



Figures and figure supplements

The impact of measles immunization campaigns in India using a nationally representative sample of 27,000 child deaths

Benjamin KC Wong *et al*

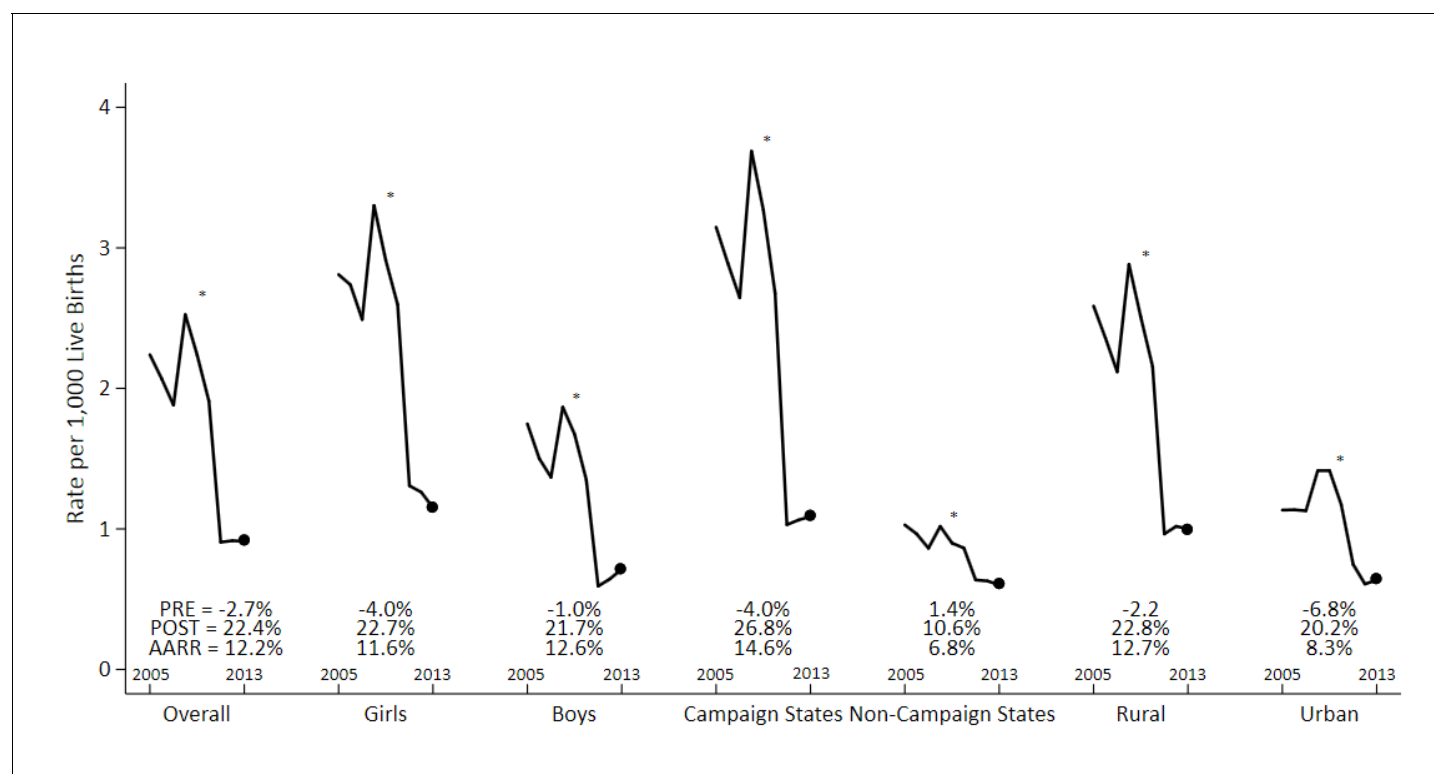


Figure 1. Measles mortality rates and average annual rate reduction among 1–59 month-old children by sex, campaign states, and residence, India, 2005–2013. The measles case definition attributed a death to measles if at least one physician assigned measles as the cause of death or if the respondent reported the deceased child to have a history of measles (using the local language term). Mortality rates were calculated using 3 year moving averages of weighted proportions applied to UN deaths and live births estimates for India. Campaign states include: Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Rajasthan, Tripura, and Uttar Pradesh. Non-campaign states include all other states and union territories. * indicates the year 2010. PRE = average annual rate reduction pre-intervention. POST = average annual rate reduction post-intervention. AARR = average annual rate reduction overall.

