

# THE LANCET Infectious Diseases

## Supplementary webappendix

This webappendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Nic Lochlainn LM, de Gier B, van der Maas N, et al. Immunogenicity, effectiveness, and safety of measles vaccination in infants younger than 9 months: a systematic review and meta-analysis. *Lancet Infect Dis* 2019; published online Sept 20. [https://doi.org/10.1016/S1473-3099\(19\)30395-0](https://doi.org/10.1016/S1473-3099(19)30395-0).

**Supplementary webappendix for:**

**Immunogenicity, effectiveness, and safety of measles vaccination in infants younger than 9 months: a systematic review and meta-analysis**

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## Database search strategy

**Table 1: Database search strategy, search conducted 2 June 2015 and updated 14 January 2019**

Database	Strategy
<b>PubMed, MEDLINE</b>	<p>1 ((measles[ti] OR mmr*[ti] OR schwarz[ti] OR moraten[ti] OR edmonston[ti] OR edmonston-zagreb[ti] OR Leningrad-16[ti] OR Shanghai-191[ti] OR CAM-70[ti] OR AIK-C[ti] OR TD97[ti]) AND (vaccine*[ti] OR vaccination*[ti] OR immunization*[ti] OR immunisation*[ti])) OR (mr vaccine*[ti] OR mmrv[ti]) 4.787</p> <p>2 "measles vaccine"[mj] OR "measles-mumps-rubella vaccine"[mj] OR ("measles vaccine"[mh] AND ("vaccination"[mj] OR "immunization programs"[mjj])) 6.215</p> <p>3 ("measles virus/immunology"[mj] OR "measles/immunology"[mjj]) and ("vaccination"[mh] OR "immunization schedule"[mh]) 558</p> <p>4 #1 OR #2 OR #3 7.292</p> <p>5 "9 months"[tiab] 48.137</p> <p>6 "0 month"[tiab] OR "1 month"[tiab] OR "2 month"[tiab] OR "3 month"[tiab] OR "4 month"[tiab] OR "5 month"[tiab] OR "6 month"[tiab] OR "7 month"[tiab] OR "8 month"[tiab] OR "9 months"[tiab] OR "1 months"[tiab] OR "2 months"[tiab] OR "3 months"[tiab] OR "4 months"[tiab] OR "5 months"[tiab] OR "6 months"[tiab] OR "7 months"[tiab] OR "8 months"[tiab]</p> <p>7 "1-2 month"[tiab] OR "1-3 month"[tiab] OR "1-4 month"[tiab] OR "1-5 month"[tiab] OR "1-6 month"[tiab] OR "1-7 month"[tiab] OR "1-8 month"[tiab] OR "1-9 month"[tiab] OR "1-10 month"[tiab] OR "1-11 month"[tiab] OR "1-12 month"[tiab] OR "1-13 month"[tiab] OR "1-14 month"[tiab] OR "2-3 month"[tiab] OR "2-4 month"[tiab] OR "2-5 month"[tiab] OR "2-6 month"[tiab] OR "2-7 month"[tiab] OR "2-8 month"[tiab] OR "2-9 month"[tiab] OR "2-10 month"[tiab] OR "2-11 month"[tiab] OR "2-12 month"[tiab] OR "2-13 month"[tiab] OR "2-14 month"[tiab] OR "3-4 month"[tiab] OR "3-5 month"[tiab] OR "3-6 month"[tiab] OR "3-7 month"[tiab] OR "3-8 month"[tiab] OR "3-9 month"[tiab] OR "3-10 month"[tiab] OR "3-11 month"[tiab] OR "3-12 month"[tiab] OR "3-13 month"[tiab] OR "3-14 month"[tiab]</p> <p>8 "1-2 months"[tiab] OR "1-3 months"[tiab] OR "1-4 months"[tiab] OR "1-5 months"[tiab] OR "1-6 months"[tiab] OR "1-7 months"[tiab] OR "1-8 months"[tiab] OR "1-9 months"[tiab] OR "1-10 months"[tiab] OR "1-11 months"[tiab] OR "1-12 months"[tiab] OR "1-13 months"[tiab] OR "1-14 months"[tiab] OR "2-3 months"[tiab] OR "2-4 months"[tiab] OR "2-5 months"[tiab] OR "2-6 months"[tiab] OR "2-7 months"[tiab] OR "2-8 months"[tiab] OR "2-9 months"[tiab] OR "2-10 months"[tiab] OR "2-11 months"[tiab] OR "2-12 months"[tiab] OR "2-13 months"[tiab] OR "2-14 months"[tiab] OR "3-4 months"[tiab] OR "3-5 months"[tiab] OR "3-6 months"[tiab] OR "3-7 months"[tiab] OR "3-8 months"[tiab] OR "3-9 months"[tiab] OR "3-10 months"[tiab] OR "3-11 months"[tiab] OR "3-12 months"[tiab] OR "3-13 months"[tiab] OR "3-14 months"[tiab]</p> <p>9 "4-5 month"[tiab] OR "4-6 month"[tiab] OR "4-7 month"[tiab] OR "4-8 month"[tiab] OR "4-9 month"[tiab] OR "4-10 month"[tiab] OR "4-11 month"[tiab] OR "4-12 month"[tiab] OR "4-13 month"[tiab] OR "4-14 month"[tiab] OR "5-6 month"[tiab] OR "5-7 month"[tiab] OR "5-8 month"[tiab] OR "5-9 month"[tiab] OR "5-10 month"[tiab] OR "5-11 month"[tiab] OR "5-12 month"[tiab] OR "5-13 month"[tiab] OR "5-14 month"[tiab] OR "6-7 month"[tiab] OR "6-8 month"[tiab] OR "6-9 month"[tiab] OR "6-10 month"[tiab] OR "6-11 month"[tiab] OR "6-12 month"[tiab] OR "6-13 month"[tiab] OR "6-14 month"[tiab] OR "7-8 month"[tiab] OR "7-9 month"[tiab] OR "7-10 month"[tiab] OR "7-11 month"[tiab] OR "7-12 month"[tiab] OR "7-13 month"[tiab] OR "7-14 month"[tiab] OR "8-9 month"[tiab] OR "8-10 month"[tiab] OR "8-11 month"[tiab] OR "8-12 month"[tiab] OR "8-13 month"[tiab] OR "8-14 month"[tiab] OR "4-5 months"[tiab] OR "4-6 months"[tiab] OR "4-7 months"[tiab] OR "4-8 months"[tiab] OR "4-9 months"[tiab] OR "4-10 months"[tiab] OR "4-11 months"[tiab] OR "4-12 months"[tiab] OR "4-13 months"[tiab] OR "4-14 months"[tiab] OR "5-6 months"[tiab] OR "5-7 months"[tiab] OR "5-8 months"[tiab] OR "5-9 months"[tiab] OR "5-10 months"[tiab] OR "5-11 months"[tiab] OR "5-12 months"[tiab] OR "5-13 months"[tiab] OR "5-14 months"[tiab] OR "6-7 months"[tiab] OR "6-8 months"[tiab] OR "6-9 months"[tiab] OR "6-10 months"[tiab] OR "6-11 months"[tiab] OR "6-12 months"[tiab] OR "6-13 months"[tiab] OR "6-14 months"[tiab] OR "7-8 months"[tiab] OR "7-9 months"[tiab] OR "7-10 months"[tiab] OR "7-11 months"[tiab] OR "7-12 months"[tiab] OR "7-13 months"[tiab] OR "7-14 months"[tiab] OR "8-9 months"[tiab] OR "8-10 months"[tiab] OR "8-11 months"[tiab] OR "8-12 months"[tiab] OR "8-13 months"[tiab] OR "8-14 months"[tiab]</p> <p>10 "at birth"[tiab] OR newborn*[tiab] OR "one month"[tiab] OR "two month"[tiab] OR "three month"[tiab] OR "four month"[tiab] OR "five month"[tiab] OR "six month"[tiab] OR "seven month"[tiab] OR "eight month"[tiab] OR "two months"[tiab] OR "three months"[tiab] OR "four months"[tiab] OR "five months"[tiab] OR "six months"[tiab] OR "seven months"[tiab] OR "eight months"[tiab] OR "nine months"[tiab] 401.784</p> <p>11 "first month"[tiab] OR "second month"[tiab] OR "third month"[tiab] OR "fourth month"[tiab] OR "fifth month"[tiab] OR "sixth month"[tiab] OR "seventh month"[tiab] OR "eighth month"[tiab] OR "first two months"[tiab] OR "first three months"[tiab] OR "first four months"[tiab] OR "first five months"[tiab] OR "first six months"[tiab] OR "first seven months"[tiab] OR "first eight months"[tiab] OR "first nine months"[tiab] OR "first 2 months"[tiab] OR "first 3 months"[tiab] OR "first 4 months"[tiab] OR "first 5 months"[tiab] OR "first 6 months"[tiab] OR "first 7 months"[tiab]</p>

OR "first 8 months"[tiab] OR "first 9 months"[tiab] 40.451

12 "4.5 months"[tiab] OR ("first dose"[tiab] AND before[tiab] AND "9 months"[tiab]) 3.073

13 "early vaccination"[tiab] OR "early immunization"[tiab] OR "early immunisation"[tiab] OR "early mv"[tiab] OR "early schedule"[tiab] OR "give earlier"[tiab] OR "early mv"[tiab] OR "primary mv"[tiab] OR "given earlier"[tiab] OR "early infancy"[tiab] 5.842

14 #4 AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13) 829

15 (immunogenicity[tiab] OR efficacy[tiab] OR effectiveness[tiab]) OR (immunogenicity[ot] OR efficacy[ot] OR effectiveness[ot]) OR ("optimal age"[ti] OR "optimum age"[ti]) 820505

16 "measles cases"[tiab] OR ("measles"[mh] AND "incidence"[mh]) OR "measles/mortality"[mh] OR ("infant mortality"[mh] OR "mortality"[mh]) AND "measles vaccine"[mh]) OR (measles[tiab] AND(death\*[tiab] OR mortality[tiab])) 1.093.324

17 "antibodies, viral/blood"[mh] OR "antibodies, neutralizing/blood"[mh] OR "immunoglobulin g/blood"[mh] OR "enzyme-linked immunosorbent assay"[mh] OR "hemagglutination inhibition tests"[mh] OR "neutralization tests"[mh] 226.931

18 "plaque reduction neutralization test"[tiab] OR prnt[tiab] OR "enzyme-linked immunosorbent assay"[tiab] OR elisa[tiab] OR "hemagglutination inhibition assay"[tiab] OR "hi assay"[tiab] OR "complement fixation assay"[tiab] OR "cf assay"[tiab] OR avidity[tiab] 198.862

19 "measles virus/immunology"[mh] OR "measles/immunology"[mh] OR "measles vaccine/immunology"[mh] OR "measles vaccine/adverse effects"[mj] OR "antibody formation"[mh] OR "antibodies, viral/immunology"[mh] OR "antibody affinity"[mh] OR "immunity, active"[mh] OR "t-lymphocytes/immunology"[mh] OR "immunity, cellular"[mh] OR "lymphocyte activation"[mh] OR "cytopathogenic effect, viral"[mh] OR "stimulation index"[tiab] OR "t-cell proliferation"[tiab] 398.241

20 "antibody response"[tiab] OR "antibody responses"[tiab] OR "antibody titer"[tiab] OR "antibody titers"[tiab] OR "antibody titre"[tiab] OR "antibody titres"[tiab] OR "antibody level"[tiab] OR "antibody levels"[tiab] OR "immune response"[tiab] OR "immune responses"[tiab] OR "t-cell response"[tiab] OR "t-cell responses"[tiab] OR "cell-mediated immunity"[tiab] OR "humoral immunity"[tiab] OR "measles igg"[tiab] OR seroconversion[tiab] OR "response to vaccination"[tiab] OR (response[tiab] AND "measles vaccination"[tiab]) 324.861

21 "improve survival"[tiab] OR "improves survival"[tiab] OR "mortality reduction"[tiab] OR "child mortality"[tiab] OR ((prevention[tiab] OR risk\*[tiab]) AND measles[tiab]) 59.283

22 (reactogenicity[tiab] OR safety[tiab] OR "adverse events"[tiab] OR "adverse effects"[tiab] OR "side effects"[tiab] OR fever[tiab] OR "local reaction"[tiab] OR "local reactions"[tiab] OR convulsion[tiab] OR convulsions[tiab] OR purpura[tiab] OR rash[tiab]) OR (reactogenicity[ot] OR safety[ot] OR "adverse events"[ot] OR "adverse effects"[ot] OR "side effects"[ot] OR fever[ot] OR "local reaction"[ot] OR "local reactions"[ot] OR convulsion[ot] OR convulsions[ot] OR purpura[ot] OR rash[ot]) 988.546

23 "aseptic meningitis"[tiab] OR seizures[tiab] OR encephalopathy[tiab] OR anaphylaxis[tiab] OR hypersensitivity[tiab] OR "allergic reaction"[tiab] OR "allergic reactions"[tiab] OR "joint pain"[tiab] OR arthropathy[tiab] OR arthralgia[tiab] OR arthritis[tiab] OR cough[tiab] OR diarrhoea[tiab] OR diarrhea[tiab] 522.928

24 "measles vaccine/adverse effects"[mh] OR "measles-mumps-rubella vaccine/adverse effects"[mh] OR ("measles vaccine"[mh] AND ("adverse effects"[sh] OR "chemically induced"[sh]) OR complications[sh] OR toxicity[sh] OR poisoning[sh] OR drug effects[sh])) 2388

25 (adverse[tiab] AND (effect\*[tiab] OR event\*[tiab])) OR "side effect"[tiab] OR "side effects"[tiab] OR hypersensitiv\*[tiab] OR sensitiv\*[tiab] OR safe\*[tiab] OR pharmacovigilance[tiab] 2.479.698

