Occasional Review

Meningococcal disease in Scandinavia

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Abstract

Scandinavia (Denmark, Finland, Iceland, Norway, and Sweden) comprises with mutual borders and 22.3 million inhabitants an area where the socioeconomic and cultural conditions are similar. Epidemic diseases, such as meningococcal infection, might therefore be expected to be uniformly distributed. An epidemiological study in the 10-year period 1970-9 shows, however, remarkable differences in the incidence, age, and serogroup and type distribution, as well as in the general dynamics of the disease. Three epidemics, two caused by different serotypes of group B (Norway and Iceland) and one by group A (Finland) occurred within the observation period. The annual overall incidence was generally around 3/100 000 but increased from fivefold (Finland) to eightfold (northern Norway) during epidemics. The epidemic strains caused infection in over 3000 patients and the loss of at least 250 lives. The overall case fatality rate was 8.6% (range 4.1-13.7%). Men were more susceptible and had a worse prognosis than women of the same age group. The group A epidemic in Finland was influenced by a large vaccination campaign, but this possibility was not feasible in the two other epidemics.

Introduction

Scandinavia, with its five countries, Denmark, Finland, Iceland, Norway, and Sweden, has experienced three meningococcal epidemics in the 1970s.¹⁻³ Living in similar socioeconomic conditions and travelling freely across the area, the 22.3 million people comprise an interesting unit in terms of the epidemiology of meningococcal disease.

We describe here the general features of this disease in Scandinavia, especially during the past 10 years. We hope to increase general knowledge of a problem whose significance

does not seem to be decreasing despite the continuing sensitivity to penicillin of the causative agents and the recent advent of efficacious vaccines.⁴⁻⁷

Methods

All data given are based on records kept at a central national laboratory in each country. Collection of the data was helped because for decades statutory nominal reports on the disease have been sent to the central office by the hospital wards or the isolating laboratory, or both.

The reliability of the reports was tested in Finland in 1976-80,⁸ and results showed at least 90% coverage of the actual cases in the country. A very effective surveillance was also the rule in the other Scandinavian countries because the epidemics in the 1970s had caused much concern about the problem.

In Norway and Sweden the centre has regularly published an epidemiological synopsis giving data also on meningococcal disease; in other cases such information has been published only incidentally in scientific or epidemiological reports.^{1-3 9-19} Serogrouping and antimicrobial sensitivity determinations of isolated meningococci were in most cases performed or confirmed in the respective national laboratories. Several strains from Iceland were serogrouped by Dr R J Fallon, Meningococcus Reference Laboratory, Ruchill Hospital, Glasgow. Serotyping of selected strains has been performed by Dr C E Frasch, Bureau of Biologics, Food and Drug Administration, Bethesda, Maryland (strains from Finland); Dr D M Jones, Public Health Laboratory, Withington Hospital, Manchester, (Iceland); and locally by Dr E Holten, Department of Microbiology, Central Hospital of Akershus County (Norway).

Statistical analysis was based on the Student's *t* test or the chi square test.

Results

GENERAL OCCURRENCE

The oldest information of the number of patients with meningococcal disease is available from Norway and Sweden, which both show rather regular epidemics (figure). In Norway major peaks occurred every 30-40 years with smaller peaks at intervals of under 10 years. Several major epidemics raged consecutively in Sweden until the 1910s, but since then only minor fluctuations in the incidence of meningococcal disease have occurred. This is in sharp contrast to the neighbouring countries, in each of which a definite meningococcal epidemic appeared during the second world war. This is also true of Iceland, even if not shown in the figure because of missing comprehensive records. Nevertheless, an epidemic of bacterial meningitis started there in 1940 and reached a peak incidence of 38/100 000 in 1941.²⁰ The outbreak was thought to have originated among the British troops who occupied Iceland in May 1940 and were stationed throughout the country. A similar epidemic occurred in Norway, with its peak about one year after the Germans occupied the country.¹⁰ Then, a couple of years later, an epidemic was seen in Finland and Denmark. Within the past decade a clear-cut epidemic has been experienced in three Scandinavian countries: Finland, Norway, and Iceland (figure).

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Occurrence of meningococcal disease in Scandinavia to end of 1970s. Presumable or proved serogroups causing major epidemics marked with capitals. m = Million.

The yearly incidence rate of meningococcal disease has been generally around 3.0-5.0/100 000. Table I gives the incidences of the past 10 years; the figures for northern Norway are given separately because of the peculiar distribution of the disease there (see below).

The highest incidence of 37.7/100 000 was reached in Iceland in 1976 and the morbidity has remained rather high since then, but because of the small population of the country (226 000 inhabitants) the total number of cases has been modest. The lowest yearly incidences were seen in 1972 and 1979 in Sweden (1.1 and 1.2/100 000), where the disease has remained rare, and in 1979 after the epidemic in Finland (1.2/100 000).

