UK Health Security Agency

Routes of transmission of meningococcal infection

A systematic evidence summary

Contents

Main messages

1. This systematic evidence summary (search up to 26 March 2026) identified and summarised evidence relating to the most common routes of transmission of meningococcal infection.

2. Three studies were included, of which 2 were case series (1, 2), and one was an outbreak report (3). One study was conducted in New Zealand (1), one in the UK (2), and one in the USA (3). Transmission events were reported in clusters of 2 to 3 individuals. One study reported on meningococcal serogroup B (1), one reported on meningococcal serogroup C (3), and one could not determine the meningococcal serogroup (2).

3. Two studies (one case series and one outbreak report) reported on presumed sexual transmission of meningococcal infection: one in meningococcal serogroup B (1), and one with undetermined meningococcal serogroup (2). One case series reported on presumed transmission through infectious respiratory secretions (meningococcal serogroup C) (3).

4. No evidence was identified on routes of transmission for meningococcal serogroups A, W, X, or Y, nor for the transmission routes of direct contact or fomites. No evidence was identified in children.

5. Critical appraisal was not performed, which restricts the interpretation of the findings, although limitations of the evidence have been highlighted. The available studies where transmission of meningococcal infection had occurred all only had a small number of transmission events, and so may not be generalisable to wider populations. Included evidence consisted of case series and outbreak reports, which are generally considered lower-quality study designs and more likely to be affected by methodological limitations such as recall bias, incomplete reporting and not adjusting for other factors that may have affected the outcome.

6. In summary, available evidence on the routes of transmission was limited in both quantity and quality. Although some evidence was identified suggesting the possibility of sexual transmission, and one study through infectious respiratory secretions, these were not confirmed and so other transmission routes (such as direct contact) may have contributed. It is not possible from the available evidence to conclude what the most common routes of transmission of meningococcal infection are. No evidence was identified in this systematic evidence summary for direct contact or fomite transmission, but this should not be taken as confirmation that this does not occur.

Purpose

The purpose of this systematic evidence summary was to identify and summarise the available evidence to determine the most common routes of transmission for meningococcal infection, considering all meningococcal serogroups.

The review question was:

1. What are the most common routes of transmission for meningococcal infection in humans?

This systematic evidence summary was commissioned to help inform the UKHSA response to the meningococcal disease outbreak in Kent in March 2026.

Methods

A systematic evidence summary was conducted, following streamlined rapid systematic review methods to accelerate the review process. A literature search was undertaken to look for relevant observational (cohort, cross-sectional or case-control) or descriptive (case series or outbreak reports), published or available as preprints, up to 26 March 2026. Three databases were searched OVID Medline, OVID Embase, and Web of Science Preprint Citation Index.

Studies were included if they reported on confirmed human-to-human transmission of meningococcal infection (any meningococcal serogroup) through the following routes:

- infectious respiratory secretions (droplet or aerosol)
- direct contact
- fomite
- sexual

Studies were not included if they did not report an explicit route of transmission, such as studies that reported on risk factors for carriage or infection, or studies that reported a potential location (such as a bar, or place of education) of transmission without an explicit route. Studies that reported ‘close contact’ without an explicit route of transmission were also excluded.

A protocol was produced before the literature search was conducted, including the review question, the eligibility criteria, and all other methods. Full details of the methodology are provided in the protocol in Annexe A.

There were no deviations from the protocol, but 4 clarifications were made:

- the review question was amended from ‘meningococcal disease’ to meningococcal infection’

- outbreak reports were included regardless of whether they had been peer-reviewed
- the transmission routes ‘droplet’, ‘respiratory’, and ‘airborne or aerosol’ were changed to ‘infectious respiratory secretions (droplet or aerosol)’
- exposure was altered from ‘meningococcal disease’ to ‘meningococcal infection (at least one case confirmed with meningococcal disease)’

Screening of title and abstracts was undertaken in duplicate by 2 reviewers for 10% of records, with the remainder completed by one reviewer. Screening on full texts was undertaken by one reviewer and excluded studies were checked by a second reviewer.

Data extraction was performed by one reviewer and checked by a second.

Evidence

In total, 4,352 studies were screened at title and abstract and 139 studies were screened at full text stage. Of these, 3 studies met the inclusion criteria. A PRISMA diagram showing the flow of studies through the systematic evidence summary is shown in Annexe B, and studies excluded on full text screening are available with the reasons why in Annexe C. Study characteristics are available in Annexe D.

Of the 3 included studies, 2 were case series (1, 2) and one was an outbreak report (3). One study was conducted in New Zealand (1), one in the UK (2), and one in the USA (3). Transmission events were limited to clusters of 2 to 3 individuals.

Meningococcal serogroup B

One study was identified that reported on the route of transmission of meningococcal serogroup B (1). Findings from this study are presented in Table D.1.

Mitchell and others reported a series of 5 cases where *Neisseria meningitidis* (*N. meningitidis)* was isolated from genital swabs in people attending a sexual health clinic in New Zealand in 2007 (1). There was suspected transmission between 2 of the 5 cases. One case, a 20 year old woman presenting with intermenstrual and post coital bleeding, had throat, vaginal, cervical and urethral swabs taken. *N. meningitidis* was identified at all sites, and tests for all other sexually transmitted infections were negative. She reported unprotected vaginal and oral sex with a regular partner, a 23 year old man. A throat swab was subsequently taken from him, which was positive for meningococcal serogroup B. He did not have any symptoms, but both were treated with ciprofloxacin. A second throat swab taken 4 days later was negative for meningococcal serogroup B. It is unclear whether the woman or man was the index case, and transmission route was presumed as sexual, infection may have been transmitted through another route (such as contact with infectious respiratory secretions). There was no information on the likely route of transmission for the other cases, and no reported connection between the other cases.

Meningococcal serogroup C

One study (an outbreak report) reported on routes of transmission for meningococcal serogroup C (3). Evidence from this study is summarised in Table D.2.