26 #14 AND (#15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25) 659

27 english[la] OR dutch[la] OR german[la] OR french[la] OR spanish[la] 26.515.482

28 #26 AND #27 622

29 #28 AND 2015:2019[dp] 70

30 #29 AND "2015/05/01 15.00"[mhda]:"2019/01/14 15.00"[mhda]

**GLOBAL Health, EMBASE**

1. ((measles:ti OR mmr\*:ti OR schwarz:ti OR moraten:ti OR edmonston:ti OR 'edmonston zagreb':ti OR 'leningrad 16':ti OR 'shanghai 191':ti OR 'cam 70':ti OR 'aik c':ti OR td97:ti) AND (vaccine\*:ti OR vaccination\*:ti OR immunization\*:ti OR immunisation\*:ti)) OR 'mr vaccine\*:ti OR mmrv:ti

2. 'measles vaccine'/mj OR 'measles mumps rubella vaccine'/mj OR 'measles rubella vaccine'/mj OR 'measles mumps vaccine'/mj OR ('measles vaccine'/de AND ('vaccination'/mj OR 'immunization'/mj))

3. ('measles'/mj OR 'measles virus'/mj) AND ('vaccination'/mj OR 'immunization'/mj)

4. #1 OR #2 OR #3

5. 'before 9 months':ti,ab OR ('less than' NEAR/4 '9 months'):ti,ab OR (earlier NEAR/4 '9 months'):ti,ab OR 'under 9 months':ti,ab OR 'below 9 months':ti,ab OR ('younger than' NEAR/4 '9 months'):ti,ab

6. '0 month\*':ti,ab OR '1 month\*':ti,ab OR '2 month\*':ti,ab OR '3 month\*':ti,ab OR '4 month\*':ti,ab OR '5 month\*':ti,ab OR '6 month\*':ti,ab OR '7 month\*':ti,ab OR '8 month\*':ti,ab OR '9 month\*':ti,ab OR '1-2 month\*':ti,ab OR '1-3 month\*':ti,ab OR '1-4 month\*':ti,ab OR '1-5 month\*':ti,ab OR '1-6 month\*':ti,ab OR '1-7 month\*':ti,ab OR '1-8 month\*':ti,ab OR '1-9 month\*':ti,ab OR '2-3 month\*':ti,ab OR '2-4 month\*':ti,ab OR '2-5 month\*':ti,ab OR '2-6

month\*:ti,ab OR '2-7 month\*:ti,ab OR '2-8 month\*:ti,ab OR '2-9 month\*:ti,ab

7. '3-4 month\*:ti,ab OR '3-5 month\*:ti,ab OR '3-6 month\*:ti,ab OR '3-7 month\*:ti,ab OR '3-8 month\*:ti,ab OR '3-9 month\*:ti,ab OR '4-5 month\*:ti,ab OR '4-6 month\*:ti,ab OR '4-7 month\*:ti,ab OR '4-8 month\*:ti,ab OR '4-9 month\*:ti,ab OR '5-6 month\*:ti,ab OR '5-7 month\*:ti,ab OR '5-8 month\*:ti,ab OR '5-9 month\*:ti,ab OR '6-7 month\*:ti,ab OR '6-8 month\*:ti,ab OR '6-9 month\*:ti,ab OR '7-8 month\*:ti,ab OR '7-9 month\*:ti,ab OR '8-9 month\*:ti,ab

8. 'at birth':ti,ab OR newborn\*:ti,ab OR (one NEAR/4 month\*):ti,ab OR (two NEAR/4 month\*):ti,ab OR (three NEAR/4 month\*):ti,ab OR (four NEAR/4 month\*):ti,ab OR (five NEAR/4 month\*):ti,ab OR (six NEAR/4 month\*):ti,ab OR (seven NEAR/4 month\*):ti,ab OR (eight NEAR/4 month\*):ti,ab OR (nine NEAR/4 month\*):ti,ab

9. 'first month\*:ti,ab OR 'second month\*:ti,ab OR 'third month\*:ti,ab OR 'fourth month\*:ti,ab OR 'fifth month\*:ti,ab OR 'first two month\*:ti,ab OR 'first three month\*:ti,ab OR 'first four month\*:ti,ab OR 'first five month\*:ti,ab OR 'first six month\*:ti,ab OR 'first seven month\*:ti,ab OR 'first eight month\*:ti,ab OR 'first nine month\*:ti,ab OR 'first 2 month\*:ti,ab OR 'first 3 month\*:ti,ab OR 'first 4 month\*:ti,ab OR 'first 5 month\*:ti,ab OR 'first 6 month\*:ti,ab OR 'first 7 month\*:ti,ab OR 'first 8 month\*:ti,ab OR 'first 9 month\*:ti,ab

10. (weeks NEAR/4 age):ti,ab

11. '4.5 months':ti,ab OR ('first dose':ti,ab AND (before NEAR/9 months):ti,ab)

12. (early NEAR/3 vaccination):ti,ab OR (early NEAR/3 immunization):ti,ab OR (early NEAR/3 immunisation):ti,ab OR (early NEAR/3 mv):ti,ab OR (early NEAR/3 schedule):ti,ab OR 'give earlier':ti,ab OR 'early mv':ti,ab OR 'primary mv':ti,ab OR 'given earlier':ti,ab OR 'early infancy':ti,ab

13. #4 AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12)

14. immunogenicity:ti,ab,de OR efficacy:ti,ab,de OR effectiveness:ti,ab,de OR effectivity:ti,ab,de OR immunological impact':ti,ab,de OR 'immunogenicity'/de OR 'vaccine immunogenicity'/de OR 'drug efficacy'/de OR 'optimal age':ti OR 'optimum age':ti

15. 'measles cases':ti,ab OR ('measles'/de AND 'incidence'/de) OR ('infant mortality'/de OR 'mortality'/de OR 'death'/de AND 'measles vaccine'/de) OR (measles NEAR/4 (death\* OR mortality OR incidence)):ti,ab

16. 'virus antibody'/de OR 'neutralizing antibody'/de OR 'immunoglobulin g'/de OR 'enzyme-linked immunosorbent assay'/de OR 'enzyme-linked immunosorbent assay'/de OR 'hemagglutination inhibition test'/de OR 'virus neutralization'/de OR 'serodiagnosis'/de

17. 'plaque reduction neutralization test\*':ti,ab OR prnt:ti,ab OR 'enzyme-linked immunosorbent assay':ti,ab OR 'enzyme-linked immunosorbent assay':ti,ab OR 'hemagglutination inhibition assay':ti,ab OR 'hi assay':ti,ab OR 'complement fixation assay':ti,ab OR 'cf assay':ti,ab OR avidity:ti,ab

18. ('measles vaccine'/de AND 'drug administration'/lnk) OR 'antibody production' OR 'antibody affinity'/de OR 'cellular immunity'/de OR 'lymphocyte activation'/de OR 'cytopathogenic effect'/de OR ('stimulation index':ti,ab AND 't-cell proliferation':ti,ab)

19. 'antibody response\*':ti,ab OR 'antibody titer\*':ti,ab OR 'antibody titre\*':ti,ab OR 'antibody level\*':ti,ab OR 'immune response\*':ti,ab OR 't-cell response\*':ti,ab OR 'cell-mediated immunity':ti,ab OR (humoral NEAR/3 immunity):ti,ab OR 'measles igg':ti,ab OR seroconversion:ti,ab OR 'response to vaccination':ti,ab OR (response NEAR/3 'measles vaccination'):ti,ab

20. (improve NEAR/3 survival):ti,ab OR (improves NEAR/3 survival):ti,ab OR 'mortality reduction':ti,ab OR 'child mortality':ti,ab OR (prevention NEAR/3 measles):ti,ab OR (risk NEAR/3 measles):ti,ab

21. reactogenicity:ti,ab,de OR safety:ti,ab,de OR 'adverse events':ti,ab,de OR 'adverse effects':ti,ab,de OR 'side effects':ti,ab,de OR fever:ti,ab,de OR 'local reaction\*':ti,ab,de OR convulsion\*:ti,ab,de OR purpura:ti,ab,de OR rash:ti,ab,de

22. 'aseptic meningitis':ti,ab OR seizures:ti,ab OR encephalopathy:ti,ab OR anaphylaxis:ti,ab OR hypersensitivity:ti,ab OR 'allergic reaction\*':ti,ab OR 'joint pain':ti,ab OR arthropathy:ti,ab OR arthralgia:ti,ab OR arthritis:ti,ab OR cough:ti,ab OR diarrhoea:ti,ab OR diarrhea:ti,ab

23. 'measles vaccine'/de OR 'measles mumps rubella vaccine'/de OR 'measles rubella vaccine'/de OR 'measles mumps vaccine'/de AND ('adverse drug reaction'/lnk OR 'side effect'/lnk)

24. 'measles vaccine'/de OR 'measles mumps rubella vaccine'/de OR 'measles rubella vaccine'/de OR 'measles mumps vaccine'/de AND ('adverse events':de OR 'side effects':de OR 'chemically induced':de OR complications:de OR contraindications:de OR toxicity:de OR poisoning:de OR 'drug effects':de)

25. (adverse:ti,ab AND (effect\*:ti,ab OR event\*:ti,ab)) OR 'side effect\*':ti,ab OR hypersensitiv\*:ti,ab OR sensitiv\*:ti,ab OR safe\*:ti,ab OR pharmacovigil\*:ti,ab

26. #13 AND (#14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25)

27. english:la OR dutch:la OR german:la OR french:la OR spanish:la

28. #26 AND #27

29. [animals]/lim NOT [humans]/lim

30. macaque\*:ti OR primate\*:ti OR rodent\*:ti OR mice:ti OR mouse:ti OR murine:ti OR rat:ti OR rats:ti

31. 'case report':it OR news:it OR letter:it OR note:it OR comment:it OR editorial:it OR erratum:it

32. #28 NOT (#29 OR #30 OR #31)

33. [2015-2019]/py AND [01-05-2015]/sd

- 
34. #32 AND #33
1. (TITLE(measles\* OR mmr\* OR schwarz OR moraten OR edmonston OR edmonston-zagreb OR (Leningrad-16) OR (Shanghai-191) OR (CAM-70) OR (AIK-C) OR TD97) AND TITLE(vaccine\* OR vaccination\* OR immunization\* OR immunisation\*)) OR TITLE((mr-vaccine\*) OR mmrv)
  2. (KEY(measles\* OR mmr\* OR schwarz OR moraten OR edmonston OR edmonston-zagreb OR (Leningrad-16) OR (Shanghai-191) OR (CAM-70) OR (AIK-C) OR TD97) AND KEY(vaccine\* OR vaccination\* OR immunization\* OR immunisation\*)) OR KEY((mr-vaccine\*) OR mmrv)
  3. #1 OR #2
  4. TITLE-ABS-KEY((before-9-months) OR ((less-than) W/4 (9-months)) OR (earlier W/4 (9-months)) OR (under-9-months) OR (below-9-months) OR ((younger-than) W/4 (9-months)))
  5. TITLE-ABS-KEY((0-month\*) OR (1-month\*) OR (2-month\*) OR (3-month\*) OR (4-month\*) OR (5-month\*) OR (6-month\*) OR (7-month\*) OR (8-month\*) OR (9-month\*) OR (1-2-month\*) OR (1-3-month\*) OR (1-4-month\*) OR (1-5-month\*) OR (1-6-month\*) OR (1-7-month\*) OR (1-8-month\*) OR (1-9-month\*) OR (2-3-month\*) OR (2-4-month\*) OR (2-5-month\*) OR (2-6-month\*) OR (2-7-month\*) OR (2-8-month\*) OR (2-9-month\*))
  6. TITLE-ABS-KEY ((3-4-month\*) OR (3-5-month\*) OR (3-6 month\*) OR (3-7 month\*) OR (3-8 month\*) OR (3-9 month\*) OR (4-5-month\*) OR (4-6-month\*) OR (4-7-month\*) OR (4-8-month\*) OR (4-9-month\*) OR (5-6-month\*) OR (5-7-month\*) OR (5-8-month\*) OR (5-9-month\*) OR (6-7-month\*) OR (6-8-month\*) OR (6-9-month\*) OR (7-8-month\*) OR (7-9-month\*) OR (8-9-month\*))
  7. TITLE-ABS-KEY((at-birth) OR newborn\* OR (one W/4 month\*) OR (two W/4 month\*) OR (three W/4 month\*) OR (four W/4 month\*) OR (five W/4 month\*) OR (six W/4 month\*) OR (seven W/4 month\*) OR (eight W/4 month\*))
  8. TITLE-ABS-KEY((first-month\*) OR (second-month\*) OR (third-month\*) OR (fourth-month\*) OR (fifth-month\*) OR (sixth-month\*) OR (seventh-month\*) OR (eighth-month\*) OR (first-two-month\*) OR (first-three month\*) OR (first-four-month\*) OR (first- five month\*) OR (first-six month\*) OR (first-seven month\*) OR (first-eight month\*) OR (first-nine month\*) OR (first-2-month\*) OR (first-3-month\*) OR (first-4-month\*) OR (first-5-month\*) OR (first-6-month\*) OR (first-7-month\*) OR (first-8-month\*) OR (first-9-month\*))
  9. TITLE-ABS-KEY(weeks W/4 age)
  10. TITLE-ABS-KEY(4.5-months) OR (TITLE-ABS-KEY(first-dose) AND TITLE-ABS-KEY(before W/9 months))
  11. TITLE-ABS-KEY((early W/3 vaccination) OR (early W/3 immunization) OR (early W/3 immunisation) OR (early W/3 mv) OR (early W/3 schedule) OR (give-earlier) OR (early-mv) OR (primary-mv) OR (given-earlier) OR (early-infancy))
  12. #3 AND (#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11)
  13. TITLE-ABS-KEY(immunogenic\* OR efficacy OR effectiveness OR effectivity OR (immunological-impact) OR immunogenicity) OR TITLE((optimal-age) OR (optimum-age))
  14. TITLE-ABS-KEY((measles-cases) OR (measles AND incidence) OR ((mortality OR death) AND (measles-vaccin\*))) OR TITLE-ABS-KEY(measles W/4 (death\* OR mortality OR incidence))
  15. TITLE-ABS-KEY((plaque-reduction-neutralization-test\*) OR prnt OR (enzyme-linked-immunosorbent-assay) OR (enzyme-linked-immunospot-assay) OR elisa OR (hemagglutination-inhibition assay) OR (hi-assay) OR (complement-fixation-assay) OR (cf-assay) OR avidity OR (virus-anitibod\*) OR (neutralizing-antibod\*) OR (immunogloublin-g) OR (virus-neutralization) OR serodiagnosis)
  16. (KEY(measles vaccine) AND KEY(drug-administration)) OR KEY((antibody-production) OR (antibody-affinity) OR (cellular-immunity) OR (lymphocyte-activation) OR (cytopathogenic-effect) OR ((stimulation-index) AND (t-cell-proliferation)))
  17. TITLE-ABS-KEY((antibody-response\*) OR (antibody-titer\*) OR (antibody-titre\*) OR (antibody-level\*) OR (immune-response\*) OR (t-cell-response\*) OR (cell-mediated-immunity) OR (humoral W/3 immunity) OR (measles-igg) OR seroconversion OR (response-to-vaccination) OR (response W/3 (measles-vaccination)))
  18. TITLE-ABS-KEY((improve W/3 survival) OR (improves W/3 survival) OR (mortality-reduction) OR (child-mortality) OR (prevention W/3 measles) OR (risk W/3 measles))
  19. TITLE-ABS-KEY(reactogenicity OR safety OR (adverse-events) OR (adverse-effects) OR (side-effects) OR fever OR (local-reaction\*) OR convulsion\* OR purpura OR rash)
  20. TITLE-ABS-KEY((aseptic-meningitis) OR seizures OR encephalopath\* OR anaphylaxis OR hypersensitivity OR (allergic-reaction\*) OR (joint-pain) OR arthropathy OR arthralgia OR arthritis OR cough OR diarrhoea OR diarrhea)
  21. KEY((measles-vaccine) OR (measles-mumps-rubella-vaccine) OR (measles-rubella vaccine) OR (measles-mumps-vaccine) ) AND KEY((adverse-drug-reaction\*) OR (adverse-effect\*) OR (adverse-event\*) OR (side-effect\*) OR (chemically-induced) OR complications OR contraindications OR toxicity OR poisoning OR (drug-effects))
  22. TITLE-ABS-KEY(adverse W/5 (effect\* OR event\*)) OR TITLE-ABS-KEY((side-effect\*) OR hypersensitiv\* OR sensitiv\* OR safe\* OR pharmacovigil\*)
  23. #12 AND (#13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22)
  24. LANGUAGE(english OR dutch OR german OR french OR spanish)
  25. #23 AND #24
  26. KEY(animal\*) NOT KEY(human\*)
  18. TITLE(macaque\* OR primate\* OR rodent\* OR mice OR mouse OR murine OR rat OR rats)
  19. DOCTYPE(ed) OR DOCTYPE(er) OR DOCTYPE(no) OR DOCTYPE(le)
  20. #25 AND NOT (#26 OR #27 OR #28)
-