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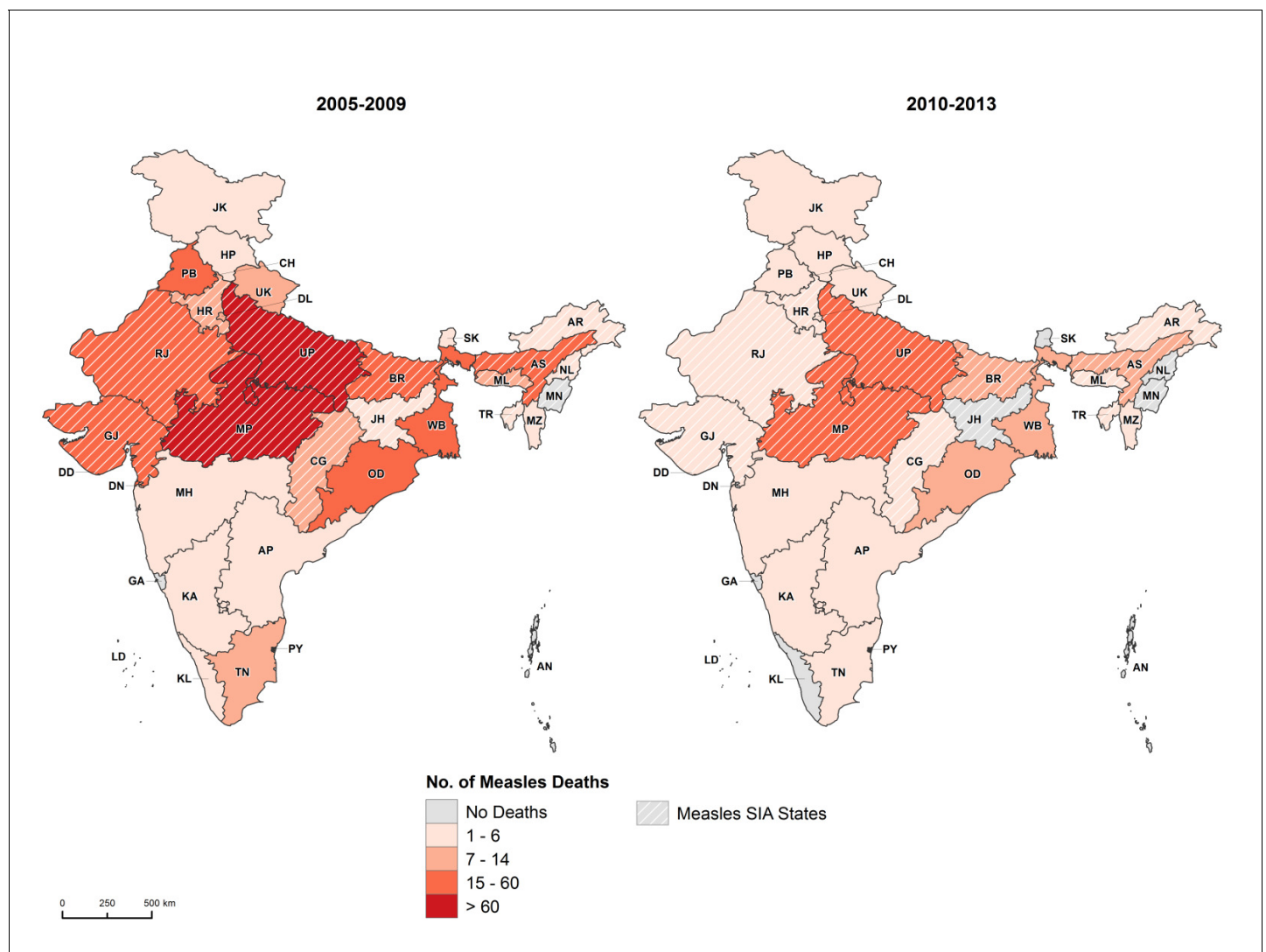


Figure 1—figure supplement 1. State-level distribution of 1–59 month measles deaths before and after measles campaign launch, India, 2005–2013. Cross-hatched regions represent campaign states. AN = Andaman and Nicobar Islands. AP = Andhra Pradesh. AR = Arunachal Pradesh. AS = Assam. BR = Bihar. CH = Chandigarh. CG = Chhattisgarh. DD = Daman and Diu. DN = Dadra and Nagar Haveli. DL = Delhi. GA = Goa. GJ = Gujarat. HP = Himachal Pradesh. HR = Haryana. JH = Jharkhand. JK = Jammu and Kashmir. KA = Karnataka. KL = Kerala. LD = Lakshadweep. MH = Maharashtra. ML = Meghalaya. MN = Manipur. MP = Madhya Pradesh. MZ = Mizoram. NL = Nagaland. OD = Odisha. PB = Punjab. PY = Puducherry. RJ = Rajasthan. SK = Sikkim. TN = Tamil Nadu. TR = Tripura. UP = Uttar Pradesh. UT = Uttarakhand. WB = West Bengal. National Health Mission states represent 18 states identified as having poor health infrastructure and low public health spending including: Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Jammu and Kashmir, Manipur, Mizoram, Meghalaya, Madhya Pradesh, Nagaland, Odisha, Rajasthan, Sikkim, Uttarakhand, Uttar Pradesh, and Tripura. Empowered Action Group (EAG) states represent eight poor states lagging in socioeconomic indicators in India including: Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttarakhand, and Uttar Pradesh.