The outbreak report, by Materna and others, reported transmission events of meningococcal serogroup C, after occupational contact with a person with confirmed meningococcal disease in the USA in 2009 (3). The index case, a 36 year old man, was found unconscious in his home with a partially obstructed airway and vomit and faeces on his clothes and body. Two secondary cases were subsequently reported:

1. A 30 year old man who was a police officer began experiencing symptoms 2 days after attending the scene. After hospitalisation, blood and cerebrospinal fluid samples were positive for *N. meningitidis*. He adjusted the body and head of the index case to assist with their breathing and then left the room. He reported hearing hacking and gurgling from the patient but reported no droplets on his skin nor contact with respiratory secretions. He wore gloves while attending the patient, but did not wear a mask.
2. A 47 year old man who was a respiratory therapist assisted with suction of the airway of the index case and placement of a tube into their airway. He reported symptoms 5 days after coming into contact with the index case, and blood and cerebrospinal fluid samples were positive for *N. meningitidis*. He wore gloves while attending the patient, but did not wear a mask.

The authors suggest that in both secondary cases, unprotected exposure to infectious respiratory secretions (defined by the authors as respiratory aerosols or secretions) may have resulted in the transmission of meningococcal infection.

Meningococcal serogroup not determined

One case series was identified that reported transmission of meningococcal infection where meningococcal serogroup could not be determined (2). This paper is summarised in Table D.3.

One case, a 26 year old man, presented with urethral discharge and dysuria. He reported sexual intercourse with 2 women (ages not reported), both of whom subsequently attended the clinic on his advice. Urethral swabs were taken from the man, while throat, urethral, cervical and rectal swabs were taken from the 2 women. *N. meningitidis* was isolated from the urethral swab of the man, the cervical swab of one woman and the throat swab of the other woman. Sexual transmission was presumed as the likely route by the authors, who suggested that the man acquired meningococcal infection from sexual contact with one woman via oral-genital exposure and then transmitted meningococcal infection to the second woman through vaginal sexual intercourse. However, meningococcal infection may have been transmitted through another route (such as contact with infectious respiratory secretions) due to close proximity during sexual intercourse.

Health inequalities

No evidence was identified for any of the subgroups listed in the protocol for whom the outcome of meningococcal disease may differ, such as those in school or university, those who reside in high-risk settings such as boarding school, children's homes or places of detention, or those under 18 years of age who are unvaccinated. No evidence was identified on ethnicity or deprivation.

Limitations

This systematic evidence summary used streamlined systematic methods to accelerate the rapid evidence summary process. Sources of evidence searched included databases of peer-reviewed and preprint research, but an extensive search of other sources was not conducted and most article screening was completed without duplication, so it is possible relevant evidence may have been missed.

Critical appraisal was not performed due to the rapid completion of this work. This restricts the interpretation of the findings, but the main limitations have been highlighted. Included studies were case series and outbreak reports. Evidence from these sources is generally considered of lower quality, and there are important methodological considerations (including incomplete reporting of linked cases, and uncertainties around exposures and potential transmission events) that limit the ability to interpret the evidence identified. There was only available evidence for 2 to 3 people per study where likely transmission route could be identified. This is too few to be able to make any conclusions on common transmission routes. Two of the 3 included studies reported sexual transmission, however, it is possible that other transmission routes could have also contributed to transmission. The fact that 2 out of 3 studies highlighted sexual transmission could be an overrepresentation of what occurs, as case series or outbreak reports tend to present unexpected events. It is also unlikely that these studies identified all cases related to the outbreaks – asymptomatic or mild cases may have been missed.

The available evidence on routes of transmission of meningococcal infection was very limited. It can be difficult to determine the route of transmission, for example while sexual transmission may be presumed, there is the potential that other routes of transmission (such as respiratory or direct contact) may have contributed. In general, the route of transmission of meningococcal infection was not well documented. This may be due to limited transmissibility, the unpredictability of transmission events, or that asymptomatic carriage of *N. meningitidis* in the population is common, making it difficult to identify a single source of transmission. In addition, there may have been rapid deployment of antibiotics to identified close contacts of cases which would make sustained transmission unlikely.

This evidence summary sought to identify evidence on the route of transmission of meningococcal infection and so did not include studies that reported on risk factors for carriage

or infection, nor studies that reported a potential location of transmission without an explicit route. Studies that reported ‘close contact’ without an explicit route of transmission were also excluded. Evidence from such studies may be able to provide additional information to inform most common transmission route.

Evidence gaps

This evidence summary identified available evidence on the most common routes of transmission of meningococcal infection. Evidence was limited for meningococcal serogroups B and C. No evidence was identified for meningococcal serogroups A, W, X, or Y.

Although evidence on direct contact, fomite, infectious respiratory secretions (droplet or aerosol), or sexual transmission was searched for, the only evidence identified was for sexual and infectious respiratory secretions (droplet or aerosol). No evidence was identified that specified transmission through direct contact or fomite transmission.

No evidence was identified in children and only one study included a transmission event between young adults (1).

Conclusion

This systematic evidence summary identified 3 studies that reported on routes of transmission of meningococcal infection, where confirmed transmission events had occurred; 2 studies reported on presumed sexual transmission, and one reported on suspected transmission through infectious respiratory secretions. However, it can be difficult to determine route of transmission, as for example while sexual transmission was presumed in 2 of the included studies, there is the potential that other routes of transmission (such as infectious respiratory secretions or direct contact) may have contributed.

Critical appraisal was not performed, which restricts the interpretation of the findings. However, important limitations have been highlighted in this report, most notably the very small numbers of people in whom a possible transmission route was described. The route of transmission of meningococcal infection was not well documented, and evidence was limited to outbreak reports and case series. From the identified evidence, it is not possible to conclude what the most common routes of transmission of meningococcal infection are.

Acknowledgments

We would like to thank colleagues within the All Hazards Public Health Response division who either reviewed or input into aspects of the evidence summary.

Disclaimer

UKHSA's rapid reviews and evidence summaries aim to provide the best available evidence to decision makers in a timely and accessible way, based on published peer-reviewed scientific papers, and papers on preprint servers. Note that the reviews:

- use accelerated methods and may not be representative of the whole body of evidence publicly available
- have undergone an internal independent peer review but not an external peer review
- are only valid as of the date stated on the review

In the event that this evidence summary is shared externally, note additionally, to the greatest extent possible under any applicable law, that UKHSA accepts no liability for any claim, loss or damage arising out of, or connected with the use of, this review by the recipient or any third party including that arising or resulting from any reliance placed on, or any conclusions drawn from, the review.