Seasonal variation has been small with some exceptions, such as the extremely high incidence in March 1978 in Norway.¹⁸ Only in summer have the number of cases shown a small decrease.¹⁰

DISTRIBUTION OF SEROGROUPS IN THE COUNTRIES WITH A RECENT OR PRESENT EPIDEMIC (FINLAND, ICELAND, NORWAY)

No serogrouping data are available from the epidemics before 1970, but since group A has traditionally been found to have caused large epidemics in industrialised²¹ and non-industrialised countries,²²⁻²³ most of the epidemics shown in the figure may have been due to group A.

The largest epidemic of the 1970s was that in Finland during 1973-6.¹³⁻²⁴ The incidence was highest in 1974, 14.6/100 000 (table I), and the causative agent was of group A. Out of a total of 1527 cases in the epidemic years, 84% (calculated on the basis of 756 bacteriologically fully analysed cases) were caused by group A meningococci (table II). The remaining 16% of the cases were rather equally distributed between groups B and C. After the epidemic the normal equilibrium with preponderance of group B returned.³⁻²⁵ Other serogroups have been rare: maximally, four group Y cases in 1976, four group Y and four group W135 cases in 1979.

In Iceland an epidemic of purulent meningitis started in 1975 with 29 diagnosed cases. Meningococci were isolated from 16 of these,

but none were serogrouped. The peak incidence was reached in 1976 with 83 cases (37.7/100 000). During the first six months of that year, meningococci were cultured from 19 of 40 cases; of these 19, eight were of group A, three of group B, and eight strains could not be serogrouped. From August 1976 to the end of 1979, specimens were available from 134 out of a total of 145 meningococcal cases. Of 109 strains grown, 94 were of serogroup B, and one of group C (in July 1979); 14 were ungroupable.

A rather different occurrence has been seen in Norway.²⁻¹⁰ After 15 years, obviously with a slight preponderance of group A, there was in 1974 a sharp increase in the number of patients with group B meningococci.¹⁴ The numbers have remained high since then. The incidence reached its peak in northern Norway in 1975—23.9/100 000 (table I). The epidemic has been restricted (now for more than seven years) to the three most northern counties, Nordland, Troms, and Finnmark, an area with roughly 600 000 inhabitants, and only a slow movement to the south has been observed. In the rest of the country the total incidence has been one-third of that in northern Norway, around 5 to 6/100 000/year. During 1975-9, 1214 isolates (from 1574 cases) were serogrouped. Of these, 815 (67%) belonged to group B. In 1979 group B was responsible for 84% of all the clinical isolates in Norway.¹⁰

Of the other serogroups, group C has been more common (roughly 10-15% more) than A. Other serogroups have been found only occasionally (at most, two group Y cases in both 1975 and 1978). In addition one group X case was diagnosed in 1975 and one group Z in 1978.

TABLE I—Incidence (cases per 100 000/y) of meningococcal disease in Scandinavia in the 1970s

	Country and its population (in millions)					
	Denmark (5.1)	Finland (4.8)	Iceland (0.23)	Norway North (0.6)	Whole (4.0)	Sweden (8.2)
1970		1.7		4.1	2.6	
1971		1.6		3.3	2.0	
1972	2.7	2.4		3.3	2.0	1.1
1973	3.3	5.4		5.7	3.6	1.2
1974	4.4	14.6		11.3	5.3	2.0
1975	4.1	9.7	13.3	23.9	8.1	2.8
1976	3.7	2.8	37.7	18.4	7.9	2.4
1977	1.9	3.1	25.5	18.2	6.7	1.7
1978	2.9	1.8	9.5	22.0	8.1	1.7
1979	2.9	1.2	11.4	16.0	8.1	1.2
Average	3.2	4.4	19.5	12.6	5.1	1.9

TABLE II—Average distribution of the serogroups (%) during the peak of the epidemic (Finland, Iceland, Norway) compared with the countries (Denmark, Sweden) where no epidemic occurred

	A	B	C	Y	W135	Other	Strains analysed	
							No	(%)
Epidemic conditions								
Finland 1974-5	84	9	7			0.1	756	(66)
Iceland 1976	16	50				34*	50	(98)
Norway 1975-8	11	63	25			1	988	(80)
Non-epidemic conditions								
Denmark 1974-8	39	41	15		1	4*	698	(80)
Sweden 1974-8	32	35	30	3			608	(80)

*Reported as non-groupable.

DISTRIBUTION OF SEROGROUPS IN DENMARK AND SWEDEN WHICH HAVE NOT EXPERIENCED A RECENT EPIDEMIC (table II)

Group B has been slightly more common than other groups. Moreover, in Denmark, it has been increasing; in 1974 it was responsible for 27% of the 137 cases analysed but in 1978 for 56% of 131 isolations. Group C has also become more common (from 10% to 23% during the respective years), whereas group A has decreased from 54% to 18%.

Group C in Sweden was responsible for 19% of the 65 analysed cases in 1974 but for 39% (of 110 cases analysed) in 1978. The proportions of the group B meningococci were 23% and 42%, respectively. During the same period, group A decreased to one-third, from 55% to 15%.