	21.	(PUBYEAR AFT 2014 OR PUBYEAR IS 2014) AND ORIG-LOAD-DATE AFT 20150501
	22.	#20 AND #21
<b>Proquest</b>	1.	(TI(measles* OR mmr* OR schwarz OR moraten OR edmonston OR (edmonston-zagreb) OR (Leningrad-16) OR (Shanghai-191) OR (CAM-70) OR (AIK-C) OR TD97) AND TI(vaccine* OR vaccination* OR immunization* OR immunisation*)) OR TI((mr-vaccine*) OR mmrv)
	2.	(SU(measles* OR mmr* OR schwarz OR moraten OR edmonston OR edmonston-zagreb) OR (Leningrad-16) OR (Shanghai-191) OR (CAM-70) OR (AIK-C) OR TD97) AND SU(vaccine* OR vaccination* OR immunization* OR immunisation*)) OR SU((mr-vaccine*) OR mmrv)
	3.	S1 OR S2
	4.	TI,AB((before-9-months) OR ((less-than) W/4 (9-months)) OR (earlier W/4 (9-months)) OR (under-9-months) OR (below-9-months) OR ((younger-than) W/4 (9-months)))
	5.	TI,AB((0-month*) OR (1-month*) OR (2-month*) OR (3-month*) OR (4-month*) OR (5-month*) OR (1-2-month*) OR (1-3-month*) OR (1-4-month*) OR (1-5-month*) OR (1-6-month*) OR (1-7-month*) OR (1-8-month*) OR (1-9-month*) OR (2-3-month*) OR (2-4-month*) OR (2-5-month*) OR (2-6-month*) OR (2-7-month*) OR (2-8-month*) OR (2-9-month*))
	6.	TI,AB((3-4-month*) OR (3-5-month*) OR (3-6 month*) OR (3-7 month*) OR (3-8 month*) OR (3-9 month*) OR (4-5-month*) OR (4-6-month*) OR (4-7-month*) OR (4-8-month*) OR (4-9-month*) OR (5-6-month*) OR (5-7-month*) OR (5-8-month*) OR (5-9-month*) OR (6-7-month*) OR (6-8-month*) OR (6-9-month*) OR (7-8-month*) OR (7-9-month*) OR (8-9-month*))
	7.	TI,AB((at-birth) OR newborn* OR (one W/4 month*) OR (two W/4 month*) OR (three W/4 month*) OR (four W/4 month*) OR (five W/4 month*) OR (six W/4 month*) OR (seven W/4 month*) OR (eight W/4 month*) OR (nine W/4 month*))
	8.	TI,AB((first-month*) OR (second-month*) OR (third-month*) OR (fourth-month*) OR (fifth-month*) OR (sixth-month*) OR (seventh-month*) OR (eighth-month*) OR (nine-month*) OR (first-two-month*) OR (first-three month*) OR (first-four-month*) OR (first- five month*) OR (first-six month*) OR (first-seven month*) OR (first-eight month*) OR (first-nine month*) OR (first-2-month*) OR (first-3-month*) OR (first-4-month*) OR (first-5-month*) OR (first-6-month*) OR (first-7-month*) OR (first-8-month*) OR (first-9-month*))
	9.	TI,AB(weeks W/4 age)
	10.	TI,AB(4.5-months) OR (TI,AB,SU(first-dose) AND TI,AB,SU(before W/9 months))
	11.	TI,AB((early W/3 vaccination) OR (early W/3 immunization) OR (early W/3 immunisation) OR (early W/3 mv) OR (early W/3 schedule) OR (give-earlier) OR (early-mv) OR (primary-mv) OR (given-earlier) OR (early-infancy))
	12.	S3 AND (S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11)
	13.	TI,AB,SU(immunogenic* OR efficacy OR effectiveness OR effectivity OR (immunological-impact) OR immunogenicity) OR TI((optimal-age) OR (optimum-age))
	14.	TI,AB,SU((measles-cases) OR (measles AND incidence) OR ((mortality OR death) AND (measles-vaccin*)) OR TI,AB,SU(measles W/4 (death* OR mortality OR incidence))
	15.	TI,AB,SU((plaque-reduction-neutralization-test*) OR prnt OR (enzyme-linked-immunosorbent-assay) OR (enzyme-linked-immunospot-assay) OR elisa OR (hemagglutination-inhibition-assay) OR (hi-assay) OR (complement-fixation-assay) OR (cf-assay) OR avidity OR (virus-anitibod*) OR (neutralizing-antibod*) OR (immunoglobulin-g) OR (virus-neutralization) OR serodiagnosis)
	16.	(SU(measles vaccine) AND SU(drug-administration)) OR SU((antibody-production) OR (antibody-affinity) OR (cellular-immunity) OR (lymphocyte-activation) OR (cytopathogenic-effect) OR ((stimulation-index) AND (t-cell-proliferation)))
	17.	TI,AB,SU((antibody-response*) OR (antibody-titer*) OR (antibody-titre*) OR (antibody-level*) OR (immune-response*) OR (t-cell-response*) OR (cell-mediated-immunity) OR (humoral W/3 immunity) OR (measles-igg) OR seroconversion OR (response-to-vaccination) OR (response W/3 (measles-vaccination)))
	18.	TI,AB,SU((improve W/3 survival) OR (improves W/3 survival) OR (mortality-reduction) OR (child-mortality) OR (prevention W/3 measles) OR (risk W/3 measles))
	19.	TI,AB,SU(reactogenicity OR safety OR (adverse-events) OR (adverse-effects) OR (side-effects) OR fever OR (local-reaction*) OR convulsion* OR purpura OR rash)
	20.	TI,AB,SU((aseptic-meningitis) OR seizures OR encephalopath* OR anaphylaxis OR hypersensitivity OR (allergic-reaction*) OR (joint-pain) OR arthropathy OR arthralgia OR arthritis OR cough OR diarrhoea OR diarrhea)
	21.	SU((measles-vaccine) OR (measles-mumps-rubella-vaccine) OR (measles-rubella vaccine) OR (measles-mumps-vaccine)) AND SU((adverse-drug-reaction*) OR (adverse-effect*) OR (adverse-event*) OR (side-effect*) OR (chemically-induced) OR complications OR contraindications OR toxicity OR poisoning OR (drug-effects))
	22.	TI,AB,SU(adverse W/5 (effect* OR event*)) OR TI,AB,SU((side-effect*) OR hypersensitiv* OR sensitiv* OR safe* OR pharmacovigil*)
	23.	S12 AND (S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22)
	24.	LA(english OR dutch OR german OR french OR spanish)
	25.	S23 AND S24
	26.	SU(animal*) NOT SU(human*)
	27.	TI(macaque* OR primate* OR rodent* OR mice OR mouse OR murine OR rat OR rats)
	28.	DTYPE(editorial OR erratum OR NOTE OR news OR letter OR comment OR (case-report))
	29.	S25 NOT (S26 OR S27 OR S28)
	30.	YR(2015-2019) AND PD(20150501-20190114)

**WHO LIS**

Words or phrase: measles\$

AND

Words or phrase: vaccin\$ OR immunization\$ OR immunisation\$

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**WHO IRIS**

Search: All of WHO IRIS

For: Measles

Current filters:

Title: measles AND vaccine

OR

Title: measles AND vaccines

OR

Title: measles AND immunization

OR

Title: measles AND immunisation

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## Decision rules for data selection and extraction processes

Table 2: Decision rules for data selection and extraction processes

<p><b>Eligibility criteria</b></p> <p><b>Types of studies</b></p> <ul style="list-style-type: none"><li>• Randomized control trials (RCTs), quasi-randomised control trials (qRCTs), outbreak investigations, cohort and case control studies regarding vaccination schedules for currently licensed measles containing vaccines (MCV).</li></ul> <p><b>Types of participants</b></p> <ul style="list-style-type: none"><li>• Infants &lt;9 months of age receiving their first dose of a MCV.</li></ul> <p><b>Types of intervention</b></p> <ul style="list-style-type: none"><li>• Any currently licensed MCV administered to infants &lt;9 months of age. A currently licensed MCV can be:<ul style="list-style-type: none"><li>- Monovalent vaccine: Schwarz, Moraten, Edmonston, Edmonston-Zagreb, Leningrad-16, Shanghai-191, CAM-70, AIK-C and TD97.</li><li>- Combination vaccine containing various combinations of the above measles strains with other viruses: measles and rubella (MR), measles, mumps and rubella (MMR), measles, mumps, rubella and varicella (MMRV).</li></ul></li></ul> <p><b>Minimum data requirements</b></p> <ul style="list-style-type: none"><li>• For inclusion in the review, all articles must report age at vaccination. Likewise, for studies on safety, an adverse event following immunization case definition is required, while immunogenicity studies should report the exact vaccine strain and/or potency used and type of laboratory test used.</li></ul> <p><b>Exclusion criteria</b></p> <ul style="list-style-type: none"><li>• Ecological studies, case reports, non-human primate studies, meeting abstracts, editorials, newspaper articles and other forms of popular media were excluded.</li><li>• High titre vaccines were excluded from the review, defined as vaccines with a TCID<sub>50</sub> of ≥4.7 or p.f.u. of ≥50,000 (F. Cutts, personal communication). Titres below this cut-off were assumed to be 'standard'. Study results derived from combining MCV with gamma globulin or obtained after intradermal (rather than subcutaneous) administration of MCV were also excluded from the review.</li><li>• Failure to meet any one of the above eligibility criteria.</li></ul>
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## Definitions of seroconversion accepted for inclusion in the review

