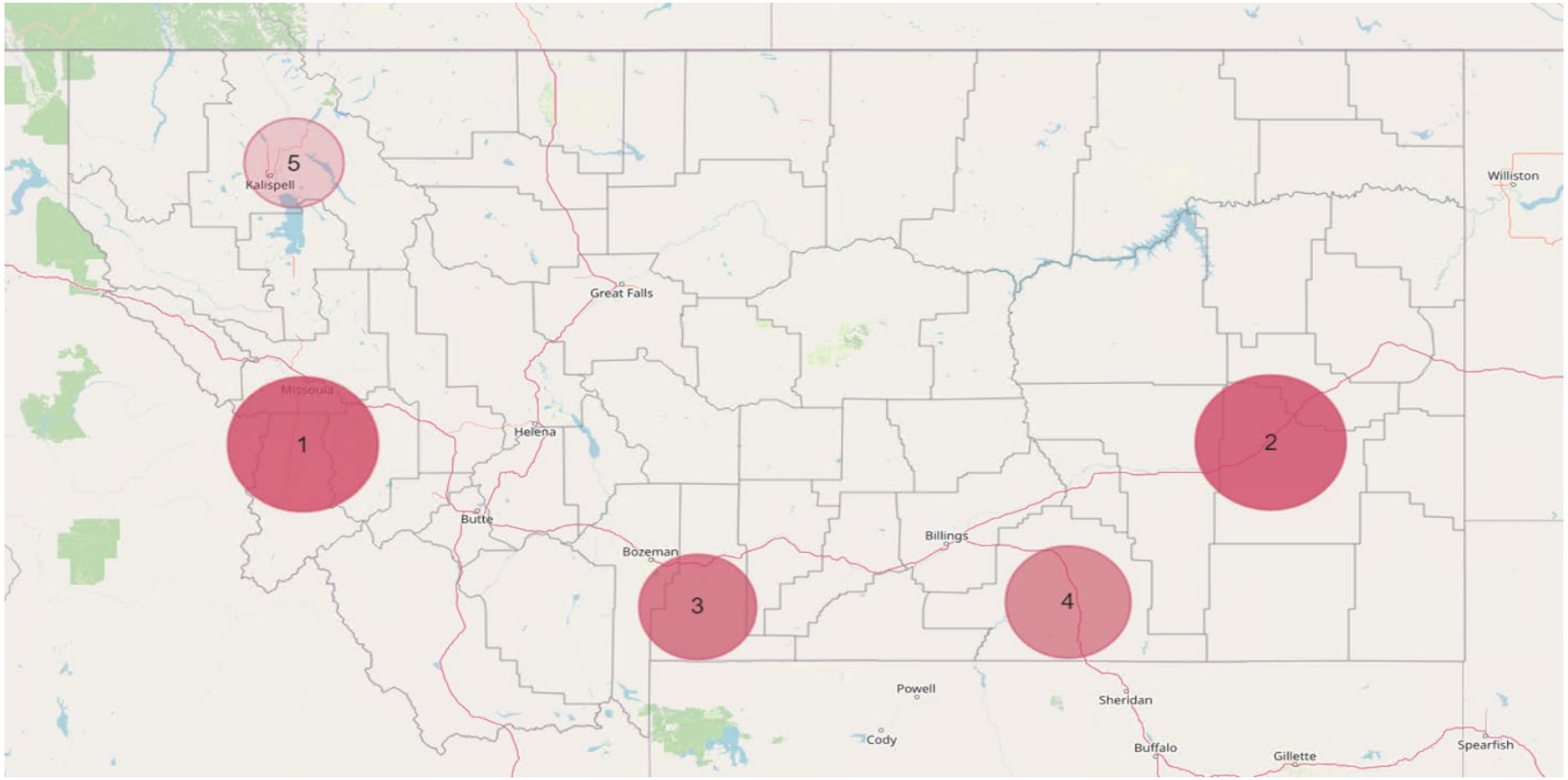
Spatial clusters

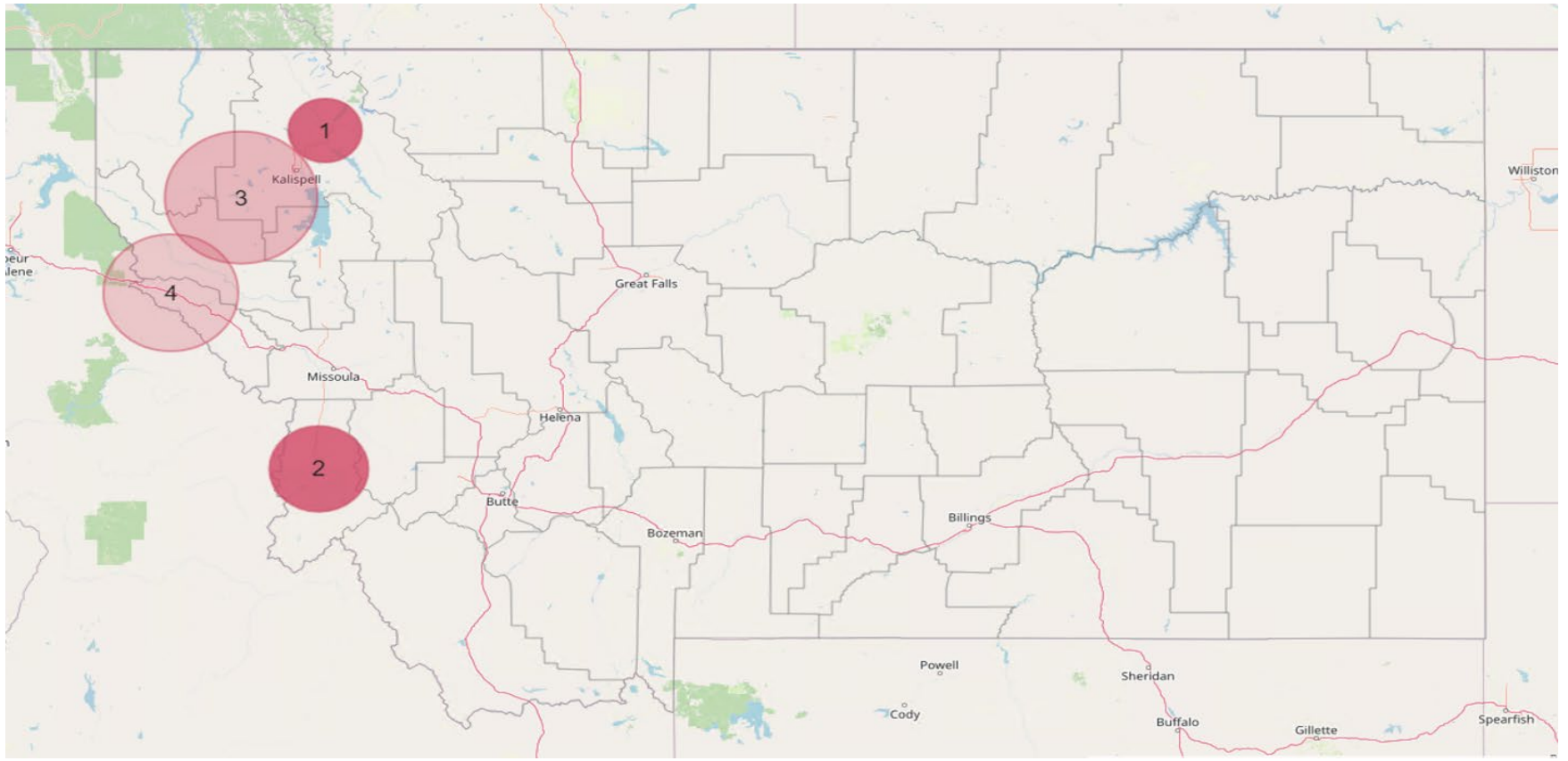
Failure to complete combined 7-vaccine series by age 24 months



Failure to complete combined 7-vaccine series by age 24 months

Cluster	Radius in miles	P-value	Observed number of cases	Expected number of cases	Relative Risk	Population Size of Cluster
1	49.41	$<10^{-14}$	1509	1247	1.24	3322
2	49.57	$<10^{-13}$	262	165	1.61	437
3	39.23	$<10^{-8}$	209	135	1.56	359
4	41.77	$<10^{-7}$	313	223	1.42	593
5	31.91	.002	1190	1046	1.15	2787

