

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. Effect of measles vaccination in infants younger than 9 months on the immune response to subsequent measles vaccine doses: a systematic review and meta-analysis. *Lancet Infect Dis* 2019; published online Sept 20. [https://doi.org/10.1016/S1473-3099\(19\)30396-2](https://doi.org/10.1016/S1473-3099(19)30396-2).

Supplementary webappendix for:

Effect of measles vaccination in infants younger than 9 months on the immune response to subsequent measles vaccine doses: a systematic review and meta-analysis

Table of Contents

Database search strategy 2

Decision rules for data selection and extraction processes 8

 Eligibility criteria 8

 Exclusion criteria 8

Characteristics of studies included in the review by outcome 9

Random effects meta-analysis of difference in proportion seropositive after MCV2 from within-study comparisons of MCV1<9 versus ≥9 months. 11

GRADE summary of evidence table..... 12

Database search strategy

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

Database	Strategy
PubMed, MEDLINE	<p>1 ((measles[ti] OR mmr*[ti] OR schwarz[ti] OR moraten[ti] OR edmonston[ti] OR edmonstonzagreb[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"[mj])) 6.215</p> <p>3 ("measles virus/immunology"[mj] OR "measles/immunology"[mj]) 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 "0 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 "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</p>

"first 4 months"[tiab] OR "first 5 months"[tiab] OR "first 6 months"[tiab] OR "first 7 months"[tiab] 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"[mh] 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 elisa: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

Scopus

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 (immunoglobulin-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

Proquest

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)
31. S29 AND S30

WHO LIS

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

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

Decision rules for data selection and extraction processes

Table 2: Decision rules for data selection and extraction processes

Eligibility criteria

Types of studies

- 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).

Types of participants

- Infants <9 months of age receiving their first dose of a MCV.

Types of intervention

- Any currently licensed MCV administered to infants <9 months of age. A currently licensed MCV can be:
 - Monovalent vaccine: Schwarz, Moraten, Edmonston, Edmonston-Zagreb, Leningrad-16, Shanghai-191, CAM-70, AIK-C and TD97.
 - 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).

Minimum data requirements

- 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.

Exclusion criteria

- Ecological studies, case reports, non-human primate studies, meeting abstracts, editorials, newspaper articles and other forms of popular media were excluded.
- High titre vaccines were excluded from the review, defined as vaccines with a TCID₅₀ of ≥ 4.7 or p.f.u. of $\geq 50,000$ (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.
- Failure to meet any one of the above eligibility criteria.

Characteristics of studies included in the review by outcome

Table 3: Characteristics of studies included in the review by outcome

Author, year	Country	MCV1 age (months)	MCV2/3 age (months)	Vaccine Strain	Time between vaccination and sampling	Type of test used	Immunogenicity				VE
							Seropositivity	GMT	Cellular	Avidity	
Abanamy <i>et al.</i> , 1992	Saudi Arabia	6, 9	15	Schwarz, Edmonston-Zagreb	2 months	EIA	Yes	-	-	-	-
Benn <i>et al.</i> , 1997	Guinea-Bissau	6	9	Schwarz	9 months	HIA	Yes	-	-	-	-
Carson <i>et al.</i> , 1995	Canada	6-8.5	15-18	Connaught	4-6 weeks	PRNT	Yes	-	-	-	-
Carson <i>et al.</i> , 2005	Canada	6	15	AIK-C, Connaught, MMR	1 year	PRNT	Yes	-	-	-	-
Davis <i>et al.</i> , 1987	USA	<9, ≥9	≥15	Unknown	-	-	-	-	-	-	Yes
Fisker <i>et al.</i> , 2017	Burkina Faso; Guinea Bissau	4.5, 9	9	Edmonston-Zagreb,	4.5 / 15 months	EIA	Yes	-	-	-	-
Fowlkes <i>et al.</i> , 2016	Malawi	6,9	9, 20	Edmonston-Zagreb	11 months, 9-12 months	PRNT	-	Yes	-	-	-
Gans <i>et al.</i> , 1999, 2001, 2003, 2004, 2013	USA	6,9	12	Moraten	24 weeks	PRNT	Yes	Yes	Yes	-	-
Garly <i>et al.</i> , 2001	Guinea-Bissau	6	9	Edmonston-Zagreb, Schwarz	6 months	HIA	Yes	-	-	-	-
He <i>et al.</i> , 2014	China	8,12	18	Hu-191	30-35 days	ELISA	Yes	Yes	-	-	-
Helfand <i>et al.</i> , 2008	Malawi	6	9	Edmonston-Zagreb	3 months	EIA	Yes	-	-	-	-
Johnson <i>et al.</i> , 1994	USA	6	15	Moraten	3 /4 weeks	EIA	Yes	-	-	-	-
Kaninda <i>et al.</i> , 1998	Niger	6-8	9	Schwarz	-	-	-	-	-	-	Yes
Khalil <i>et al.</i> , 1999	Saudi Arabia	6	12	Edmonston-Zagreb	2 months	PRNT	Yes	-	-	-	-

Martins <i>et al.</i> , 2014	Guinea-Bissau	4	9	Edmonston-Zagreb, Schwarz	6/ 15 months	HIA	Yes	-	-	-	Yes
Nair <i>et al.</i> , 2007	USA	6,9	12	Moraten	24 weeks	PRNT	-	-	-	Yes	-
Njie-Jobe <i>et al.</i> , 2012	Gambia	4	9, 36	Edmonston-Zagreb	2 weeks	HIA	Yes	Yes	Yes	-	-

Random effects meta-analysis of difference in proportion seropositive after MCV2 from within-study comparisons of MCV1<9 versus ≥9 months.