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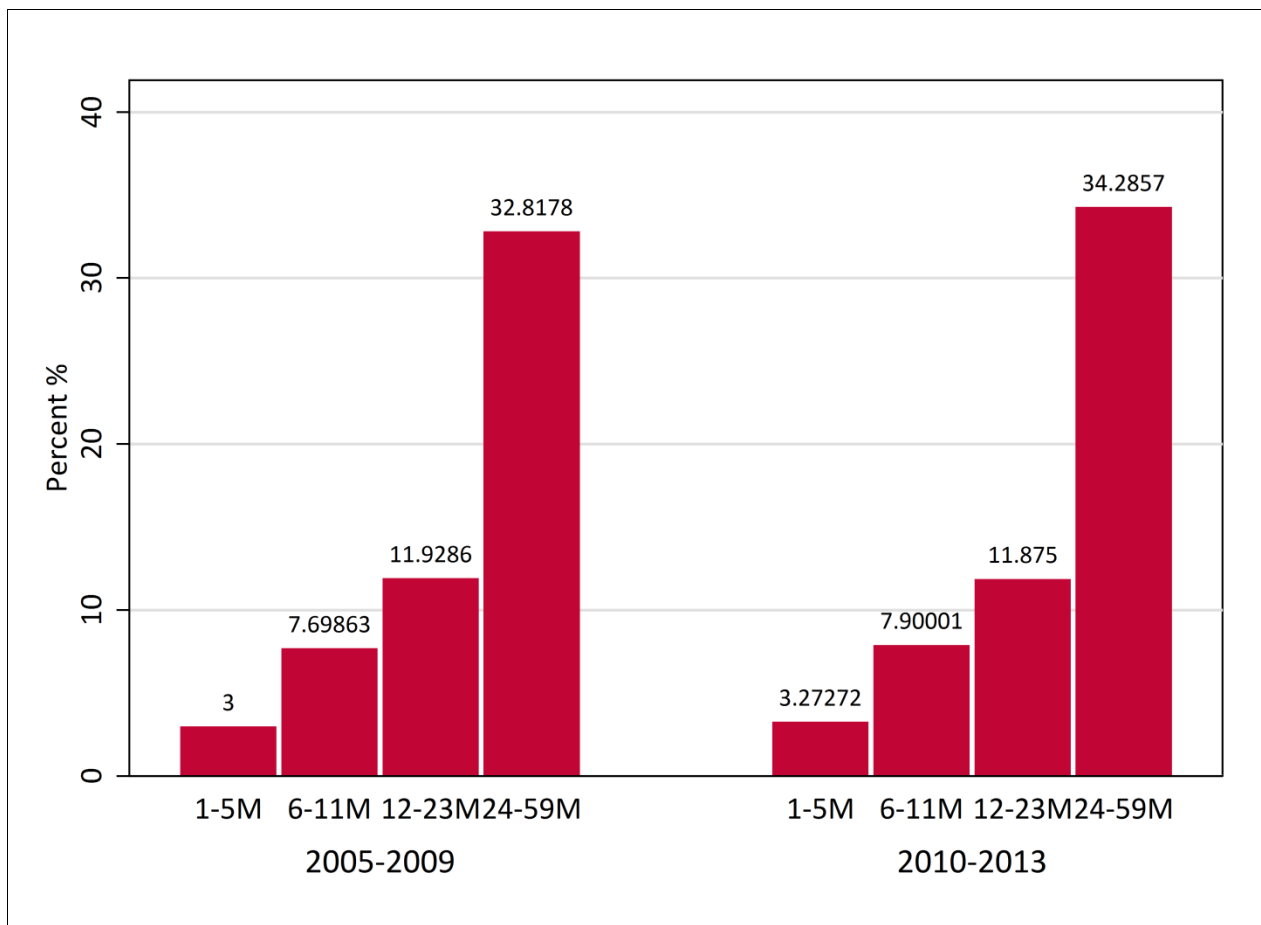


Figure 1—figure supplement 2. Proportion of measles deaths by age at death (months) among children aged 1–59 months, 2005–2009 versus 2010–2013, India.