References

1. Mitchell L and others. 'An unexpected increase in Neisseria meningitidis genital isolates among sexual health clinic attendees, Hamilton, New Zealand' Sexually Transmitted Diseases 2008: volume 35, issue 5, pages 469 to 471
2. Talbot MD and others. 'Presumed sexual transmission of meningococci' Journal of Infection 1981: volume 3, issue 3, pages 273 to 276
3. Materna. 'Occupational transmission of *Neisseria meningitidis* --- California, 2009' MMWR - Morbidity and Mortality Weekly Report 2010: volume 59, issue 45, pages 1,480 to 1,483

Annexe A. Protocol

Review question

The review question is:

1. What are the most common routes of transmission for meningococcal infection in humans?

A search for primary evidence to answer this review question will be conducted up to 26 March 2026.

Eligibility criteria

Table A.1 Inclusion and exclusion criteria

	Included	Excluded

Population	Humans (any age):
	• children (aged up to and including 17 years)
	  • 0 to 4 years, 5 to 11 years, 12 to 17 years
	• adults (18 years and over)
	  • young adults 18 to 25 years
		Animals

Settings	Any	
Intervention or exposure	Meningococcal infection (at least one case confirmed with meningococcal disease)	
Outcomes	Confirmed human-to-human transmission through the following routes: • infectious respiratory secretions (droplet or aerosol) • direct contact • fomite • sexual	Animal-to-human transmission
Language	English	Any other language
Date of publication	Up to 26 March 2026	
Study design	Observational studies: case-control, cross-sectional, and cohort studies	Experimental studies (randomised-controlled trials, quasi-experimental studies, cross-over

	Included	Excluded
	Descriptive studies including case series or outbreak reports	designs, before-and-after studies) Systematic or narrative reviews Modelling studies Case reports
Publication type	Peer-reviewed published research Preprints	Editorials Letters News articles Grey literature Conference abstracts

Identification of studies

The following databases will be searched for studies published up to 26 March 2026: OVID Medline, OVID Embase, and Web of Science Preprint Citation Index. The search strategy is presented below.

Screening

Title and abstract screening will be undertaken in duplicate by 2 reviewers for at least 10% of the eligible studies, with the remainder completed by one reviewer. Disagreement will be resolved by discussion or with involvement of a third reviewer where necessary.

Screening on full text will be undertaken by one reviewer and checked by a second.

Data extraction

Summary information for each study will be extracted and reported in tabular form. Information to be extracted will include country, study period, study design, setting, participants, results, and any relevant contextual data. This will be undertaken by one reviewer and checked by a second.

Risk of bias assessment

Risk of bias of included studies will not be assessed in this systematic evidence summary due to time constraints, but important limitations of the evidence will be highlighted.

Synthesis

Where studies are similar enough to combine and present data in a consistent format, a narrative synthesis will be produced to interpret the findings. The number of studies, the number of participants in each study, effect size and variance and a summary of study limitations across studies reporting each outcome will be summarised and presented. Alternatively, if studies present methodological differences that would make synthesis inappropriate, a narrative summary of each study will be provided.

Results will be presented in the following sub-groups: meningitis B, all other serogroups.

Health inequalities

Variations across the following populations and subgroups for whom the outcome of meningococcal disease may differ will be considered, where evidence is available:

- those in early years and educational settings, (including nurseries, schools, further education colleges, sixth form, SEN schools, universities), considering difference by year group (both school and university)
- those who take part in behaviours that may increase transmission rates (vaping, kissing, sharing social spaces, social networks)
- children (aged under 18 years) who remain unvaccinated (under one year of age who are eligible for MenB vaccination but did not receive it, children who are unvaccinated for any other reason)
- those who reside in potentially high-risk settings for disease transmission including in education (boarding schools, university halls), and other residential settings such as children's homes, adult social care settings, prisons and places of detention, asylum and migrant settings, homeless settings
- those in different ethnic groups
- by deprivation
- those who work in or who have visited higher risk congregate workplaces or entertainment venues (warehouses, factories, nightclubs, sex on premises venues, music venues, bars, student parties, religious venues, choir practices, other crowded indoor social settings)

Search strategy

Ovid MEDLINE(R) ALL (1 January 1946 to 25 March 2026)

1. exp Meningococcal Infections/ (12,165)
2. exp Meningitis, Meningococcal/ (5,802)
3. Meningitis, Bacterial/ (8,189)
4. (meningococc* adj5 (infect* or disease* or strain* or meningit*)).tw,kf. (9,324)
5. invasive meningococc*.tw,kf. (1,696)

6. meningococcosis.tw,kf. (14)
7. (meningit* and (septic?em* or sepsis or bacter?em*)).tw,kf. (9,249)
8. (meningococc* and (septic?em* or sepsis or bacter?em*)).tw,kf. (1,979)
9. exp Neisseria meningitidis/ (10,640)
10. neisseria mening*.tw,kf. (9,638)
11. "N. meningitidis".tw,kf. (3,192)
12. (meningococc* adj2 A).tw,kf. (2,165)
13. (meningit* adj3 A).tw,kf. (11,536)
14. (meningococc* adj2 B).tw,kf. (1,726)
15. (meningit* adj3 B).tw,kf. (2,266)
16. (meningococc* adj2 C).tw,kf. (1,390)
17. (meningit* adj3 C).tw,kf. (989)
18. (meningococc* adj2 W).tw,kf. (138)
19. (meningit* adj3 W).tw,kf. (144)
20. (meningococc* adj2 X).tw,kf. (34)
21. (meningit* adj3 X).tw,kf. (77)
22. (meningococc* adj2 Y).tw,kf. (131)
23. (meningit* adj3 Y).tw,kf. (185)
24. exp Sepsis/ and Meningitis/ (1,311)
25. serogroup* A.tw,kf. (1,633)
26. serogroup* B.tw,kf. (2,466)
27. serogroup* C.tw,kf. (1,482)
28. serogroup* W-135.tw,kf. (68)
29. serogroup* X.tw,kf. (118)
30. serogroup* Y.tw,kf. (297)
31. MenA.tw,kf. (2,007)
32. MenB.tw,kf. (721)
33. MenC.tw,kf. (455)
34. MenW.tw,kf. (140)
35. MenX.tw,kf. (72)
36. MenY.tw,kf. (108)
37. or/1-36 (46,427)
38. exp Disease Transmission, Infectious/ (87,295)
39. (transmi* adj5 (route* or mode or modes or path or paths or pathway* or method* or way or ways or how or direct* or indirect* or primary or secondary or pattern* or vehicle* or window*)).tw,kf. (70,902)
40. transmi*.ti. (122,313)
41. "human to human".tw,kf. (7,811)
42. "person to person".tw,kf. (4,684)
43. transmi* between human*.tw,kf. (457)
44. transmi* between people.tw,kf. (56)
45. ((direct* or indirect* or close or transmi* or physical* or regular* or frequent* or prolonged or infect*) adj3 contact*).tw,kf. (64,352)
46. interhuman.tw,kf. (240)