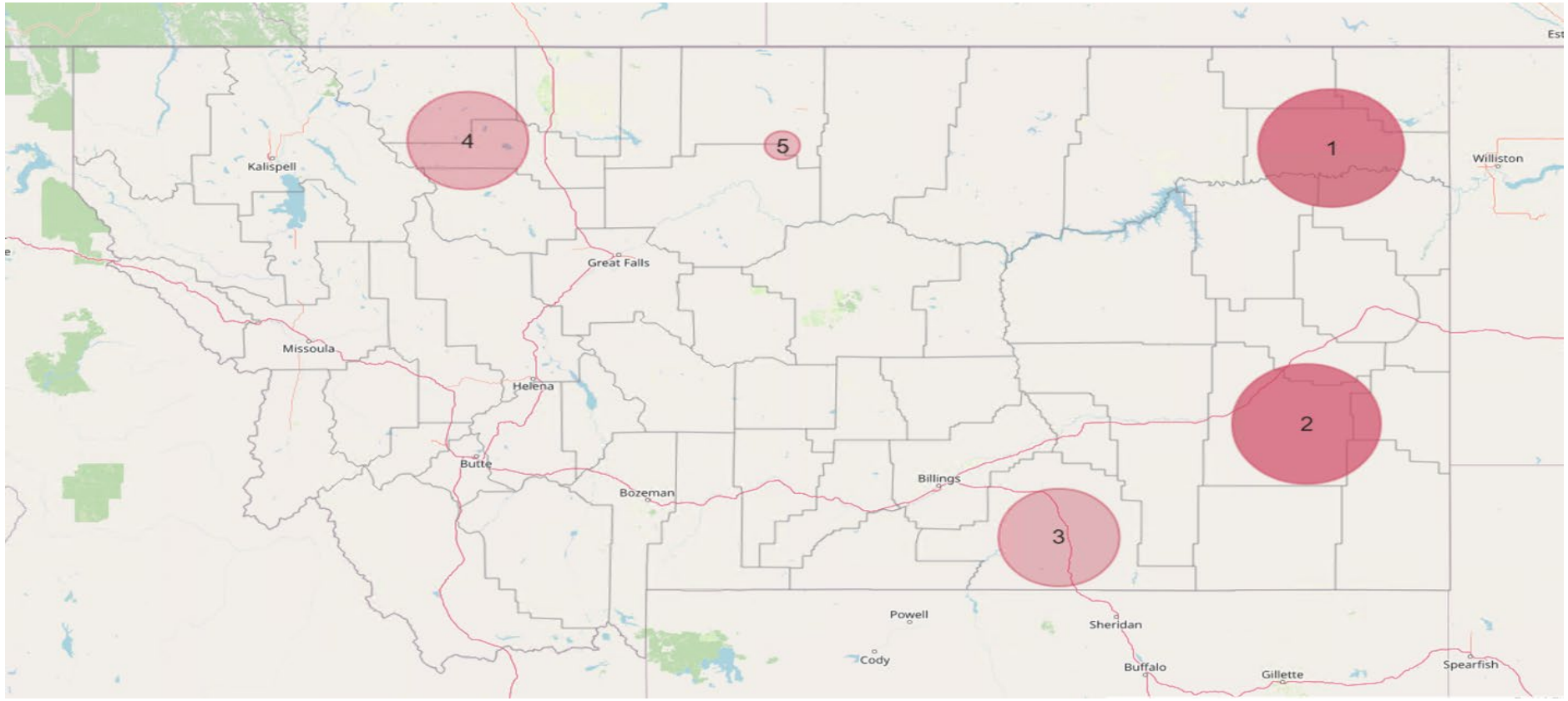
Undervaccination patterns indicative of vaccine hesitancy



Undervaccination patterns indicative of vaccine hesitancy

Cluster	Radius in miles	P-value	Observed number of cases	Expected number of cases	Relative Risk	Population Size of Cluster
1	23.65	$<10^{-16}$	316	142	2.30	762
2	32.92	$<10^{-16}$	192	95	2.06	508
3	48.93	.0001	466	359	1.33	1925
4	43.86	.0016	66	33	2.00	178

Undervaccination patterns indicative of structural barriers



Undervaccination patterns indicative of structural barriers

Cluster	Radius in miles	P-value	Observed number of cases	Expected number of cases	Relative Risk	Population Size of Cluster
1	47.56	$<10^{-8}$	301	213	1.43	511
2	49.54	$<10^{-8}$	247	169	1.47	405
3	41.53	$<10^{-4}$	296	222	1.34	533
4	39.10	$<10^{-4}$	285	213	1.35	512
5	11.00	.0001	143	96	1.50	230

Key findings

- Fewer than 2 in 5 Montana children receive all recommended vaccines on-time before their 2nd birthday
- Around 18% of children have a pattern of undervaccination consistent with vaccine hesitancy
- Approximately 1 in 5 Montana children are missing doses needed to complete vaccine series

Key findings, cont.

- Significant spatial clusters were identified:
  - Vaccine hesitancy → Western Montana
  - Other structural barriers → Eastern Montana

Implications

- Interventions to increase vaccination rates fundamentally differ across these two sets of barriers
- IIS-based analyses can aid in targeting the right intervention to the right population

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