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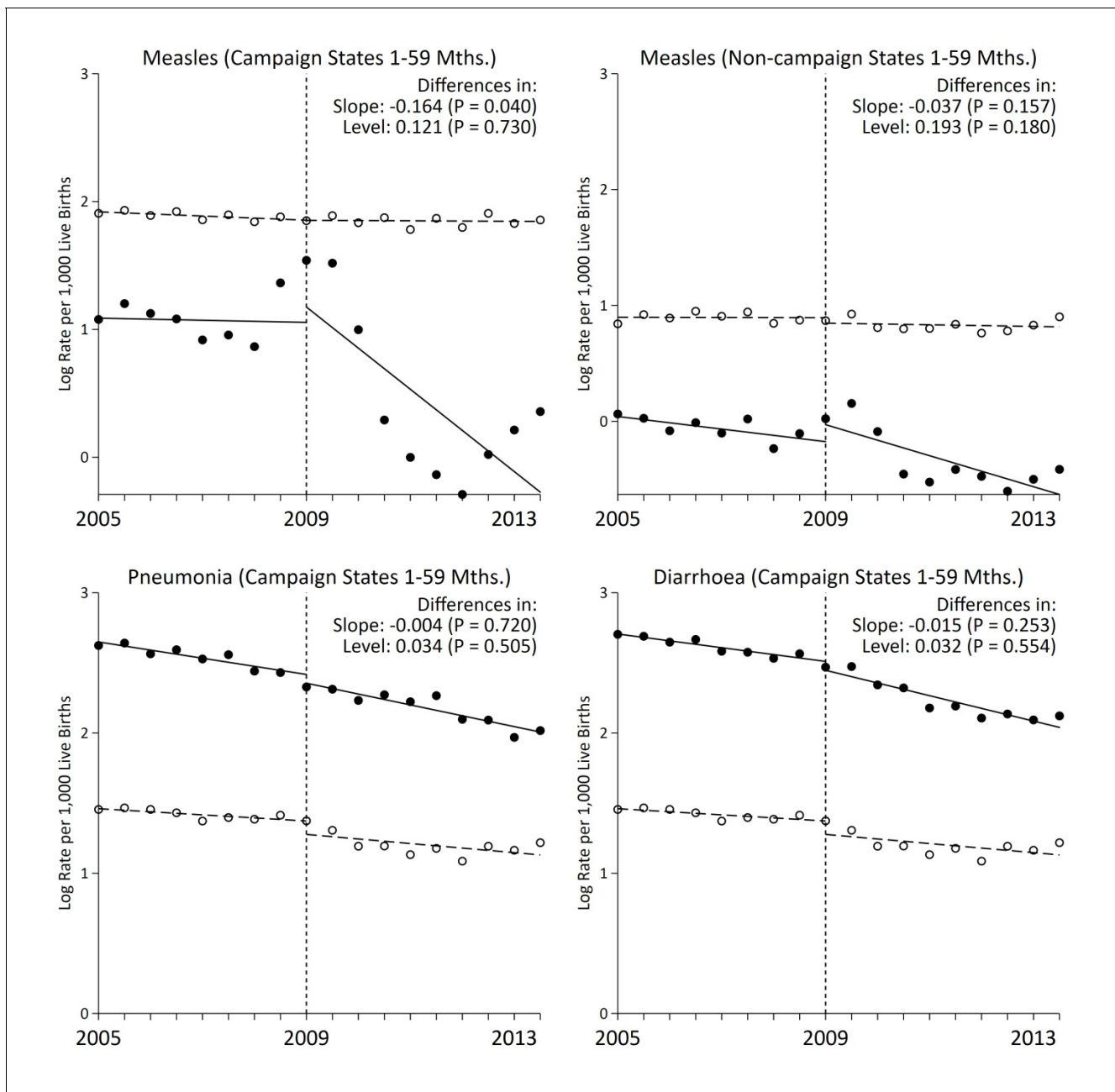


Figure 2. Interrupted time-series analysis on measles, pneumonia, and diarrhoea mortality (black) and control mortality (white) among 1–59 month-old children during the measles campaign in India, 2005–2013. Refer to **Figure 1** for the definition of measles deaths. Control deaths were selected based on comparability of their pre-intervention trends to trends for measles. For measles in campaign states and non-campaign states, control deaths were injuries, non-communicable diseases, or congenital anomalies. For pneumonia ($n = 4,403$) and diarrhoea ($n = 3,468$) deaths in campaign states, control deaths were non-communicable diseases or congenital anomalies. Difference in slope represents the difference in pre-post trends between the measles and control deaths. Difference in level represents the difference between the level of measles and control mortality rates immediately following campaign launch. We observed no significant difference when comparing pre-intervention trends for the control deaths to the deaths from measles, pneumonia, or diarrhoea in the campaign states, or to measles deaths in the non-campaign states ($p > 0.1$ for all four comparisons).

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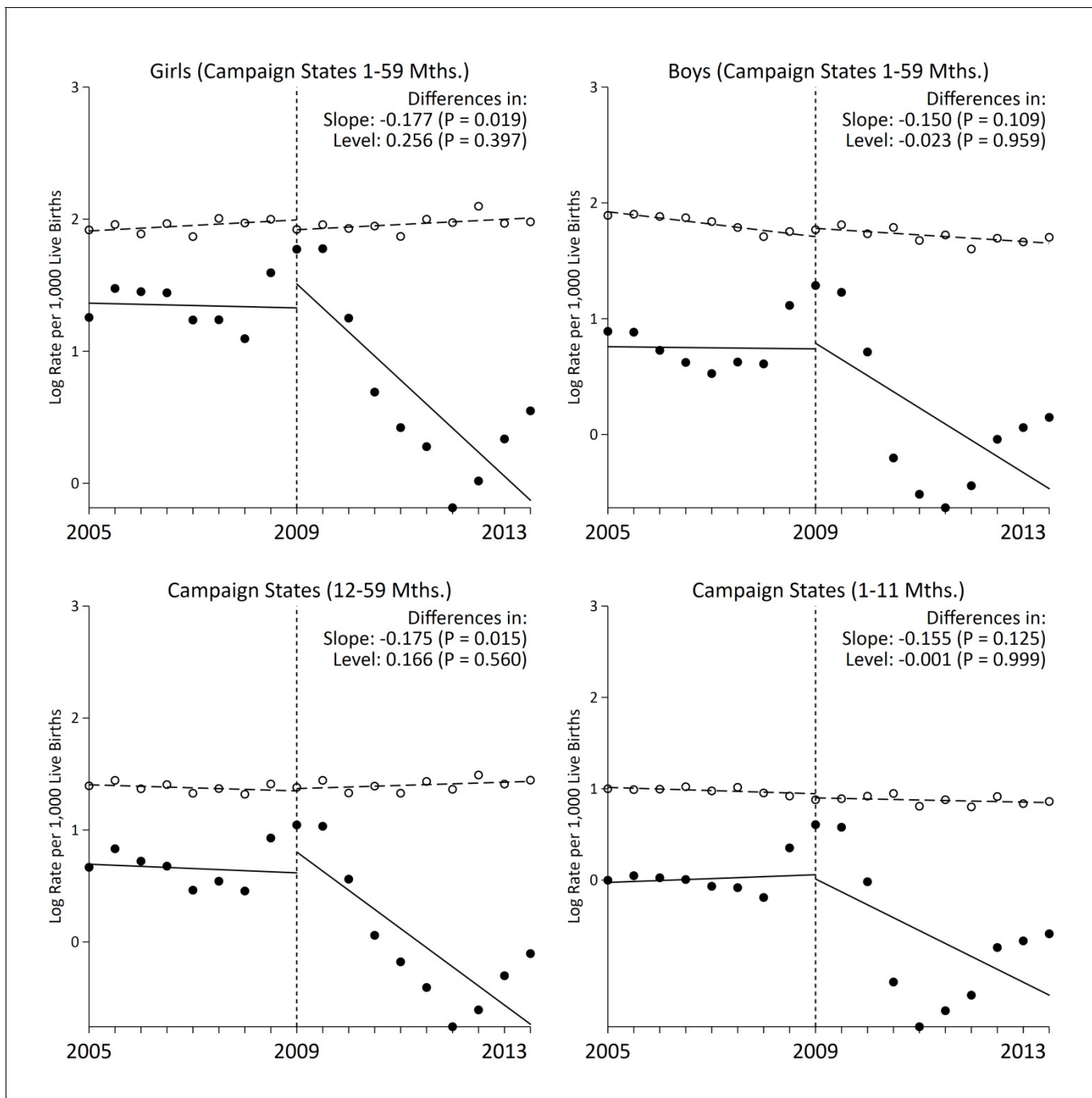