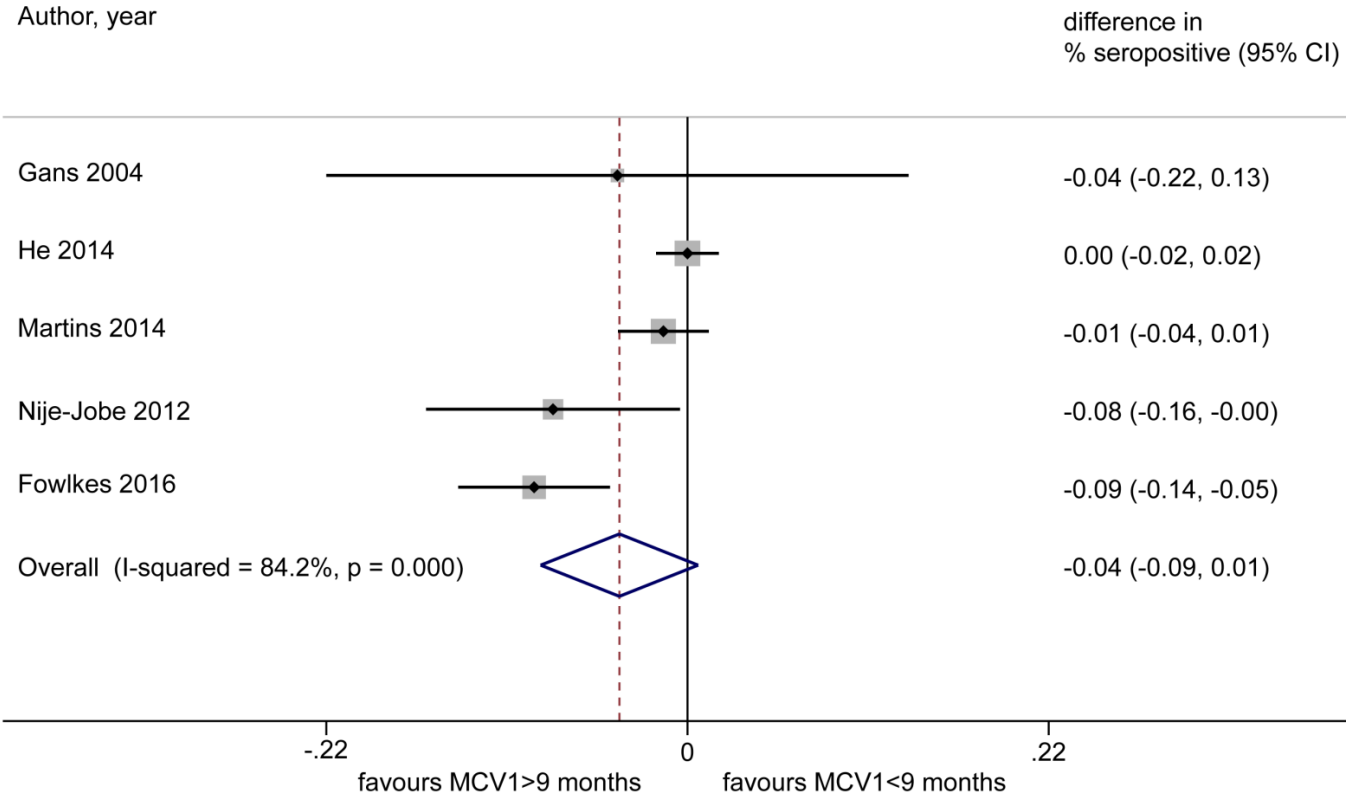


Figure 1: Random effects meta-analysis of difference in proportion seropositive after MCV2 from within-study comparisons of MCV1<9 versus ≥9 months.

GRADE summary of evidence table

Table 4: GRADE summary of evidence table

Quality assessment							Summary of findings					Importance
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	No of patients		Effect		Quality	
							Intervention	Control	Relative (95% CI)	Absolute		
Immunogenicity												
9	Observational	No serious limitations	No serious inconsistency	No serious indirectness	Serious ¹	Many studies had high loss to follow-up. Very few studies available. Small sample size.	#	#	#	#	⊕○○○ Very low	IMPORTANT
10	RCT	No serious limitations	No serious inconsistency	No serious indirectness	Serious ¹	Lack of methodological information.	#	#	#	#	⊕⊕⊕○ Moderate	IMPORTANT
Duration of immunity												
0	-	-	-	-	-	-	#	#	#	#	-	-
Vaccine effectiveness/ efficacy												
2	Observational	No serious limitations	No serious inconsistency	No serious indirectness	Serious ¹	Very few studies available. Small sample size.	#	#	#	#	⊕○○○ Very low	IMPORTANT

¹ Very wide confidence intervals.

#: no summary estimates per intervention or control group are applicable