47. "inter human".tw,kf. (154)
48. (inter-person* or interperson*).tw,kf. (64,732)
49. (between adj2 (person* or people or population*)).tw,kf. (56,532)
50. (within adj2 population*).tw,kf. (34,109)
51. ((communit* or disease* or infection* or population* or human* or people* or group*) adj3 spread*).tw,kf. (41,835)
52. ((communit* or disease* or infection* or population* or human* or people* or group*) adj3 contagio*).tw,kf. (7,636)
53. "skin to skin".tw,kf. (8,974)
54. "mouth to mouth".tw,kf. (738)
55. "mouth to skin".tw,kf. (172)
56. "hand to mouth".tw,kf. (1,371)
57. "face to face".tw,kf. (51,955)
58. touch*.tw,kf. (49,442)
59. (horizontal* adj2 transmit*).tw,kf. (773)
60. exp Inhalation Exposure/ (11,075)
61. exp Inhalation/ (6,088)
62. exp Exhalation/ (5,416)
63. exp Respiration/ (126,127)
64. exp "Aerosolized Particles and Droplets"/ (45)
65. exp "Respiratory Aerosols and Droplets"/ (692)
66. (respiratory adj3 transmi*).tw,kf. (2,219)
67. exp Aerosols/ (38,592)
68. exp Air Microbiology/ (8,988)
69. aerosol*.tw,kf. (63,965)
70. droplet*.tw,kf. (77,992)
71. airborne.tw,kf. (30,844)
72. air borne.tw,kf. (1,169)
73. air* particle*.tw,kf. (3,500)
74. respiratory particle*.tw,kf. (134)
75. expiratory particle*.tw,kf. (8)
76. exhal*.tw,kf. (19,678)
77. inhal*.tw,kf. (141,838)
78. air sampl*.tw,kf. (8,876)
79. (respiratory adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (10,695)
80. (expiratory adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (24)
81. (airway* adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (1,941)
82. (air way* adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (0)
83. (breath* adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (1,836)
84. ((air flow* or airflow* or aerodynamic* or air condition* or cough* or sneez* or breath* or sing or singing or shout* or (air adj2 circulat*) or (air adj2 recirculation) or (air adj2 re-circulation)) and (transmission* or transmit* or distanc* or dispers*)).tw,kf. (13,243)
85. ((ventilation or ventilated) and (transmission* or distanc* or dispers*)).tw,kf. (5,564)

86. bioaerosol*.tw,kf. (2,782)
87. exp Fomites/ (705)
88. (fomite* or fomes).tw,kf. (1,983)
89. ((contaminat* or transmi*) adj3 (surface* or environment* or touch* or object* or equipment or food or drink*)).tw,kf. (47,522)
90. ((Virus or viral*) adj5 (touch* or surface*)).tw,kf. (11,431)
91. (bacteri* adj5 (touch* or surface*)).tw,kf. (23,194)
92. Body Fluids/ (36,106)
93. exp Bodily Secretions/ (299,981)
94. ((body or bodily) adj fluid*).tw,kf. (32,289)
95. ((body or bodily) adj secretion*).tw,kf. (416)
96. exp Saliva/ (50,687)
97. exp Respiratory Mucosa/ (40,746)
98. exp Nasal Mucosa/ (29,635)
99. saliva*.tw,kf. (136,430)
100. spit*.tw,kf. (86,757)
101. (muc$us or mucosa).tw,kf. (202,882)
102. (phlegm or sputum).tw,kf. (43,647)
103. ((nostril* or nasal) adj3 (discharge* or secretion*)).tw,kf. (6,614)
104. (kiss or kissing).tw,kf. (5,697)
105. ((mouth or tongue or lip*) adj3 contact*).tw,kf. (1,630)
106. ((shared or sharing) adj3 (utensil* or fork* or spoon* or knife or knives or cup* or mug* or glass* or tumbler* or food or drink*)).tw,kf. (1,123)
107. exp Sexual Behavior/ (134,278)
108. (sexual* adj3 (transmi* or spread* or contact* or disease* or infect*)).tw,kf. (56,584)
109. exp Vaginal Discharge/ (1,939)
110. (Vagina* adj3 (fluid* or secret* or discharge* or transmi* or spread* or disease* or contact*)).tw,kf. (10,492)
111. ((penile or penis) adj3 (fluid* or secret* or discharge* or ejaculat* or transmi* or spread* or disease* or contact*)).tw,kf. (1,443)
112. (ejaculat* adj3 fluid*).tw,kf. (170)
113. seminal fluid*.tw,kf. (3,269)
114. exp Semen/ (26,662)
115. semen.tw,kf. (41,338)
116. or/38-115 (2,046,227)
117. 37 and 116 (3,137)
118. limit 117 to (comment or editorial or letter or news or newspaper article) (86)
119. 117 not 118 (3,051)

Embase (1 January 1974 to 25 March 2026)