Figure 3. Stratified analysis of interrupted time-series models on measles mortality (black) versus control mortality (white) among 1–59 month-old children, India. The measles case definition attributed a death to measles if at least one physician assigned measles as the cause of death or if the respondent reported the deceased child to have a history of measles (using the local language term). Control deaths were selected based on comparability of pre-intervention trends to trends for measles. Control deaths were injuries, non-communicable diseases, or congenital anomalies.

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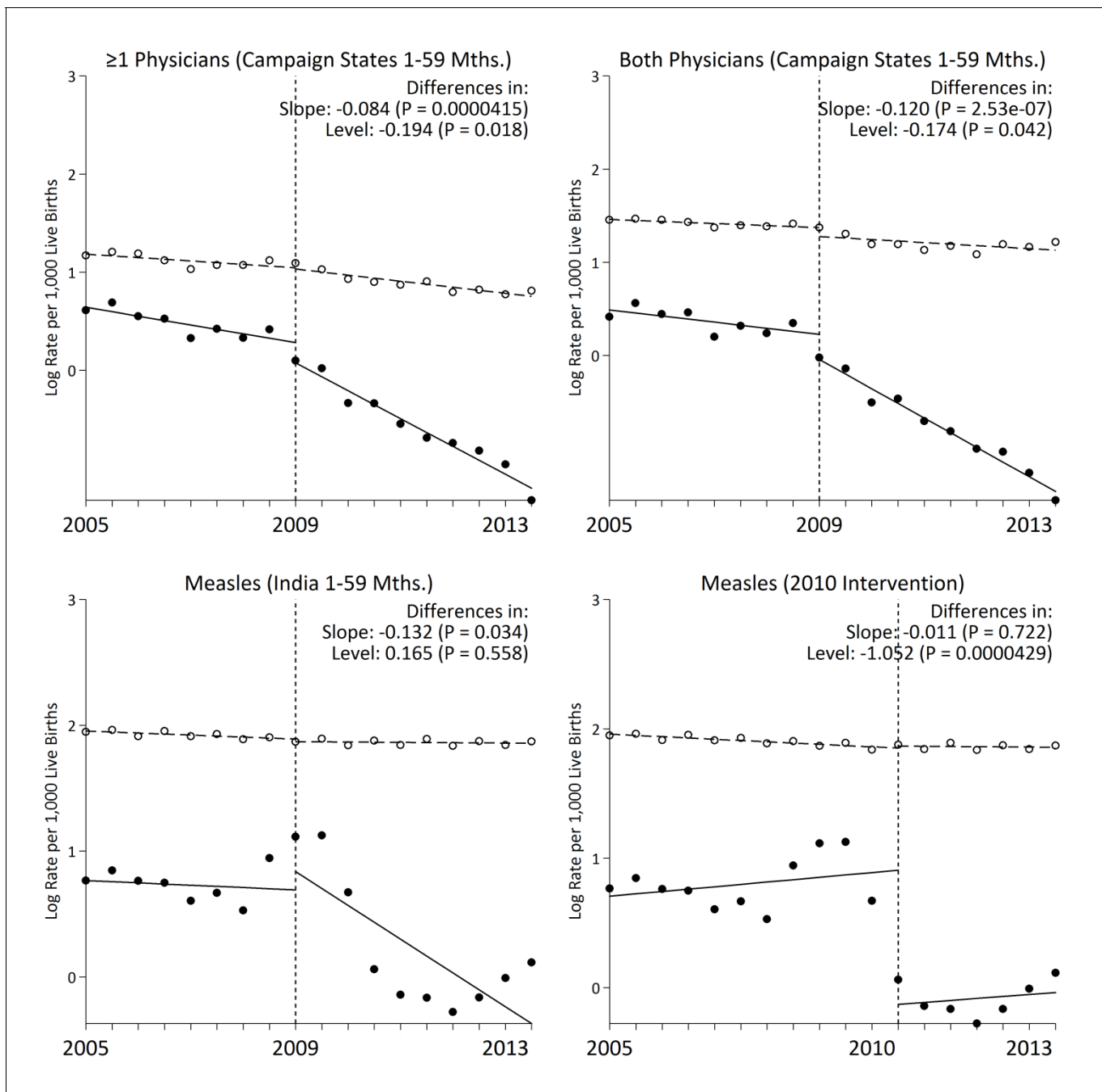