**Table 3: Definitions of seroconversion accepted for inclusion in the review**

Author, year	Definitions accepted for seroconversion	Type of sample	Type of test
Abanamy et al., 1992	Greater or equal than fourfold rise in titre	Serum	Other
Anonymous, 1977	Greater or equal than fourfold rise	Blood cells	Other
Anonymous, 1981	From seronegative to seropositive	Fingerstick	HIA
Anonymous, 1982	Greater or equal than fourfold increase in titre or greater or equal 1:10	Serum	HIA
Bolotovskii et al., 1994	From negative to positive or a greater or equal than fourfold titre rise above expected decay	Fingerstick	HIA
Carson et al., 1995	PRNT: fourfold increase in measles antibody titre	Serum	PRNT
Cutts et al., 1994	Fourfold rise in titre pre/(expected) post vaccination 6 weeks and 6 months post vaccination	Fingerstick	PRNT
Diaz-Ortega et al., 1986	Fourfold increase or change from seronegative to seropositive	Fingerstick	HIA
Ekunwe, 1985	Fourfold rise in antibody titre	Fingerstick	HIA
Fernandez de Castro et al., 1986	Greater or equal than fourfold increase pre/post vaccination	Serum	HIA
Gans et al., 2013	Greater or equal than fourfold increase in GMT (1998 paper)	Serum	PRNT
He et al., 2014	Any positive antibody response in seronegative infants or $\geq 4$ titer increase	Serum	ELISA
Job et al., 1984	Seronegative to seropositive	Fingerstick	HIA
Johnson et al., 1994	Seronegative to seropositive	Serum	Other
Katiyar et al., 1985	Greater than fourfold rise in HAI titre	Serum	HIA
Khanum et al., 1987	Fourfold increase in HI	Heel prick	HIA
Mandara et al., 1985	Fourfold rise in titre post-vaccination	Serum	HIA
Markowitz et al., 1990	Change from negative ( $< 40$ miu) pre-vaccination to positive post-vaccination or fourfold increase in level above calculated titre expected 8 or 18 weeks post-vaccination	Fingerstick	PRNT
Ndumbe et al., 1995	Prevaccination $< 200$ mu/ml and postvaccination positive or greater or equal fourfold increase 6 weeks postvaccination	Serum	ELISA
Nkrumah et al., 1998	Seronegative to seropositive, or greater or equal fourfold increase in titre given decay	Serum	HIA
Pabst et al., 1999	Fourfold increase in titer, adjusted for decay of maternal antibodies	Serum	PRNT
Pongrithsukda et al., 1991	No detectable to detectable antibody	Serum	PRNT
Rogers et al., 1991	Fourfold increase	Blood cells	ELISA
Schatzmayr et al., 1982	Proportion seroconverted in those negative before vaccination (HI $< 10$ )	Serum	HIA
Semba et al., 1995	Greater or equal than fourfold titre rise	Serum	PRNT
Soula et al., 1991	Lower antibody titer of 1/10 before vaccination and equal or higher post vaccination	Serum	HIA
Stewien et al., 1978	Greater or equal than fourfold titre increase between pre and post vaccination sample	Serum	HIA

## Definitions of seroconversion not accepted for inclusion in the review

**Table 4: Definitions of seroconversion not accepted for inclusion in the review**

Author, year	Definitions not accepted for seroconversion	Type of sample	Type of test
Breman et al., 1975	No definition given	Serum	HIA
Cutts et al., 1994	Optical density ratio pre/post $\geq 1.47$	Other	ELISA
Deivanayagam et al., 1990	Conversion from negative to positive or $\geq$ twofold rise in titre	Serum	HIA
Gendrel et al., 1988	Greater or equal than twofold rise of dilutions	Dried blood spots	HIA
Halsey et al., 1985	From negative to $\geq 1:10$ Fourfold rise at 2 weeks, twofold rise at 3 months or conc $\geq 200$ miu/ml post-vacc with $<200$ prevaccination	Dried blood spots	HIA
Hussey et al., 1995	Greater or equal than 200 mlu/ml	Serum	PRNT
Job et al., 1991	No definition given	Dried blood spots	PRNT
King et al., 1978	No definition given	Dried blood spots	HIA
Kumar et al., 1998	Titer $\leq 10$ (NT)	Serum	PRNT
Kurubi et al., 2009	No definition given	Serum	ELISA
Lhuillier et al., 1989	No definition given	Serum	HIA
McGraw et al., 1986	Titre $\geq 10$	Dried blood spots	HIA
Mirchamsy et al., 1991	Fourfold increase in HI titre	Other	HIA
Ogunmekan et al., 1981	No definition given	Other	HIA
Sabin et al., 1984	In Reference 1 (no full text available)	Red blood cells	PRNT
Sakatoku et al., 1994	Seropositive/ total samples	Serum	HIA
Simasathien et al., 1997	Positive 9 month NT and $\geq 6$ month sample	Serum	PRNT
Vidyashankar et al., 2002	No definition given	Serum	ELISA
Whittle et al., 1988	No definition given	Other	PRNT
Wilkins et al., 1979	No definition given	Serum	HIA
Youwang et al., 2001	Negative to positive or $\geq$ fourfold rise following re-immunisation	Dried blood spots	ELISA

## Characteristics of studies included in the review by outcome

Table 5: Characteristics of studies included in the review by outcome

Author, year	Country	MCV1 age (months)	Vaccine Strain	Immunogenicity				Duration of immunity	Vaccine effectiveness	Safety
				SC	GMT	Cellular	Avidity			
Abanamy et al., 1992	Saudi Arabia	6, 9	Schwarz, Edmonston-Zagreb	Yes	-	-	-	-	-	-
Anonymous, 1977	Kenya	4,5,6,7,8,11	Schwarz	Yes	-	-	-	-	-	-
Anonymous, 1981	Tanzania	4-5, 6-7, 8-9, 10-11, 12-13, 14-15	Schwarz	Yes	-	-	-	-	-	-
Anonymous, 1982	Brazil, Chile, Costa Rica, Ecuador	6-12	Moraten	Yes	-	-	-	-	-	-
Berry et al., 1992	Peru	5-6, 8-9	Schwarz, Edmonston-Zagreb	-	-	-	-	-	-	Yes
Bolotovskii et al., 1994	Uzbekistan	6, 9	AIK-C, Edmonston-Zagreb, Leningrad 16, Schwarz	Yes	-	-	-	-	-	Yes
Carson et al., 1975	Canada	6-8.5	Connaught	Yes	-	-	-	-	-	-
Cutts et al., 1994	DRC	<5, 5, 5-6, 6, 6-7, 7-8, >9	Edmonston-Zagreb	Yes	Yes	-	-	-	-	-
Diaz-Ortega et al., 1986	Mexico	8,9-10,11-12,13-14,15-16,17-18	Schwarz	Yes	-	-	-	-	-	-
Dick et al., 1975	South Africa	6,7,8,9,10,11, 12	Moraten	-	-	-	-	-	-	Yes
Do et al., 2017	Guinea Bissau	4.5, 9	Edmonston-Zagreb	-	-	-	-	-	-	Yes

Ekunwe, 1985	Nigeria	6,7,8,9-12,13-19,20-26	Edmonston	Yes	-	-	-	-	-	-
Fernandez de Castro et al., 1986	Mexico	6-9	Edmonston-Zagreb, Schwarz	Yes	-	-	-	-	-	Yes
Fisker et al, 2018	Burkina Faso, Guinea Bissau	4-7, 9	Edmonston-Zagreb	-	-	-	-	-	-	Yes
Gans et al., 1998	USA	6,9,12	Moraten	-	-	Yes	-	-	-	-
Gans et al., 1999	USA	6,9,12	Moraten	-	-	Yes	-	-	-	-
Gans et al., 2001	USA	6,9,12	Moraten	-	Yes	Yes	-	-	-	-
Garly et al., 2001	Guinea-Bissau	6,9	Edmonston-Zagreb, Schwarz	-	Yes	-	-	-	-	-
He et al., 2014	China	8,12	Hu-191	Yes	-	-	-	Yes	-	Yes
Helfand et al., 2008	Malawi	6,9	Edmonston-Zagreb	-	-	-	-	-	-	Yes
Hull et al., 1983 (61)	Gambia	<6, 6-8, 9-11, 12-14, >15	Moraten	-	-	-	-	-	Yes	-
Job et al., 1984	India	6,7,8,9,10,11, 12,13-15	Moraten	Yes	-	-	-	-	-	-
Job et al., 1991	Haiti	6,8	Edmonston-Zagreb, Schwarz	-	-	-	-	-	-	Yes
John et al., 2009	India	6,6-8,>8,9	Unknown	-	-	-	-	-	Yes	-
Johnson et al., 1994	USA	6,15	Moraten	Yes	-	-	-	-	-	Yes
Judelson et al., 1980	USA	≤9, >10	Unknown	-	-	-	-	-	Yes	-
Kaninda et al., 1998	Niger	6-8,9	Schwarz	-	-	-	-	-	Yes	-
Katiyar et al., 1985	India	6,7,8,9-12,13-15	Schwarz	Yes	-	-	-	-	-	-
Khanum et al., 1987	Bangladesh	3-4,4-5,5-6	Edmonston-Zagreb, Schwarz	Yes	-	-	-	-	-	-
Ko et al., 1999	England	5	Schwarz	-	Yes	-	-	-	-	-
Lee et al., 1983	Taiwan	6,7,8,9,10,11, >12	Moraten	Yes	-	-	-	-	-	-
Lhuillier et al., 1989	Ivory Coast	<7, >8	Schwarz	-	-	-	-	-	-	Yes
Mandara et al., 1985	Tanzania	6-7,8-9,10-11,12-13,14-	Schwarz	Yes	-	-	-	-	-	-

		15,16-21								
Markowitz et al., 1990	Mexico	6,9	Edmonston-Zagreb, Edmonston-Zagreb Mexico, Schwarz	Yes	-	-	-	-	-	Yes
Martins et al., 2008	Guinea-Bissau	4.5,9	Edmonston-Zagreb, Schwarz	-	-	-	-	-	Yes	-
Martins et al., 2014	Guinea-Bissau	4.5,9	Edmonston-Zagreb, Schwarz	-	-	-	-	-	Yes	-
Murray et al, 2000	Pakistan	<9, >9	Schwartz	-	-	-	-	-	Yes	-
Nair et al., 2007	USA	6,9	Moraten	-	-	-	Yes	-	-	-
Ndumbe et al., 1995	Cameroon	3,4,5,6,7,8	Connaught, Schwarz	Yes	-	-	-	-	-	Yes
Njie-Jobe et al., 2012	Gambia	4,9	Edmonston-Zagreb	-	-	Yes	-	-	-	-
Nkrumah et al., 1998	Ghana	6,9	AIK-C, Schwarz	Yes	-	-	-	-	-	-
Pabst et al., 1999	Canada	6	AIK-C, Connaught	Yes	-	Yes	-	-	-	-
Pongrithsukda et al., 1991	Thailand	4-7	Edmonston-Zagreb	-	Yes	-	-	-	-	-
Porter et al., 1990	Malawi	6-9	Unknown	-	-	-	-	-	Yes	-
Rogers et al., 1991	Papua New Guinea	4,5,6,6-7,7,<8, 8-29	Edmonston-Zagreb	Yes	-	-	-	-	-	-
Schatzmayr et al., 1982	Brazil	7,8,9,10,11,12-14,15-18,16-24,25	Schwarz	Yes	-	-	-	-	-	-
Semba et al., 1995	Indonesia	6	Schwarz	Yes	-	-	-	-	-	-
Shaoyuan et al., 1982	China	4-6,6,7,7-8,8-12,9-10,11-12,>13	Jing55	-	-	-	-	Yes	-	-
Shasby et al., 1977	USA	<9,9-11,12,>13	Unknown	-	-	-	-	-	Yes	-
Simba et al., 1995	Tanzania	6-8,>9	Unknown	-	-	-	-	-	Yes	-
Soula et al., 1991	Mali	4-8,12-24	Schwarz	-	-	-	-	-	-	Yes
Stewien et al., 1978	Brazil	7,8,9,10,11,1	Schwarz	Yes	-	-	-	-	-	-

		2								
van der Maas et al., 2017	Netherlands	<9, 14	Schwarz	-	-	-	-	-	-	Yes
Whittle et al., 1988	Gambia	4,5	Edmonston-Zagreb, Schwarz	-	Yes	-	-	-	-	-
Whittle et al., 1990	Gambia	4,9	Edmonston-Zagreb, Schwarz	-	-	-	-	Yes	-	-
Woudenberg et al., 2017	Netherlands	<9, 14	Schwarz	-	-	-	-	-	Yes	-

MCV1, first dose of measles containing vaccine; SC, seroconversion; GMT, geometric mean titre

## Proportion seroconverted by age of MCV1 (4-8 months) and measles vaccine strain

Table 6: Proportion seroconverted by age of MCV1 (4-8 months) and measles vaccine strain

Age of MCV1 (months)	Measles vaccine strain	%Seroconverted	95% CI	Author, year
4	Connaught	59	33-82	Ndumbe et al., 1995
	Edmonston-Zagreb	67	38-88	Rogers et al., 1991
	Schwarz	35	21-50	Anonymous, 1977; Ndumbe et al., 1995
5	Connaught	76	50-93	Ndumbe et al., 1995
	Edmonston-Zagreb	83	52-98	Rogers et al., 1991
	Schwarz	55	39-70	Anonymous, 1977; Ndumbe et al., 1995
6	AIK-C	80	64-92	Bolotovskii et al., 1994; Nkrumah et al., 1998; Pabst et al., 1999
	Connaught	74	74-85	Ndumbe et al., 1995; Pabst et al., 1999
	Edmonston	74	58-87	Ekunwe, 1985; Markowitz et al., 1990; Rogers et al., 1991; Abanamy et al., 1992; Bolotovskii et al., 1994; Cutts et al., 1994
	Edmonston-Zagreb	86	73-96	Markowitz et al., 1990; Rogers et al., 1991; Abanamy et al., 1992; Bolotovskii et al., 1994; Cutts et al., 1994
	Edmonston-Zagreb Mexico	95	92-97	Markowitz et al., 1990
	Leningrad-16	76	71-81	Bolotovskii et al., 1994
	Moraten	61	56-66	Anonymous, 1982; Job et al., 1984; Johnson et al., 1994; Gans et al., 2013
	Schwarz	66	56-75	Anonymous, 1977; Katiyar et al., 1985; Markowitz et al., 1990; Abanamy et al., 1992; Bolotovskii et al., 1994; Ndumbe et al., 1995; Semba et al., 1995
7	Connaught	67	30-93	Ndumbe et al., 1995
	Edmonston	75	53-90	Ekunwe, 1985
	Edmonston-Zagreb	100	59-100	Rogers et al., 1991