1. exp meningococcosis/ (15,157)
2. exp epidemic meningitis/ (3,785)
3. *bacterial meningitis/ (11,468)
4. (meningococc* adj5 (infect* or disease* or strain* or meningit*)).tw,kf. (10,774)
5. invasive meningococc*.tw,kf. (2,026)
6. meningococcosis.tw,kf. (10)
7. (meningit* and (septic?em* or sepsis or bacter?em*)).tw,kf. (12,860)
8. (meningococc* and (septic?em* or sepsis or bacter?em*)).tw,kf. (2,532)
9. exp Neisseria meningitidis/ (17,739)
10. neisseria mening*.tw,kf. (11,186)
11. "N. meningitidis".tw,kf. (3,726)
12. (meningococc* adj2 A).tw,kf. (2,701)
13. (meningit* adj3 A).tw,kf. (14,250)
14. (meningococc* adj2 B).tw,kf. (2,176)
15. (meningit* adj3 B).tw,kf. (2,669)
16. (meningococc* adj2 C).tw,kf. (1,680)
17. (meningit* adj3 C).tw,kf. (1,249)
18. (meningococc* adj2 W).tw,kf. (166)
19. (meningit* adj3 W).tw,kf. (174)
20. (meningococc* adj2 X).tw,kf. (41)
21. (meningit* adj3 X).tw,kf. (96)
22. (meningococc* adj2 Y).tw,kf. (160)
23. (meningit* adj3 Y).tw,kf. (207)
24. exp sepsis/ and meningitis/ (10,149)
25. serogroup* A.tw,kf. (1,926)
26. serogroup* B.tw,kf. (2,842)
27. serogroup* C.tw,kf. (1,687)
28. serogroup* W-135.tw,kf. (82)
29. serogroup* X.tw,kf. (140)
30. serogroup* Y.tw,kf. (348)
31. MenA.tw,kf. (2,744)
32. MenB.tw,kf. (917)
33. MenC.tw,kf. (574)
34. MenW.tw,kf. (150)
35. MenX.tw,kf. (87)
36. MenY.tw,kf. (127)
37. or/1-36 (65,865)
38. exp *disease transmission/ (46,763)
39. (transmi* adj5 (route* or mode or modes or path or paths or pathway* or method* or way or ways or how or direct* or indirect* or primary or secondary or pattern* or vehicle* or window*)).tw,kf. (86,293)
40. transmi*.ti. (129,789)

41. "human to human".tw,kf. (9,481)
42. "person to person".tw,kf. (6,031)
43. transmi* between human*.tw,kf. (520)
44. transmi* between people.tw,kf. (75)
45. ((direct* or indirect* or close or transmi* or physical* or regular* or frequent* or prolonged or infect*) adj3 contact*).tw,kf. (80,491)
46. interhuman.tw,kf. (297)
47. "inter human".tw,kf. (212)
48. (inter-person* or interperson*).tw,kf. (77,832)
49. (between adj2 (person* or people or population*)).tw,kf. (69,923)
50. (within adj2 population*).tw,kf. (42,482)
51. ((communit* or disease* or infection* or population* or human* or people* or group*) adj3 spread*).tw,kf. (49,437)
52. ((communit* or disease* or infection* or population* or human* or people* or group*) adj3 contagio*).tw,kf. (8,818)
53. "skin to skin".tw,kf. (13,556)
54. "mouth to mouth".tw,kf. (915)
55. "mouth to skin".tw,kf. (338)
56. "hand to mouth".tw,kf. (1,741)
57. "face to face".tw,kf. (73,146)
58. touch*.tw,kf. (68,298)
59. (horizontal* adj2 transmit*).tw,kf. (829)
60. exp inhalational exposure/ (955)
61. exp inhalation/ (38,007)
62. exp exhalation/ (36,231)
63. exp *breathing/ (69,177)
64. exp "aerosolized particles and droplets"/ (322)
65. exp "infectious droplets and aerosols"/ (148)
66. exp "respiratory droplets and aerosols"/ (853)
67. (respiratory adj3 transmi*).tw,kf. (2,580)
68. exp aerosol/ (74,283)
69. air microbiolog*.tw,kf. (65)
70. airborne.tw,kf. (38,314)
71. air borne.tw,kf. (1,237)
72. air* particle*.tw,kf. (4,514)
73. droplet*.tw,kf. (90,252)
74. respiratory particle*.tw,kf. (150)
75. expiratory particle*.tw,kf. (8)
76. exhal*.tw,kf. (31,931)
77. inhal*.tw,kf. (208,083)
78. air sampl*.tw,kf. (11,925)
79. (respiratory adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (14,062)
80. (expiratory adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (26)

81. (air way* adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (0)
82. (breath* adj (route* or mode* or path* or method* or transmi* or spread*)).tw,kf. (2,700)
83. ((air flow* or airflow* or aerodynamic* or air condition* or cough* or sneez* or breath* or sing or singing or shout* or (air adj2 circulat*) or (air adj2 recirculation) or (air adj2 re-circulation)) and (transmission* or transmit* or distanc* or dispers*)).tw,kf. (20,596)
84. ((ventilation or ventilated) and (transmission* or distanc* or dispers*)).tw,kf. (8412)
85. bioaerosol*.tw,kf. (3,824)
86. exp fomite/ (1029)
87. (fomite* or fomes).tw,kf. (2,243)
88. ((contaminat* or transmi*) adj3 (surface* or environment* or touch* or object* or equipment or food or drink*)).tw,kf. (54,839)
89. ((Virus or viral*) adj5 (touch* or surface*)).tw,kf. (13,052)
90. body fluid/ (29,951)
91. exp *bodily secretions/ (162,623)
92. ((body or bodily) adj fluid*).tw,kf. (37,097)
93. ((body or bodily) adj secretion*).tw,kf. (466)
94. exp saliva/ (52,194)
95. exp respiratory mucosa/ (37,801)
96. exp nose mucosa/ (20,034)
97. saliva*.tw,kf. (166,418)
98. spit*.tw,kf. (119,375)
99. (muc$us or mucosa).tw,kf. (276,800)
100. (phlegm or sputum).tw,kf. (72,691)
101. ((nostril* or nasal) adj3 (discharge* or secretion*)).tw,kf. (8,721)
102. (kiss or kissing).tw,kf. (8,494)
103. ((mouth or tongue or lip*) adj3 contact*).tw,kf. (1,925)
104. ((shared or sharing) adj3 (utensil* or fork* or spoon* or knife or knives or cup* or mug* or glass* or tumbler* or food or drink*)).tw,kf. (1,292)
105. exp sexual behavior/ (285,648)
106. (sexual* adj3 (transmi* or spread* or contact* or disease* or infect*)).tw,kf. (73,298)
107. vaginal secretion/ (3,450)
108. (Vagina* adj3 (fluid* or secret* or discharge* or transmi* or spread* or disease* or contact*)).tw,kf. (14,325)
109. ((penile or penis) adj3 (fluid* or secret* or discharge* or ejaculat* or transmi* or spread* or disease* or contact*)).tw,kf. (2,078)
110. (ejaculat* adj3 fluid*).tw,kf. (185)
111. seminal fluid*.tw,kf. (4,042)
112. exp sperm/ (93,959)
113. semen.tw,kf. (54,404)
114. or/38-113 (2,400,489)
115. 37 and 114 (4,175)
116. limit 115 to (conference abstract or conference paper or "conference review" or editorial or letter) (869)
117. 115 not 116 (3,306)