Figure 4. Interrupted time-series models on measles mortality (black) versus control mortality (white) among 1–59 month-old children using alternate measles definitions, India. We present two narrower measles definitions of one or more physician coding and both physician coding of measles. All other control deaths were injuries, non-communicable diseases, or congenital anomalies. Control deaths were selected based on comparability of pre-intervention trends to trends for measles. For both physicians and at least one physician coding measles, control deaths were congenital anomalies or non-communicable diseases. We observed no significant difference when comparing pre-intervention trends for the control deaths to those for case deaths based on the narrower definitions of at least one physician coding measles and both physicians coding measles ($p > 0.4$ for both comparisons).

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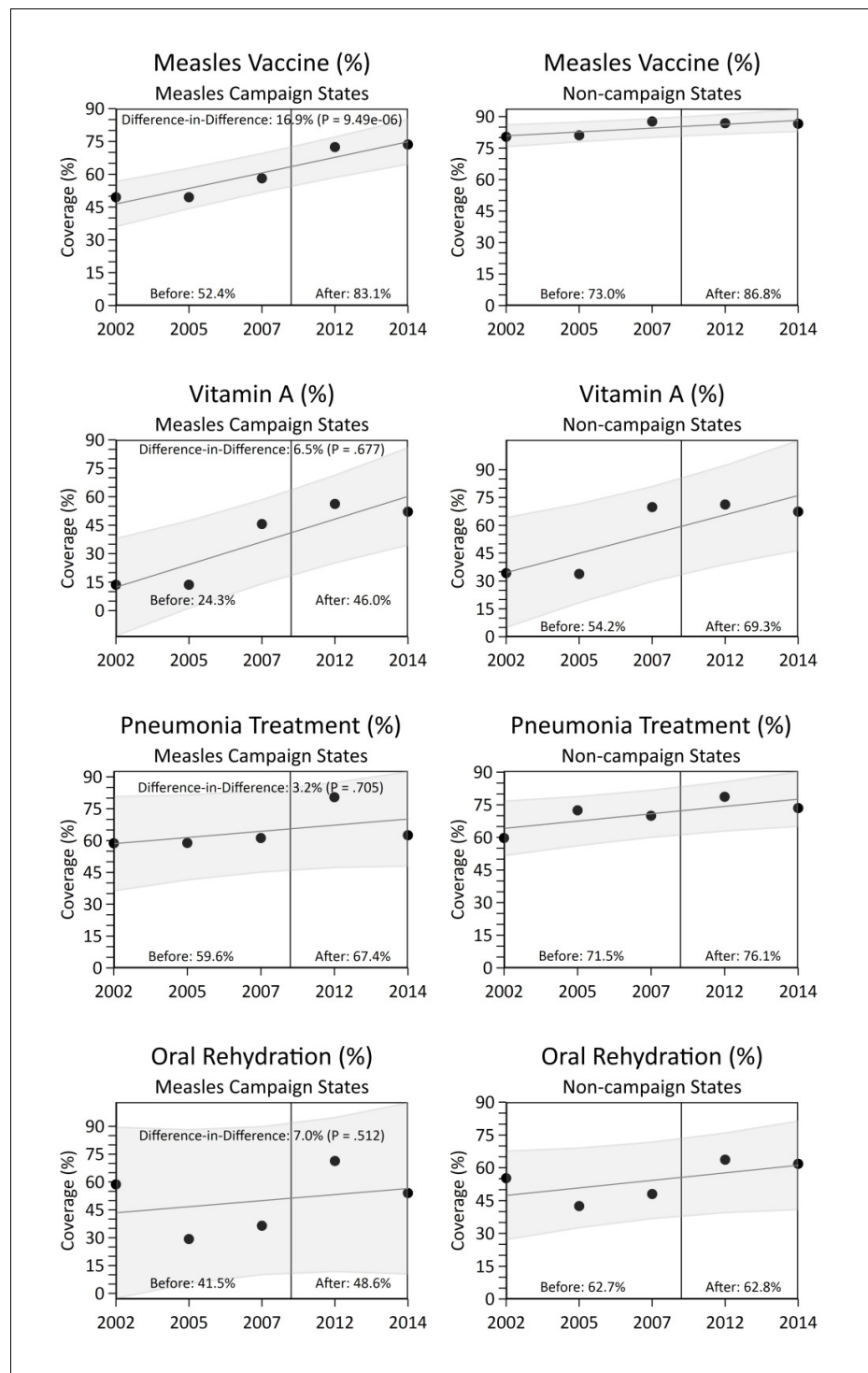