	Moraten	87	72-96	Job, et al. 1984
	Schwarz	59	31-85	Anonymous, 1977; Stewien, et al., 1978; Schatzmayr, et al., 1982; Katiyar, et al., 1985; Ndumbe, et al., 1995
<b>8</b>	Connaught	100	29-100	Ndumbe, et al., 1995
	Edmonston	89	52-100	Ekunwe, 1985
	Hu-191	99	95-100	He, et al., 2014
	Moraten	100	88-100	Job et al., 1984
	Schwarz	71	44-93	Anonymous, 1977; Stewien, et al., 1978; Schatzmayr, et al., 1982; Katiyar, et al., 1985; Diaz-Ortega, et al., 1986; Ndumbe, et al. 1995

# Forest plots for seroconversion

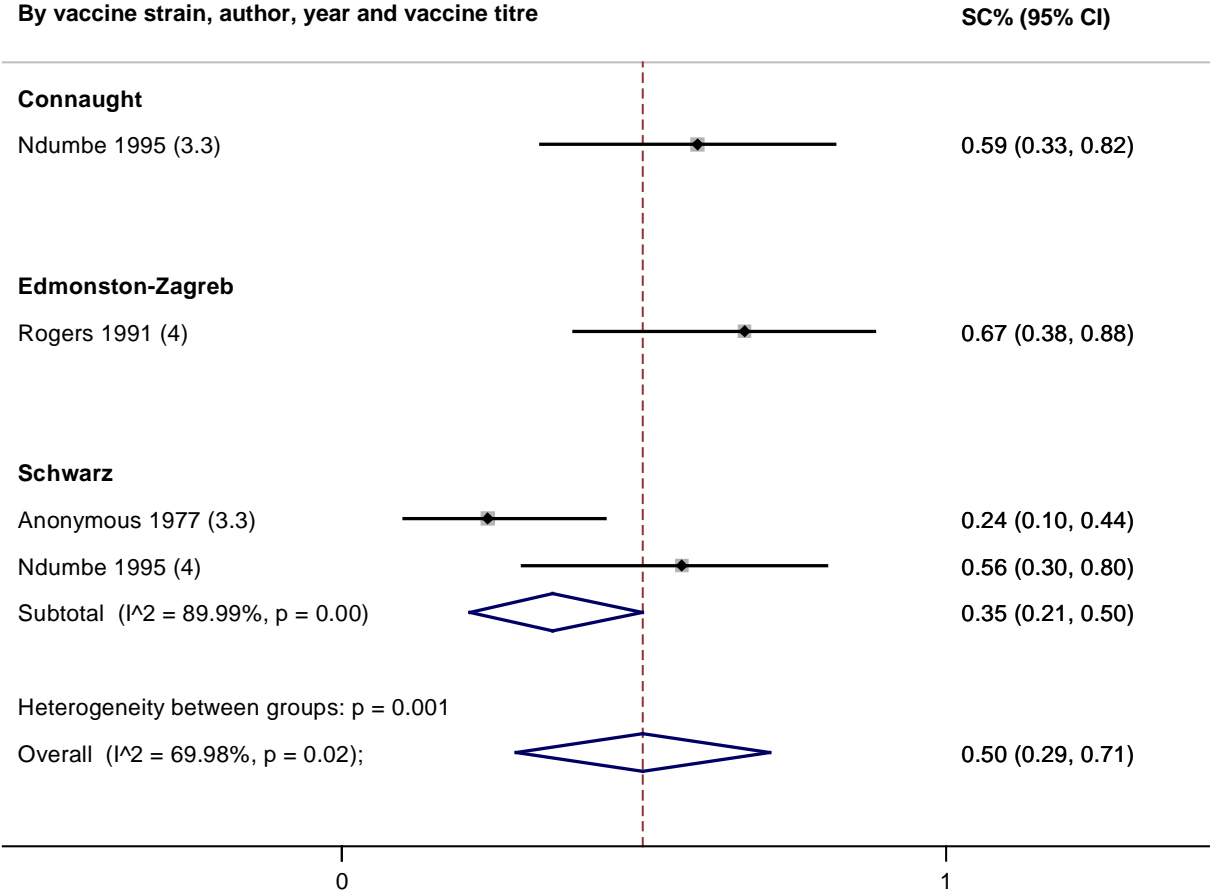
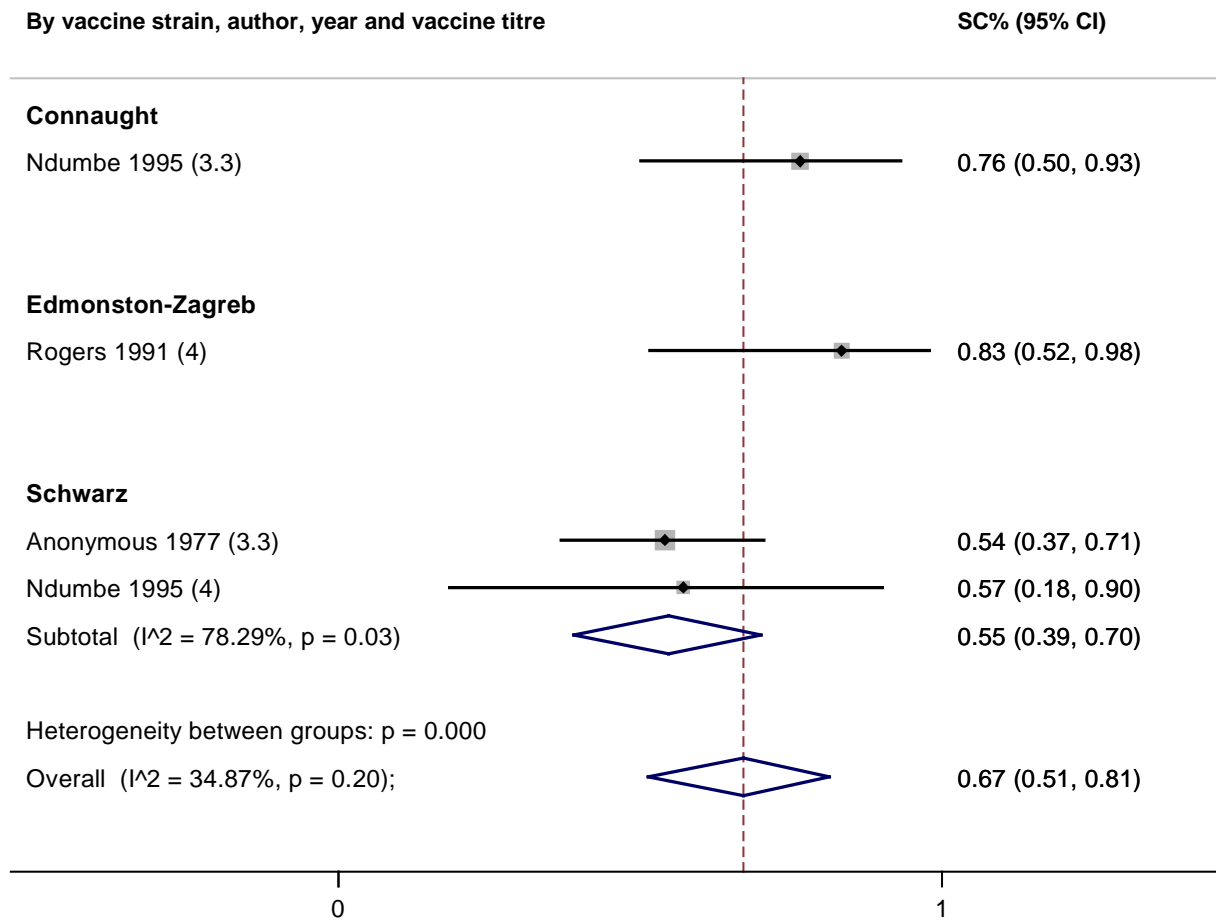
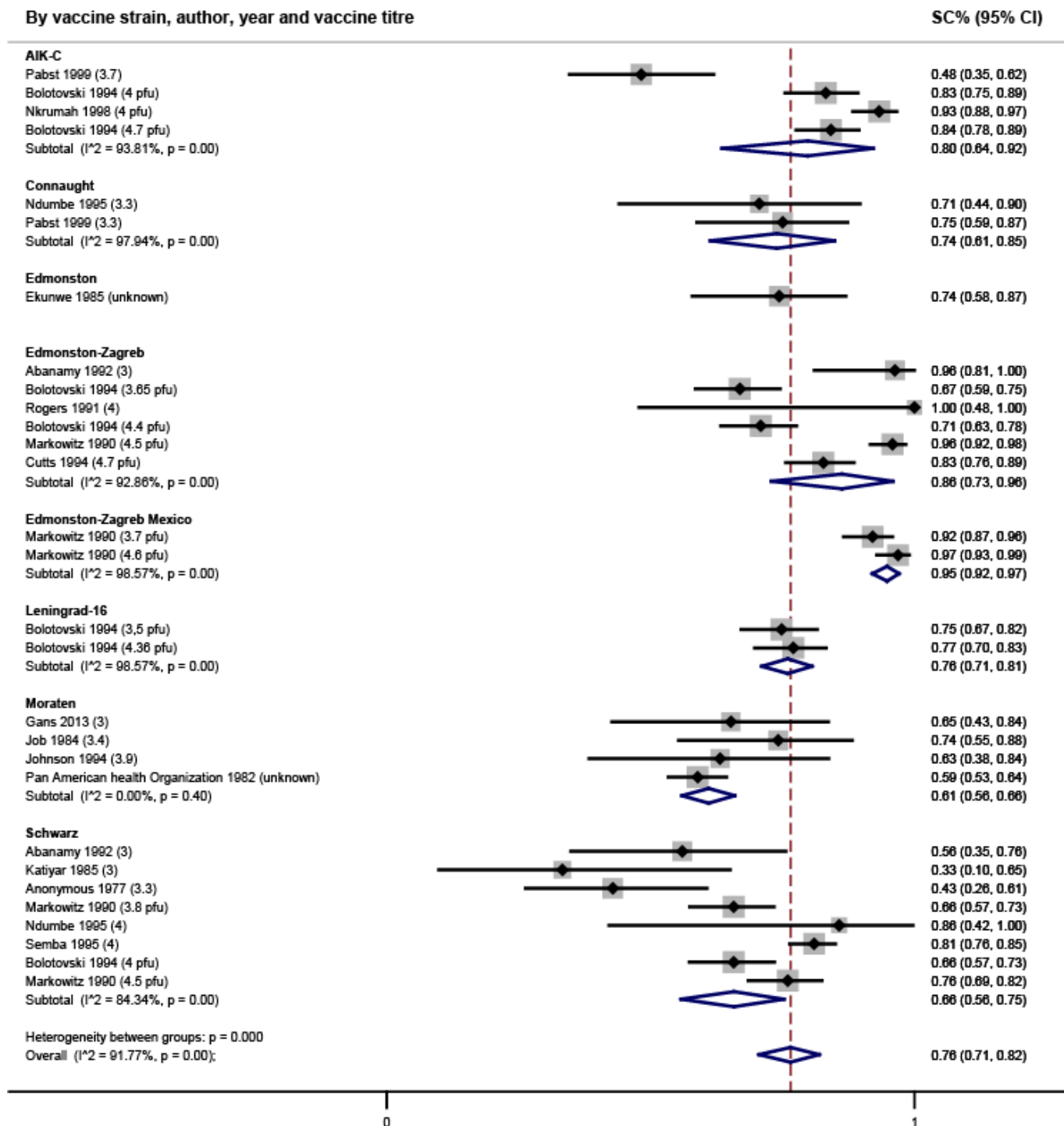