Web of Science Preprint Citation Index (1990 to current)

Date of search: 26 March 2026

TS=((meningococc* NEAR/4 (infect* or disease* or strain* or meningit*))) OR TS=("invasive meningococc*") OR TS=(meningococcosis) OR TS=((meningit* and (septic$em* or sepsis or bacter$em*))) OR TS=((meningococc* and (septic$em* or sepsis or bacter$em*))) OR TS=("neisseria mening*") OR TS=("N. meningitidis") OR TS=((meningococc* NEAR/1 A)) OR TS=((meningit* NEAR/2 A)) OR TS=((meningococc* NEAR/1 B)) OR TS=((meningit* NEAR/2 B)) OR TS=((meningococc* NEAR/1 C)) OR TS=((meningit* NEAR/2 C)) OR TS=((meningococc* NEAR/1 W)) OR TS=((meningit* NEAR/2 W)) OR TS=((meningococc* NEAR/1 X)) OR TS=((meningit* NEAR/2 X)) OR TS=((meningococc* NEAR/1 Y)) OR TS=((meningit* NEAR/2 Y)) OR TS=("serogroup* A") OR TS=("serogroup* B") OR TS=("serogroup* C") OR TS=("serogroup* W-135") OR TS=("serogroup* X") OR TS=("serogroup* Y") OR TS=(MenA) OR TS=(MenB) OR TS=(MenC) OR TS=(MenW) OR TS=(MenX) OR TS=(MenY)

AND

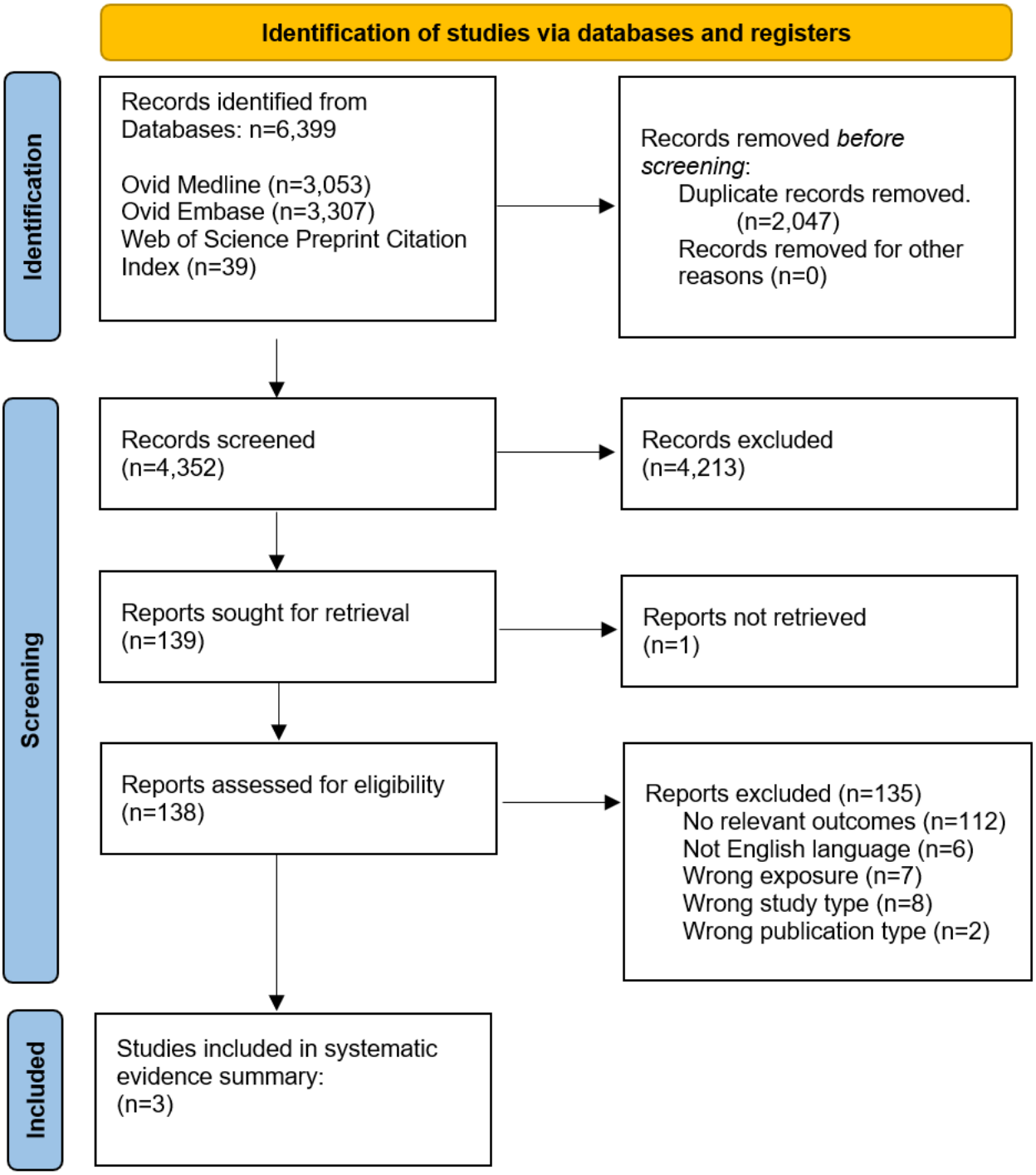
TS=((transmi* NEAR/4 (route* or mode or modes or path or paths or pathway* or method* or way or ways or how or direct* or indirect* or primary or secondary or pattern* or vehicle* or window*))) OR TI=(transmi*) OR TS=("human to human") OR TS=("person to person") OR TS=("transmi* between human*") OR TS=("transmi* between people") OR TS=(((direct* or indirect* or close or transmi* or physical* or regular* or frequent* or prolonged or infect*) NEAR/2 contact*)) OR TS=(interhuman) OR TS=("inter human") OR TS=(inter-person* OR interperson*) OR TS=((between NEAR/1 (person* or people or population*))) OR TS=((within NEAR/1 population*)) OR TS=(((communit* or disease* or infection* or population* or human* or people* or group*) NEAR/2 spread*)) OR TS=(((communit* or disease* or infection* or population* or human* or people* or group*) NEAR/2 contagio*)) OR TS=("skin to skin") OR TS=("mouth to mouth") OR TS=("mouth to skin") OR TS=("hand to mouth") OR TS=("face to face") OR TS=(touch*) OR TS=((horizontal* NEAR/1 transmit*)) OR TS=((respiratory NEAR/2 transmi*)) OR TS=(aerosol*) OR TS=(airborne) OR TS=("air borne") OR TS=(droplet*) OR TS=("air* particle*") OR TS=("respiratory particle*") OR TS=("expiratory particle*") OR TS=(exhal*) OR TS=(inhal*) OR TS=("air sampl*") OR TS=((respiratory NEAR/0 (route* or mode* or path* or method* or transmi* or spread*))) OR TS=((expiratory NEAR/0 (route* or mode* or path* or method* or transmi* or spread*))) OR TS=((airway* NEAR/0 (route* or mode* or path* or method* or transmi* or spread*))) OR TS=(("air way*" NEAR/0 (route* or mode* or path* or method* or transmi* or spread*))) OR TS=((breath* NEAR/0 (route* or mode* or path* or method* or transmi* or spread*))) OR TS=((("air flow*" or airflow* or aerodynamic* or "air condition*" or cough* or sneez* or breath* or sing or singing or shout* or (air NEAR/1 circulat*) or (air NEAR/1 recirculation) or (air NEAR/1 re-circulation)) and (transmission* or transmit* or distanc* or dispers*))) OR TS=(((ventilation or ventilated) and (transmission* or distanc* or dispers*))) OR TS=(bioaerosol*) OR TS=((fomite* or fomes)) OR TS=(((contaminat* or transmi*)