Figure 5. National coverage estimates of child immunization, maternal literacy, and oral rehydration supplementation by measles campaign states, India, 2005–2013. Estimates were obtained from the National Family Health Survey and the District Level Household and Facility Survey through 2002 to 2014. Measles vaccination coverage was defined as the percentage of children aged 12 to 23 months receiving any measles vaccine from routine immunization. The difference-in-difference test reports the change in coverage estimates before and after campaign launch in campaign states versus non-campaign states. We observed no significant change in coverage estimates between campaign states versus non-campaign states for maternal literacy and diarrhoea treatment-seeking (data not shown).

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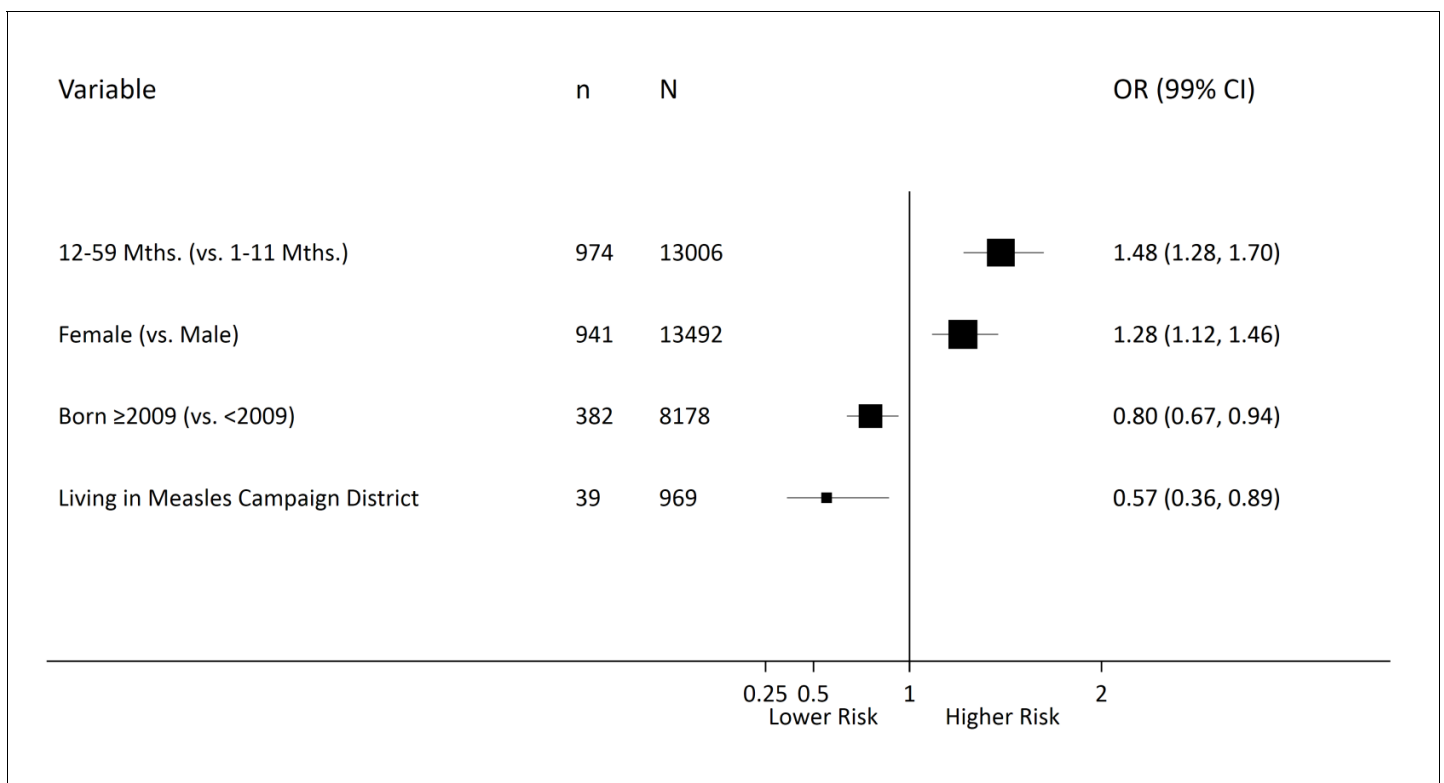


Figure 6. Multilevel logistic regression analysis of measles mortality among 1–59 month children, India, 2005–2013. N = number of observations; n = number of measles deaths. Living in a campaign district was assigned based on the individual's date of birth and the month when a particular district launched campaigns. The models were fitted with random intercepts by state and district and were adjusted for urban/rural residence, measles vaccination coverage, vitamin A supplementation, oral rehydration supplementation, maternal literacy, pneumonia treatment-seeking, and diarrhoea treatment-seeking. Effect estimates are weighted by their inverse-variance. There was significant variation in measles mortality odds across districts ($\tau = 0.094$) and across states ($\tau = 0.147$). Residual heterogeneity between regions remained significant after adjustment – the median odds ratio was 1.28 at the district level and 1.43 at the state level, while the intra-class correlation was 6.8% at the district level and 4.2% at the state level.