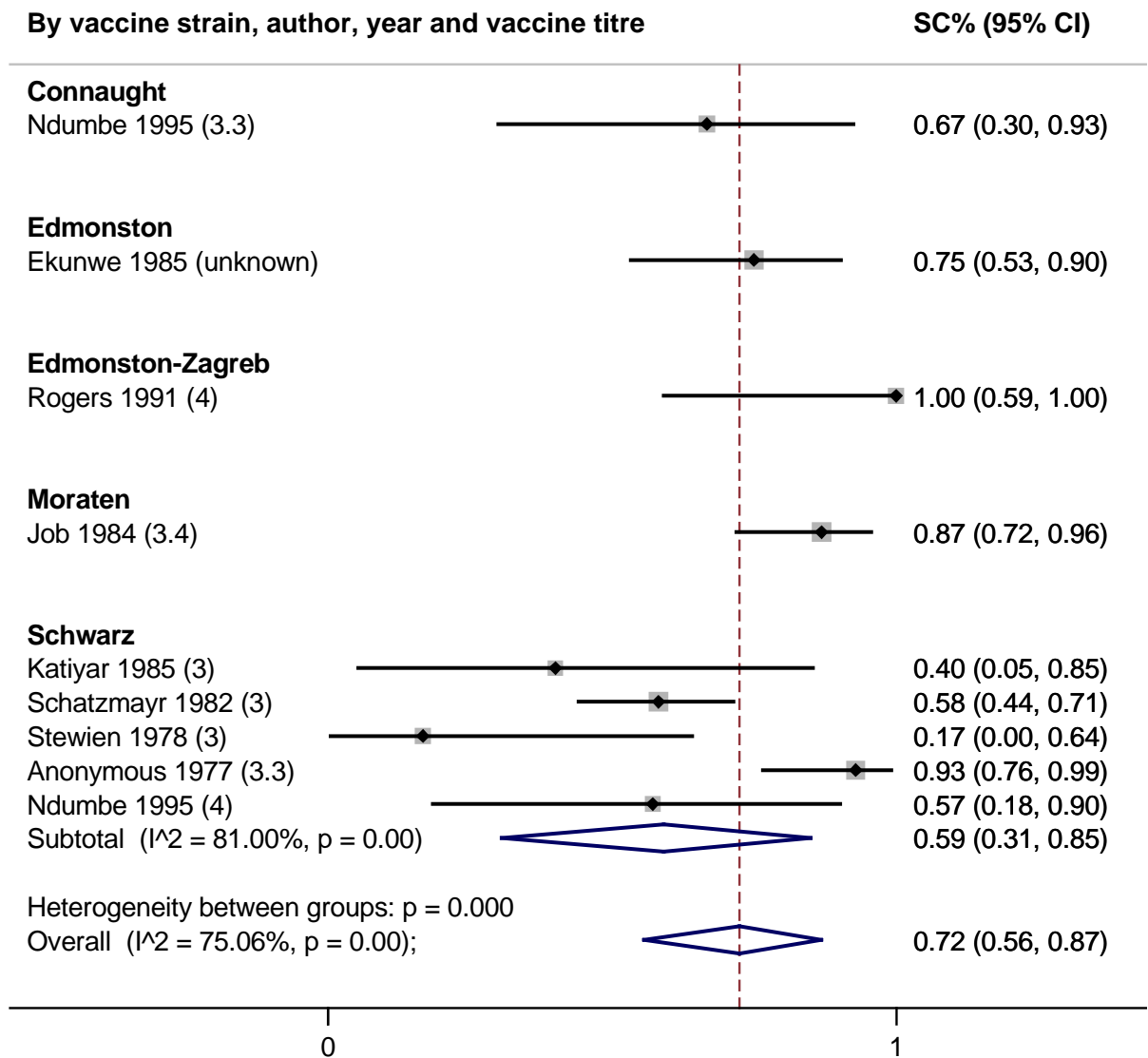
Figure 1: Random effects meta-analysis of the percentage seroconverted after MCV1 in 4-month-old infants. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. SC: seroconversion. CI: confidence interval.



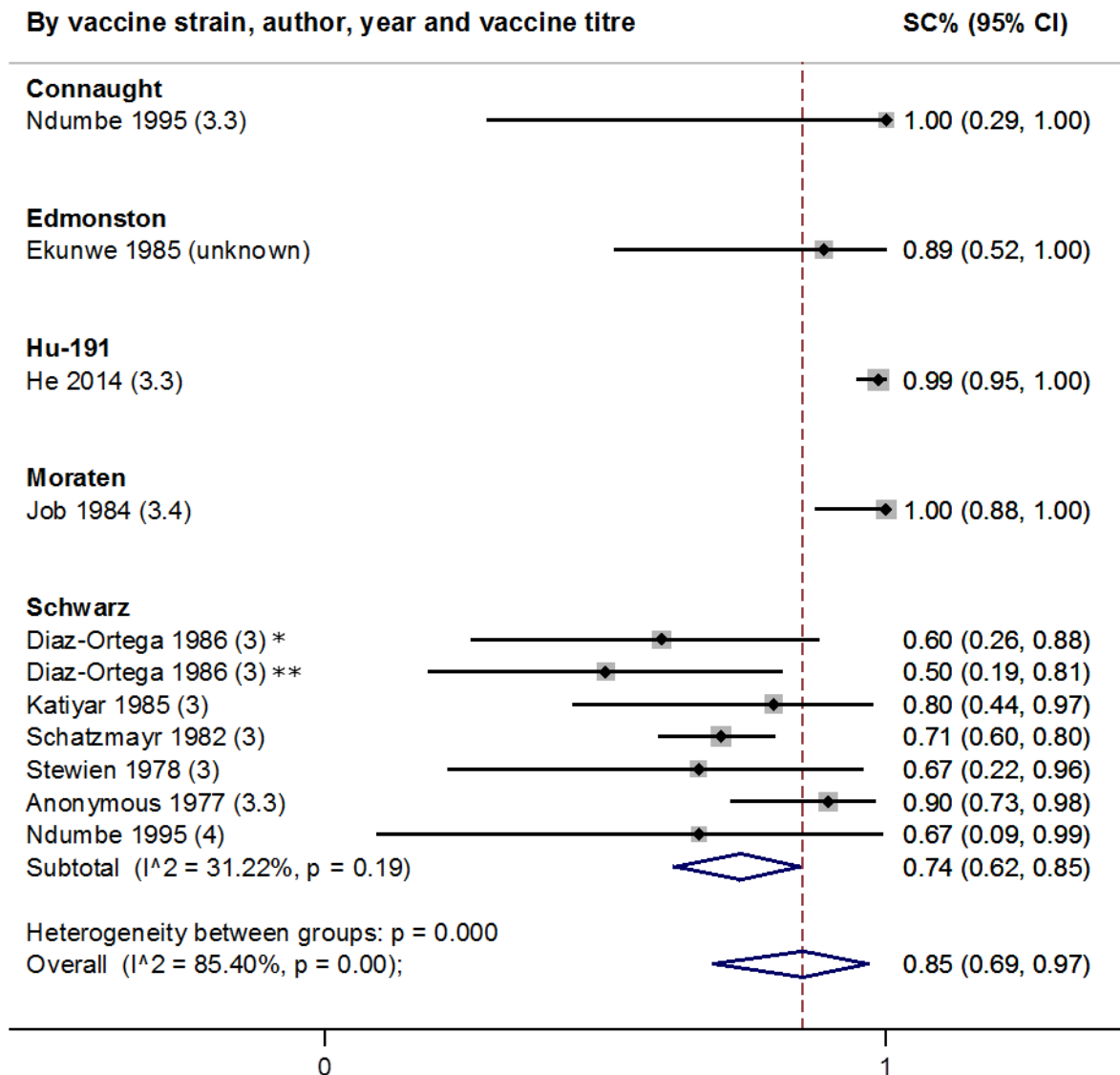
**Figure 2: Random effects meta-analysis of the percentage seroconverted after MCV1 in 5-month-old infants. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. SC: seroconversion. CI: confidence interval.**



**Figure 3: Random effects meta-analysis of the percentage seroconverted after MCV1 in 6-month-old infants. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. SC: seroconversion. CI: confidence interval.**



**Figure 4: Random effects meta-analysis of the percentage seroconverted after MCV1 in 7-month-old infants. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. SC: seroconversion. CI: confidence interval.**



**Figure 5: Random effects meta-analysis of the percentage seroconverted after MCV1 in 8-month-old infants. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. SC: seroconversion. CI: confidence interval.**

Diaz-Ortega 1986 examined two Schwarz vaccines (3 TCID<sub>50</sub>) from \*RIT and \*\*Mérieux

### Proportion seroconverted, pooled estimates per single ages and age ranges

Table 7: Sensitivity analysis of the proportion seroconverted following MCV1 <9 months pooled from meta-analysis with corresponding 95% confidence intervals (95% CI) and number of included studies presented as age ranges: a) several single ages, b) data presented as age ranges, c) a and b combined.

Age of MCV1 (months)	Seroconverted %	95% CI	Number of studies	Author, year
a) 4-5 (single)	58	44-72	3	Anonymous, 1977; Ndumbe <i>et al.</i> , 1995; Rogers <i>et al.</i> , 1991
b) 3-5 (age ranges)	55	41-69	2	Anonymous, 1981; Khanum <i>et al.</i> , 1987
c) 3-5 (combined)	56	46-66	5	Anonymous, 1977; Anonymous, 1981; Khanum <i>et al.</i> , 1987; Ndumbe <i>et al.</i> , 1995; Rogers <i>et al.</i> , 1991
a) 6-8 (single)	78	73-82	20	Abanamy <i>et al.</i> , 1992; Anonymous 1977; Bolotovskii <i>et al.</i> , 1994; Cutts <i>et al.</i> , 1994; Diaz-Ortega <i>et al.</i> , 1986; Ekunwe <i>et al.</i> , 1985; Gans <i>et al.</i> , 2013; He <i>et al.</i> , 2014; Job <i>et al.</i> , 1984; Johnson <i>et al.</i> , 1994; Katiyar <i>et al.</i> , 1985; Markowitz <i>et al.</i> , 1990; Ndumbe <i>et al.</i> , 1995; Nkrumah <i>et al.</i> , 1998; Pabst <i>et al.</i> , 1999; Pan American Health Organization, 1982; Rogers 1991; Schatzmayr <i>et al.</i> , 1982; Semba <i>et al.</i> , 1995; Stewien <i>et al.</i> , 1978
b) 6-8 (age ranges)	65	50-79	4	Anonymous, 1981; Carson <i>et al.</i> , 1995; Fernandez de Castro <i>et al.</i> , 1986; Mandara <i>et al.</i> , 1985
c) 6-8 (combined)	76	72-81	24	Abanamy <i>et al.</i> , 1992; Anonymous 1977; Anonymous, 1981; Bolotovskii <i>et al.</i> , 1994; Carson <i>et al.</i> , 1995;

Cutts et al., 1994; Diaz-Ortega et al., 1986; Ekunwe et al., 1985; Fernandez de Castro et al., 1986; Gans et al., 2013; He et al., 2014; Job et al., 1984; Johnson et al., 1994; Katiyar et al., 1985; Mandara et al., 1985; Markowitz et al., 1990; Ndumbe et al., 1995; Nkrumah et al., 1998; Pabst et al., 1999; Pan American Health Organization, 1982; Rogers et al., 1991; Schatzmayr et al., 1982; Semba et al., 1995; Stewien et al., 1978



## Univariable meta-regression results for seroconversion

**Table 8: Univariable meta-regression model of the association between seroconversion after MCV1 <9 months and age, vaccine strain, vaccine titre, decade of data collection, continent of study and type of test (N=57 observations from 20 publications)**

Independent variable	Coefficient	95% CI		P value
		Lower limit	Upper limit	
<b>Age at MCV1 (months)</b>	0.0616	0.0047	0.1185	0.034
<b><u>Vaccine strain</u></b>				
Schwarz	Reference	-	-	-
Edmonston-Zagreb	0.1410	0.0155	0.2665	0.029
Edmonston-Zagreb Mexico	0.2798	0.1075	0.4520	0.002
AIK-C	0.1475	0.0075	0.2876	0.039
Moraten	0.0299	-0.1205	0.1803	0.691
Edmonston	0.1013	-0.1627	0.3653	0.444
Leningrad-16	0.0942	-0.0780	0.2664	0.277
Connaught	0.0532	-0.1678	0.2742	0.63
Hu191	0.3205	0.0825	0.5584	0.009
<b><u>Vaccine titre</u></b>				
<b>Log titre (either pfu or TCID)</b>	0.1054	0.0187	0.1920	0.018
<b><u>Decade of data collection</u></b>				
1970s	Reference	-	-	-
1980s	0.1007	-0.0917	0.2930	0.299
1990s	0.2025	0.0301	0.3749	0.022
2010s	0.3343	0.0743	0.5943	0.013
<b><u>Continent of study</u></b>				
Africa	Reference	-	-	-
Asia	0.0504	-0.0701	0.1708	0.405
North America	0.0569	-0.0778	0.1915	0.401
South America	-0.1237	-0.2991	0.0516	0.163
<b><u>Type of test</u></b>				
PRNT	Reference	-	-	-
ELISA	-0.0037	-0.1665	0.1590	0.964
HIA	-0.0757	-0.1803	0.0289	0.152
Other test	-0.1684	-0.3355	-0.0014	0.048

TCID<sub>50</sub>, 50% Tissue Culture Infective Dose; pfu, plaque-forming unit; PRNT, plaque reduction neutralization testing; ELISA, enzyme-linked immunosorbent assay; HIA, hemagglutination inhibition assay

## Multivariable meta-regression results for seroconversion

Table 9. Multivariable meta-regression model of the association between seroconversion after MCV1 <9 months and age, vaccine strain, and vaccine titre. (N=53 observations from 20 publications)

Independent variable	Coefficient	95% CI		P value
		Lower limit	Upper limit	
Age at MCV1 (months)	0.0863	0.0220	0.1505	0.010
<b>Vaccine strain<sup>1</sup></b>				
Schwarz	Reference	-	-	-
Edmonston-Zagreb	0.0868	-0.0340	0.2076	0.155
Edmonston-Zagreb Mexico	0.2314	0.0766	0.3862	0.004
AIK-C	0.1052	-0.0250	0.2353	0.110
Moraten	0.1236	-0.0668	0.3139	0.197
Leningrad-16	0.0742	-0.0766	0.2250	0.326
Connaught	0.1460	-0.0748	0.3668	0.189
Hu191	0.2108	-0.0225	0.4440	0.075
<b>Vaccine titre</b>				
Log titre (either pfu or TCID)	0.1296	0.0352	0.2241	0.008

<sup>1</sup>Edmonston strain was dropped because titre information was missing  
TCID<sub>50</sub>, 50% Tissue Culture Infective Dose; pfu, plaque-forming unit; PRNT, plaque reduction neutralization testing; ELISA, enzyme-linked immunosorbent assay; HIA, hemagglutination inhibition assay