NEAR/2 (surface* or environment* or touch* or object* or equipment or food or drink*))) OR TS=(((Virus or viral*) NEAR/4 (touch* or surface*))) OR TS=((bacteri* NEAR/4 (touch* or surface*))) OR TS=(((body or bodily) NEAR/0 fluid*)) OR TS=(((body or bodily) NEAR/0 secretion*)) OR TS=(saliva*) OR TS=(spit*) OR TS=((muc$us or mucosa)) OR TS=((phlegm or sputum)) OR TS=(((nostril* or nasal) NEAR/2 (discharge* or secretion*))) OR TS=((kiss or kissing)) OR TS=(((mouth or tongue or lip*) NEAR/2 contact*)) OR TS=(((shared or sharing) NEAR/2 (utensil* or fork* or spoon* or knife or knives or cup* or mug* or glass* or tumbler* or food or drink*))) OR TS=(sexual* NEAR/3 (transmi* or spread* or contact* or disease* or infect*)) OR TS=(Vagina* NEAR/3 (fluid* or secret* or discharge* or transmi* or spread* or disease* or contact*)) OR TS=((penile or penis) NEAR/3 (fluid* or secret* or discharge* or ejaculat* or transmi* or spread* or disease* or contact*)) OR TS=(ejaculat* NEAR/3 fluid*) OR TS=(“seminal fluid*”) OR TS=(semen)

39 results

Annexe B. Study selection flowchart

Figure B.1. PRISMA diagram



Text version of Figure B.1. PRISMA diagram

A PRISMA diagram showing the flow of studies through this systematic evidence summary, ultimately including 3 studies.

From identification of studies via databases and registers, n=6,399 records identified from databases:

- Ovid Medline (n=3,053)
- Ovid Embase (n=3,307)
- Web of Science Preprint Citation Index (n=39)

From these, records removed before screening:

- duplicate records removed using Deduklick (n=2,047)
- records removed for other reasons (n=0)

n=4,352 records screened, of which n=4,213 were excluded, leaving n=139 papers sought for retrieval, of which n=1 was not retrieved.

No studies were identified from identification of studies via other methods.

Of the n=138 papers assessed for eligibility, n=135 reports were excluded:

- no relevant outcomes (n=112)
- not English language (n=6)
- wrong exposure (n=7)
- wrong study type (n=8)
- wrong publication type (n=2)

n=3 papers included in the systematic evidence summary.