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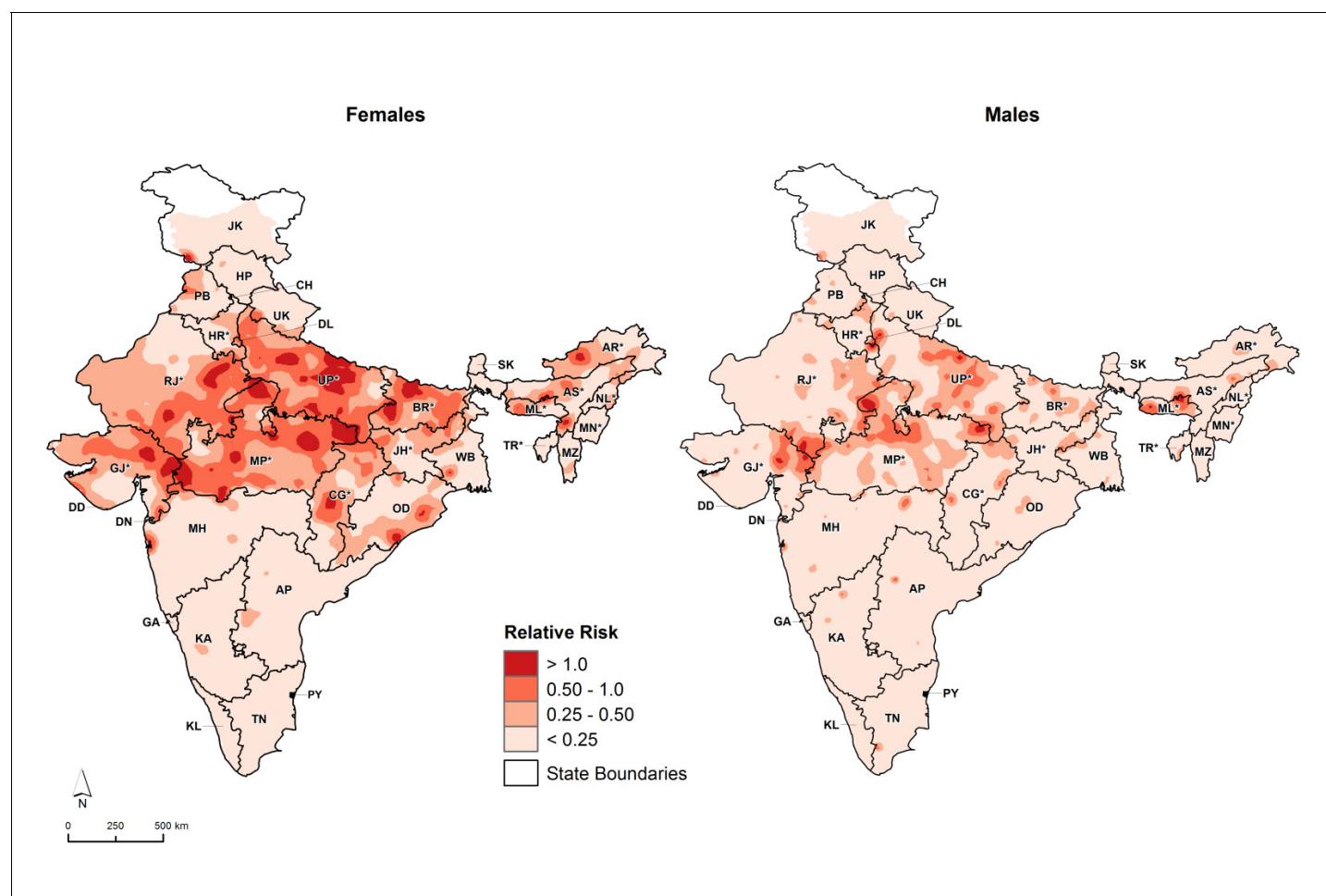


Figure 7. Distribution of 1–59 month measles mortality risk (relative to all-cause mortality) by sex, India, 2005–2013. We fitted maps using a generalized linear geostatistical model with integrated nested Laplace approximations adjusted for children living in campaign districts and urban/rural residence. * denotes campaign states. AN = Andaman and Nicobar Islands. AP = Andhra Pradesh. AR* = Arunachal Pradesh. AS* = Assam. BR* = Bihar. CH = Chandigarh. CG* = Chhattisgarh. DD = Daman and Diu. DN = Dadra and Nagar Haveli. DL = Delhi. GA = Goa. GJ* = Gujarat. HP = Himachal Pradesh. HR* = Haryana. JH* = Jharkhand. JK = Jammu and Kashmir. KA = Karnataka. KL = Kerala. LD = Lakshadweep. MH = Maharashtra. ML* = Meghalaya. MN* = Manipur. MP* = Madhya Pradesh. MZ = Mizoram. NL* = Nagaland. OD = Odisha. PB = Punjab. PY = Puducherry. RJ* = Rajasthan. SK = Sikkim. TN = Tamil Nadu. TR* = Tripura. UP* = Uttar Pradesh. UT = Uttarakhand. WB = West Bengal. Refer to **Figure 1—figure supplement 1** for the description of NHM and EAG states.

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