# Proportion seroconverted head-to-head comparison of 6-month-old infants vaccinated with Schwarz or Edmonston-Zagreb

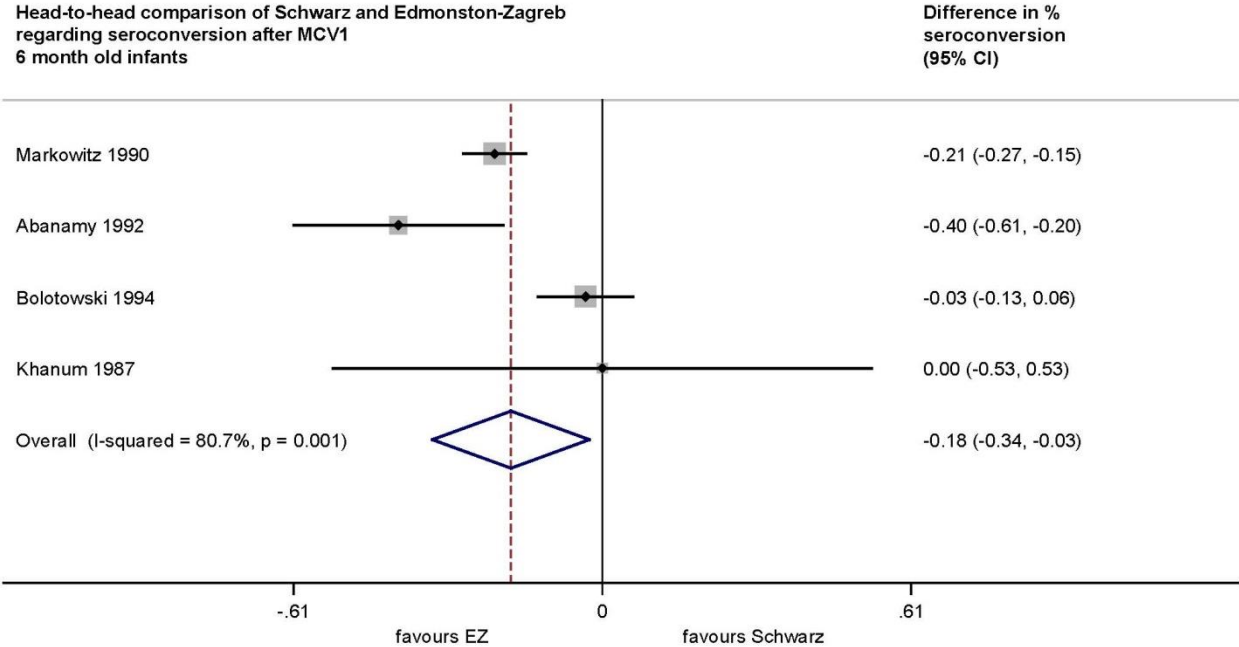
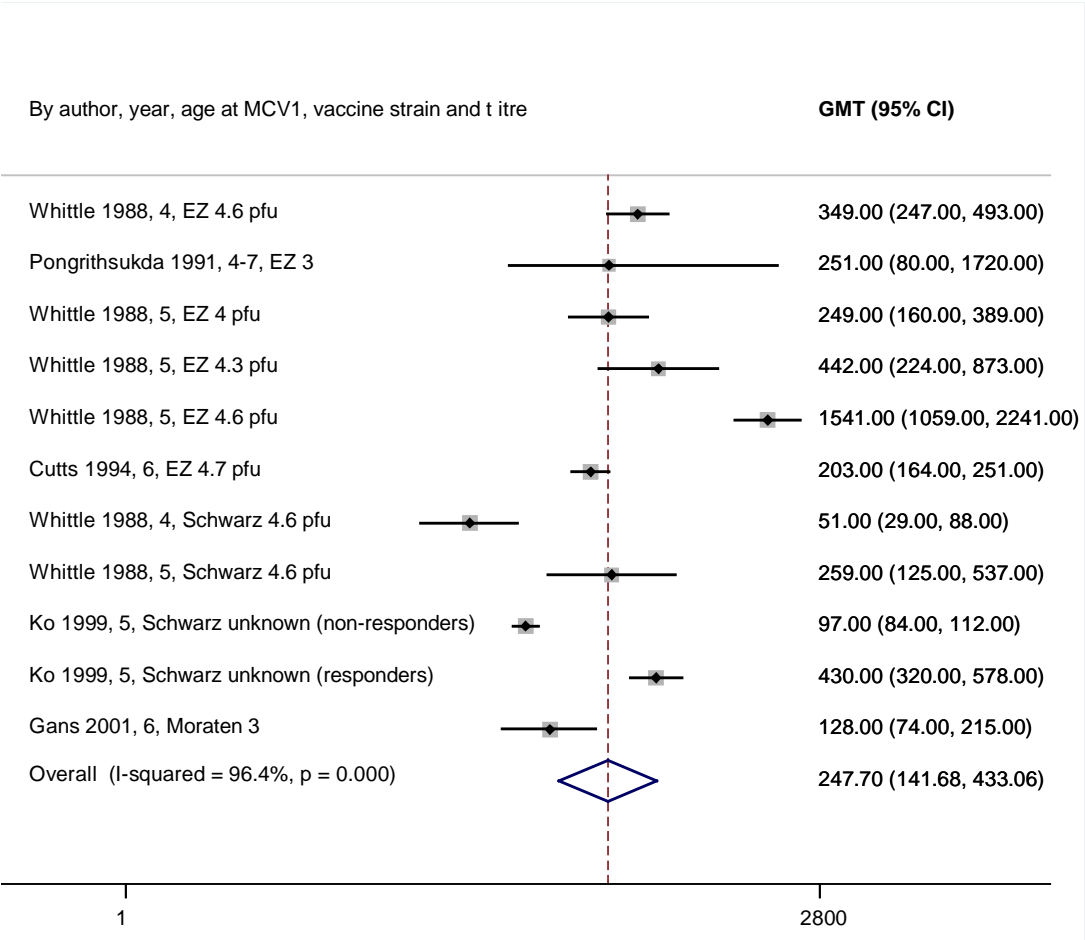


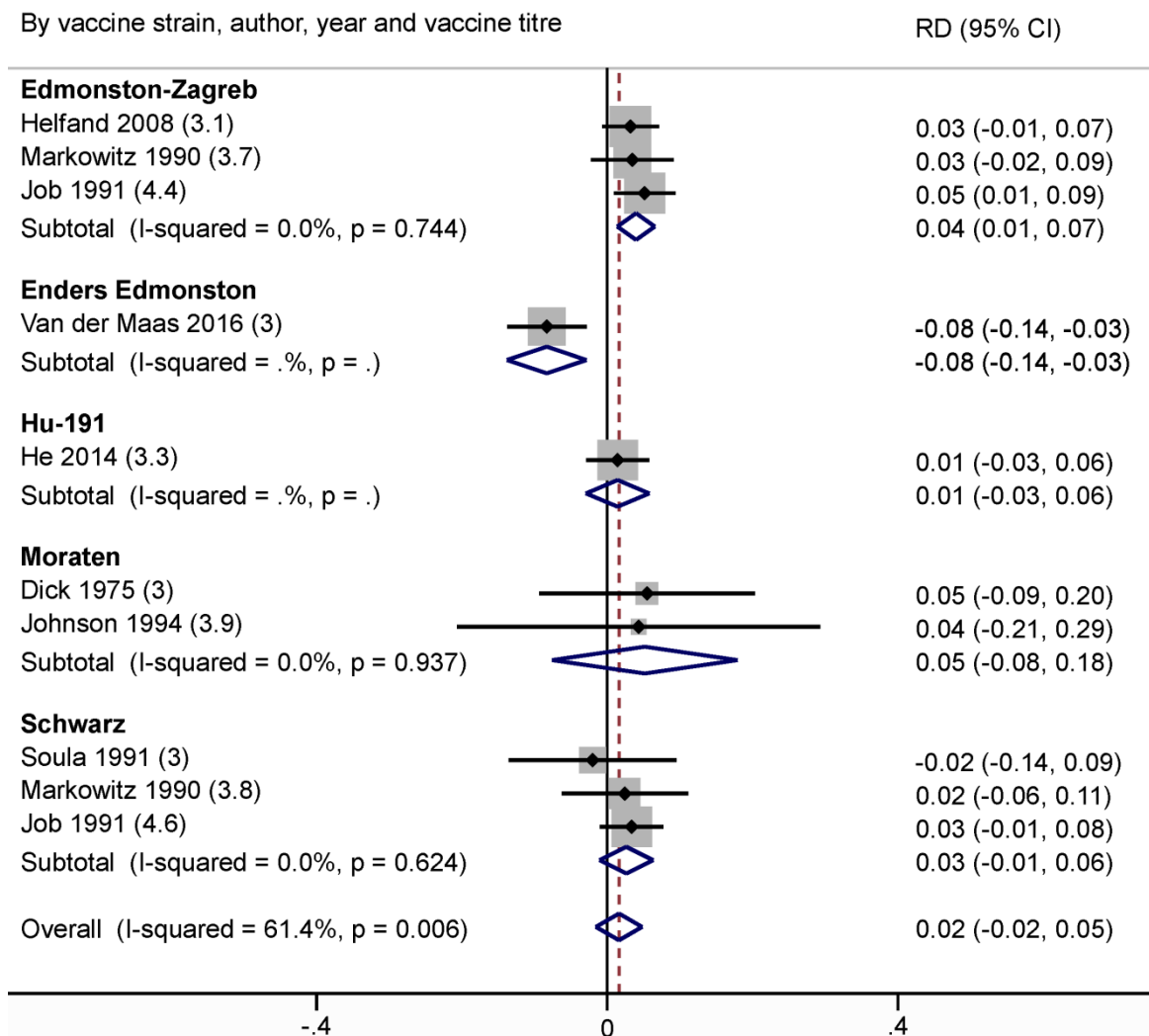
Figure 6: Random effects meta-analysis of the difference in proportion seroconverted after either Edmonston-Zagreb or Schwarz strain vaccination at 6 months of age. CI: confidence interval. EZ: Edmonston-Zagreb.

**Forest plot with geometric mean titre (GMT) results from plaque reduction neutralization testing (PRNT) with accompanying confidence intervals or standard errors following MCV1 <9 months of age**

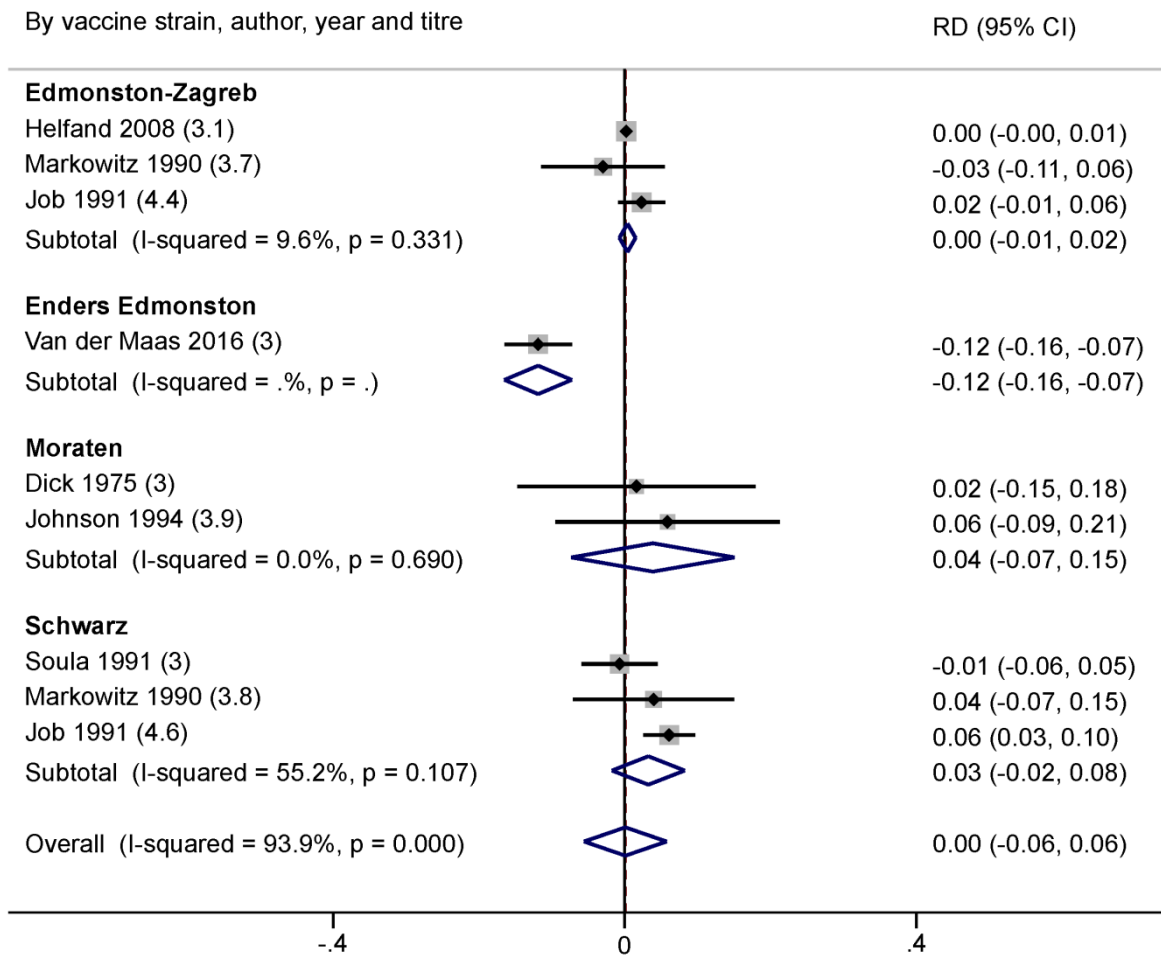


**Figure 7: Random effects meta-analysis geometric mean titres with plaque reduction neutralization testing (PRNT) after MCV1 in infants aged <9 months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. GMT: geometric mean titre. CI: confidence interval.**