Annexe C. Excluded full texts

No relevant outcomes (112 studies)

Abad R and others. 'Outbreak of invasive meningococcal disease caused by a meningococcus serogroup B expressing a rare porA genosubtype (19-54, 15), Spain, March to April 2024' Euro Surveillance: Bulletin Europeen sur les Maladies Transmissibles = European Communicable Disease Bulletin 2025: volume 30, issue 44

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Aguilera J-F and others. 'Outbreak of serogroup W135 meningococcal disease after the Hajj pilgrimage, Europe, 2000' Emerging Infectious Diseases 2002: volume 8, issue 8, pages 761 to 767

Andersen J and others. 'Surveillance of cases of meningococcal disease associated with military recruits studied for meningococcal carriage' Scandinavian Journal of Infectious Diseases 2000: volume 32, issue 5, pages 527 to 531

Anonymous. 'Household transmission of Neisseria meningitidis in the African meningitis belt: a longitudinal cohort study' The Lancet Global Health 2016: volume 4, issue 12, pages e989 to e995

Anonymous. 'Meningococcal disease associated with the Haj--update' Communicable Disease Report CDR Weekly 2000: volume 10, issue 19, pages 169

Anonymous. 'Serogroup W-135 meningococcal disease among travelers returning from Saudi Arabia--United States, 2000' MMWR - Morbidity and Mortality Weekly Report 2000: volume 49, issue 16, pages 345 to 346

Anonymous. 'Update: assessment of risk for meningococcal disease associated with the Hajj 2001' MMWR - Morbidity and Mortality Weekly Report 2001: volume 50, issue 12, pages 221 to 222

Anonymous. 'Risk for meningococcal disease associated with the Hajj 2001' MMWR - Morbidity and Mortality Weekly Report 2001: volume 50, issue 6, pages 97 to 98

Anonymous. 'Laboratory-acquired meningococcal disease--United States, 2000' MMWR - Morbidity and Mortality Weekly Report 2002: volume 51, issue 7, pages 141 to 144

Anonymous. 'Emergence of fluoroquinolone-resistant *Neisseria meningitidis*--Minnesota and North Dakota, 2007-2008' MMWR - Morbidity and Mortality Weekly Report 2008: volume 57, issue 7, pages 173 to 175

Anonymous. 'Notes from the field: serogroup C invasive meningococcal disease among men who have sex with men - New York City, 2010-2012' MMWR - Morbidity and Mortality Weekly Report 2013: volume 61, issue 51, page 1,048

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Bharti N and others. 'Spatial dynamics of meningococcal meningitis in Niger: observed patterns in comparison with measles' Epidemiology and Infection 2012: volume 140, issue 8, pages 1,356 to 1,365

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Cartwright KA and others. 'Meningococcal carriage in close contacts of cases' Epidemiology and Infection 1991: volume 106, issue 1, pages 133 to 141

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Annexe D. Data extraction tables

Table D.1. Summary of studies identified on meningococcal disease serogroup B
Abbreviations: STI: sexually transmitted infections

Author, Year, Study Type	Country, time period	Serogroup / serotype	Population	Outcomes
Mitchell and others, 2008 (1) Case series	New Zealand, February to March 2007	B (B15P1.7,16)	Five people: Case 1: 20-year-old woman, ethnicity not reported, heterosexual. Presenting with symptomatic genital infection. Case 2: 23 year old man, ethnicity not reported, heterosexual, confirmed diagnosis of hepatitis B. Asymptomatic. Cases 3 to 5: 21 to 28 years, 66.6% men (n=2), ethnicity not reported, heterosexual. Asymptomatic.	Case 1 presented at a sexual health clinic with intermenstrual and post-coital bleeding. Pharyngeal, vaginal, cervical and urethral swabs were all positive for *N. meningitidis* (and negative for all other STI). Case 2 was the regular sexual partner of case 1 for approximately one year, reporting unprotected vaginal and oral sex. A pharyngeal swab from case 2 was subsequently positive for *N. meningitidis*. Both were treated with ciprofloxacin, and a pharyngeal swab taken from case 2 four days later was negative. Cases 3 to 5 were serogroups other than serogroup B. No transmission route confirmed for any of these cases.

Table D.2. Summary of studies identified on meningococcal serogroup C

Author, Year, Study Type	Country, time period	Meningococcal Serogroup / serotype	Population	Outcomes
Materna and others, 2010 (3) Outbreak report	USA, December 2009	Meningococcal serogroup C, ST-11 clonal complex	Three people: Index case: 36 year old man, ethnicity not reported, sexual orientation not reported. Case 1: 30 year old man, ethnicity not reported, sexual orientation not reported. Case 2: 47 year old man, ethnicity not reported, sexual orientation not reported.	The index case was found unconscious with a partially obstructed airway, with vomit and faeces on his body and clothing. As part of his treatment, his airway was suctioned, and an endotracheal tube was placed. Case 1 presented at his primary care physician 2 days after the index patient was found unconscious. After hospitalisation, blood and cerebrospinal fluid were positive for N. meningitidis. He was a police officer who assisted the index patient at the scene, adjusting the patient's body and head to assist with breathing. He then left the room. While handling the patient, he reported hearing hacking and gurgling but reported no droplets on his skin nor contact with respiratory

Author, Year, Study Type	Country, time period	Meningococcal Serogroup / serotype	Population	Outcomes
				secretions. He did not wear a mask, but did wear gloves. Case 2 began experiencing symptoms 5 days after coming into contact with the index case. After hospitalisation, blood and cerebrospinal fluid were positive for N. meningitidis. He was a respiratory therapist who assisted with the suction of the airway and endotracheal tube placement of the index case. He did not wear a mask, but did wear gloves. The authors suggest that in both secondary cases, unprotected exposure to infectious respiratory secretions (author defined as respiratory aerosols or secretions) may have resulted in transmission.

Table D.3. Summary of studies identified on meningococcal disease where meningococcal serogroup could not be determined

Author, Year, Study Type	Country, time period	Serogroup / serotype	Population	Outcomes
Talbot and others, 1981 (2) Case series	UK, not reported	Could not be determined (ungroupable in laboratory tests)	Three people: 26 year old man, Caucasian, sexual orientation not reported, presented with urethral discharge and dysuria. Age not reported, woman, ethnicity and sexual orientation not reported. Age not reported, woman, ethnicity and sexual orientation not reported.	A man presented with urethral discharge and dysuria, and a urethral swab was taken. Subsequently, cases 1 and 2, who were women, sexual partners of the man and both had pharyngeal, urethral, cervical and rectal swabs taken: • man: urethral swab positive • case 1: pharyngeal swab positive • case 2: cervical swab positive The authors suggest that the man acquired meningococcal disease from sexual contact with case 1 via oral-genital exposure and then he transmitted to case 2 via sexual transmission. Case 1 and 2 remained asymptomatic.

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