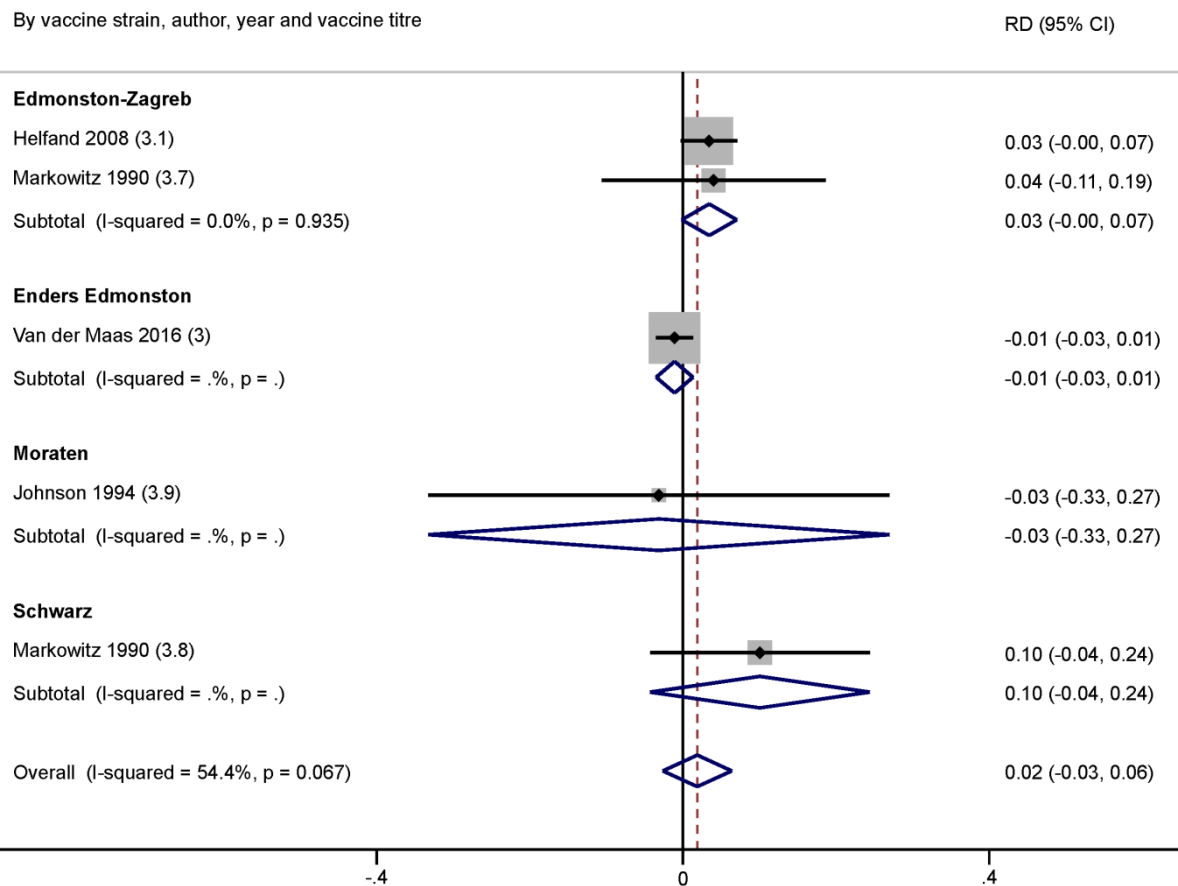
## Forest plots for safety



**Figure 8: Random effects meta-analysis of within-study comparisons of fever after MCV1 in infants aged  $\geq$  or  $<9$  months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. RD: risk difference. CI: confidence interval. A positive risk difference indicates a higher risk in infants  $<9$  months of age.**



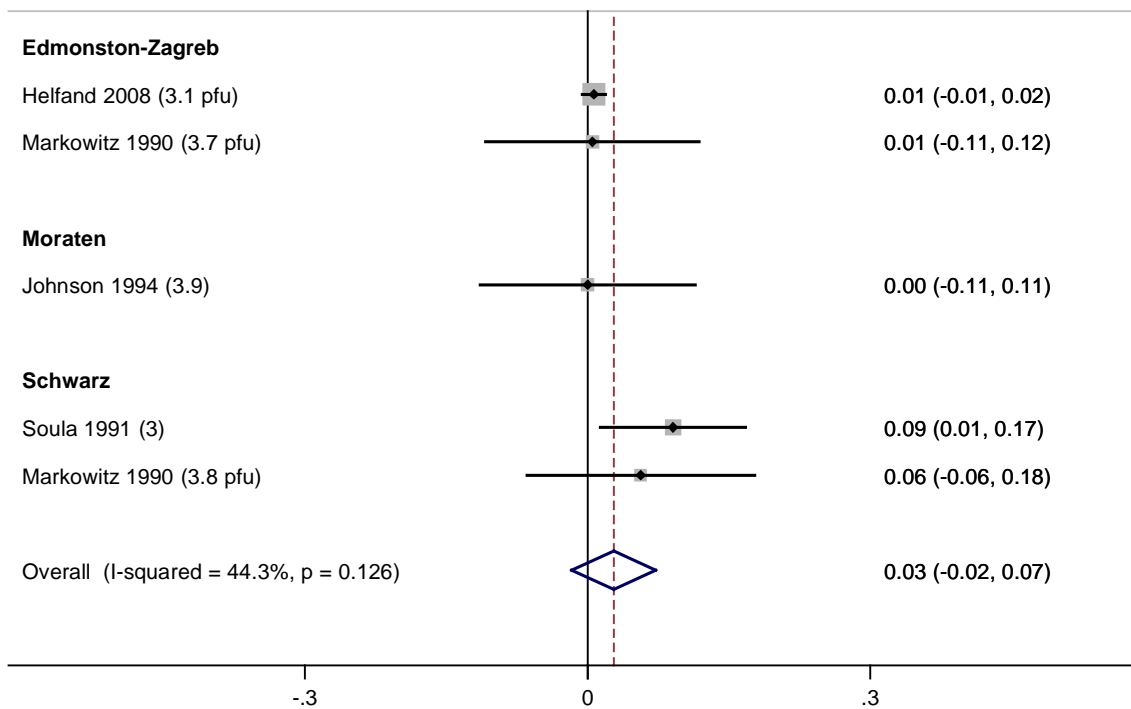
**Figure 9: Random effects meta-analysis of within-study comparisons of rash after MCV1 in infants aged  $\geq$  or  $<$ 9 months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. RD: risk difference. CI: confidence interval. A positive risk difference indicates a higher risk in infants  $<$ 9 months of age.**



**Figure 10: Random effects meta-analysis of within-study comparisons of diarrhoea after MCV1 in infants aged  $\geq$  or  $<$ 9 months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. RD: risk difference. CI: confidence interval. A positive risk difference indicates a higher risk in infants  $<$ 9 months of age.**

By vaccine strain, author, year and vaccine titre

RD (95% CI)



**Figure 11: Random effects meta-analysis of within-study comparisons of conjunctivitis after MCV1 in infants aged  $\geq$  or  $<$ 9 months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. RD: risk difference. CI: confidence interval. A positive risk difference indicates a higher risk in infants  $<$ 9 months of age.**



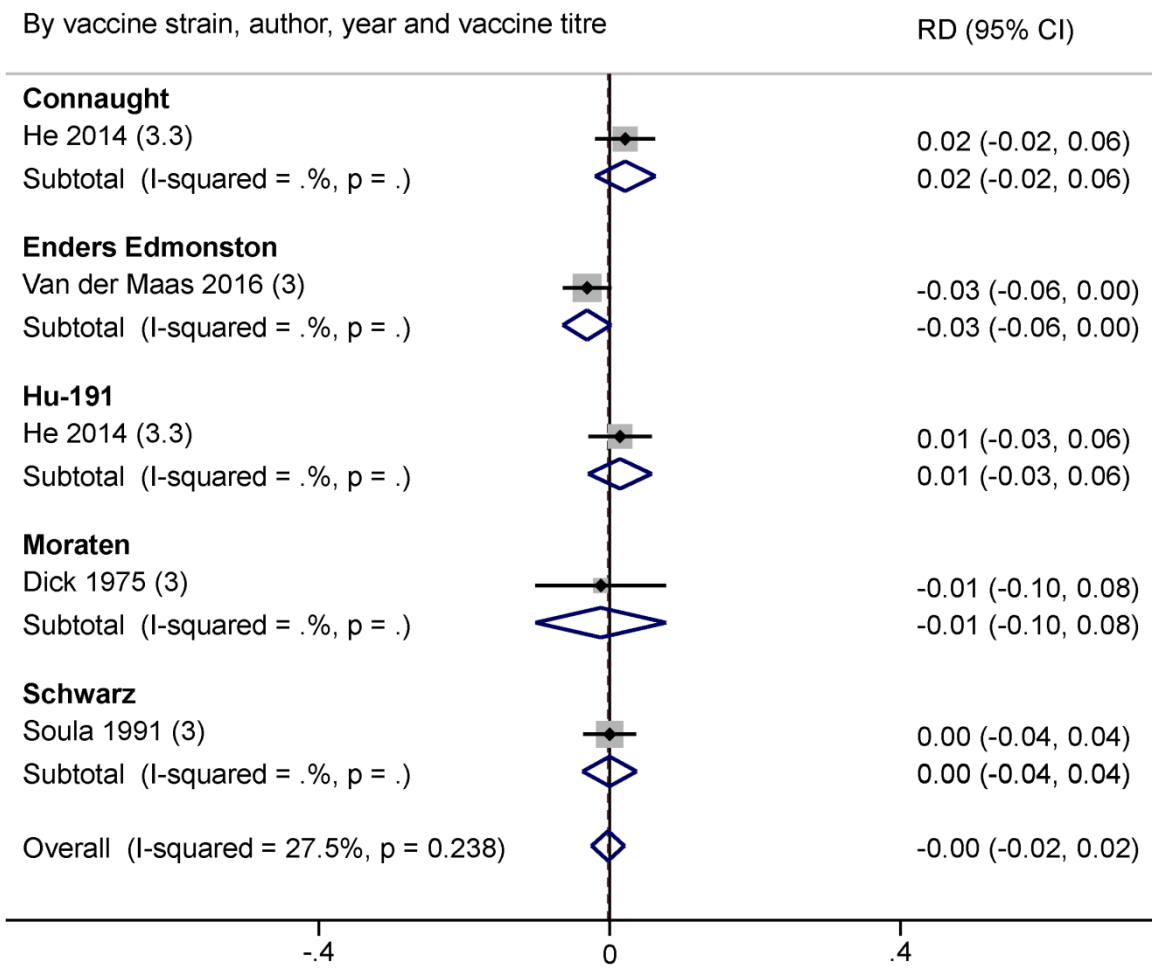


Figure 12: Random effects meta-analysis of within-study comparisons of local reactions at the injection site (redness, swelling) after MCV1 in infants aged  $\geq$  or  $<9$  months. Titres are expressed as TCID<sub>50</sub> unless specified otherwise. RD: risk difference. CI: confidence interval. A positive risk difference indicates a higher risk in infants  $<9$  months of age.

## GRADE summary of evidence table

Table 10: GRADE summary of evidence table

Quality assessment							Summary of findings				Quality	Importance
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	No of patients		Effect			
							Intervention	Control	Relative (95% CI)	Absolute		
<b>Immunogenicity</b>												
23	Observational	No serious limitations	No serious inconsistency	No serious indirectness	Serious <sup>1</sup>	Many studies had high loss to follow-up. Dose-response gradients for age and seroconversion.	#	#	#	#	⊕⊕○○ Low	IMPORTANT
12	RCT	No serious limitations	No serious inconsistency	No serious indirectness	Serious <sup>1</sup>	Lack of methodological information.	#	#	#	#	⊕⊕⊕○ Moderate	IMPORTANT
<b>Duration of immunity</b>												
2	Observational	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	Very few studies available.	#	#	#	#	⊕⊕○○ Low	IMPORTANT
1	RCT	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	Lack of methodological information.	#	#	#	#	⊕⊕⊕○ Moderate	IMPORTANT
<b>Vaccine effectiveness/ efficacy</b>												
9	Observational	Serious limitations <sup>2</sup>	No serious inconsistency	No serious indirectness	Serious <sup>1</sup>	Very few studies available. Heterogeneity between studies.	#	#	#	#	⊕○○○ Very low	IMPORTANT
2	RCT	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	Lack of methodological information.	#	#	#	#	⊕⊕⊕○ Moderate	IMPORTANT
<b>Safety</b>												
5	Observational	Serious limitations <sup>3</sup>	No serious inconsistency	No serious indirectness	No serious imprecision	In many studies, clear case definitions (e.g. for fever) are lacking.	#	#	#	#	⊕○○○ Very low	IMPORTANT
10	RCT	Serious limitations <sup>3</sup>	No serious inconsistency	No serious indirectness	No serious imprecision	Lack of methodological information. In many studies, clear case definitions (e.g. for fever) are lacking.	#	#	#	#	⊕⊕○○ Low	IMPORTANT

1: very wide confidence intervals;

2: mainly due to lack of laboratory confirmation of measles cases;

3: most studies lack an unvaccinated control group of the same age; this is important for safety results because fever and rash occur more often in younger infants due to other causes.

#: summary estimates per intervention or control group are not applicable

## Multivariable meta-regression results for seroconversion in the absence or presence of maternal antibodies

Table 11. Multivariable meta-regression of the association between seroconversion after MCV1 <9 months in the absence or presence of maternal antibodies, adjusted for age. (N=66 observations from 16 publications)

Independent variable	Coefficient	95% CI		P value
		Lower limit	Upper limit	
Age at MCV1 (months)	0.0689	0.0164	0.1213	0.011
<b><u>Maternal antibodies</u></b>				
Absence of maternal antibodies	Reference	-	-	-
Presence maternal antibodies	-0.3317	-0.4557	-0.2078	<0.001