SEROTYPES

Systematic serotyping²⁶ has not taken place. The epidemic of northern Norway, however, was found to be caused by a new serotype called type 15¹⁴; it was responsible for 82% of the group B cases (82 strains) during the first six months of 1978. This was unexpected on the basis of the generally found domination of type 2 in epidemics.²⁷⁻²⁹ The type 15 antigen was found also in 33% (9/27) of the group C strains, and in one out of four group A isolated. Most (48%, or 13/27) of the group C strains belonged, however, to the more usual type 2.

Only a few strains from Iceland and Finland were typed. Three group B strains isolated in Iceland in 1977 and four in 1979 belonged to serotype 2. In contrast, one isolate in 1979 and two in 1980 were of the Norwegian type 15. The six group B strains collected from patients with meningitis in different parts of Finland belonged to several different types, but none to type 15.³

RESISTANCE TO SULPHONAMIDES

In general, the resistance of meningococci increased only in the beginning of the decade. In northern Norway² a fast shift in all meningococcal groups to sulphonamide-resistant forms occurred in 1972 (92% of the 84 strains tested in 1974-5 showed MIC values of sulfadiazine equal to or more than 50 µg/ml), whereas in Finland only the epidemic group A (practically all strains of it) was resistant.³⁰ In Iceland only five strains from the years 1975-8 were interpreted (by the disc diffusion method) as fully resistant (100 µg/ml). In 1979, however, more than half of group B and one group C strains were resistant.

In Sweden the resistance of all groups increased in the early part of the 1970s so that in 1972 62% of the strains tested were resistant (but the MIC break-off point was 16 µg/ml, which is lower than that used in the other countries). Three years later this percentage was found somewhat decreased to 52.³¹ In Denmark only sporadic strains have shown increased resistance to sulphonamides. They have belonged mostly to groups B and C, and only to a lesser extent to A.

AGE AND SEX DISTRIBUTION

The age distribution of the cases has in each country been roughly the same and similar to that typical of industrialised countries, which is different from that, for example, in the meningitis belt of Africa.²³ Thus children under 5 years were most prone to the disease. In the epidemic conditions in Iceland 78%, and in northern Norway 33%, of the patients belonged to this age group. On the other hand, during the epidemic in Finland there was a pronounced shift towards older age groups,¹ but this change returned to "normal" soon after the epidemic.

The second most vulnerable five years' age group was that among 15-19 years.^{1,10} In northern Norway, for example, the average annual incidence was 22.6/100 000, which did not solely reflect the high morbidity among the recruits in the defence forces^{19,32} because the same higher incidence was seen among women. From the age of 25 on the incidence has remained low (around 2/100 000/year in Finland). On the whole, roughly 75-80% of the patients have been under 25.

In general men have been the majority. In some instances this was due to special social conditions: the reported excess of men (42 over 15 women) among patients aged 30 to 39 in Helsinki in 1973-4 was to a large extent accounted for by chronic alcoholics living in lodging houses.²⁴ On the other hand, men have been predominating (193 v 151 women, $p < 0.05$) also during the postepidemic years 1977-80, when virtually all the cases occurred among civilians. Of the 214 patients diagnosed in Iceland in 1975-9, 117 were men and 97 women.

Male excess was seen in all age groups in Norway in 1975-9: among the 1558 patients the annual incidence¹⁰ was 8.1/100 000, which is slightly higher than in women (7.3/100 000). In non-epidemic countries the morbidity of the two sexes has been rather similar.

CASE FATALITY RATES

The overall case death rate has varied considerably, from about 5 to 15% (table III). The present high figures of Norway are worse than earlier: among 124 patients in the Oslo area during 1966-76 the overall death rate was 8.9%.¹³ The rate in northern Norway has been con-

nected with the higher proportion of meningococcaemia without meningitis in this epidemic.¹⁰ In the series of 1246 cases collected in 1975-8 the overall case death rate was as high as 12.6%.¹⁰ Among the 370 patients (during the epidemic) in the Helsinki area, Finland,²¹ the death rate of meningitis was 2.7% but of septicaemia without meningitis much higher, 9.2%. This finding coincides with the general experience on meningococcal disease.^{9,13,23}

TABLE III—Overall case fatality rate (%) in meningococcal disease in four Scandinavian countries

	Finland (1973-4) ²¹	Iceland (1975-9)*	Norway (1975-8) ¹⁰			Sweden (1965-77) ¹⁵	In all
Fatality rate (%)	4.1	10.3	12.8	10.4	13.7	7.2	8.6
No of cases	370	214	263	136	404	69	1456

*K Jónsdóttir, unpublished data.

The sex of the patient had a clear influence on the outcome of the disease. This was best seen in northern Norway in 1975-7, when the overall case death rate was 20% among 101 men but only 7% among 83 women² ($p < 0.05$). The same trend was described in southern Norway in the years 1966-76¹³: seven (11%) out of 64 men and four (7%) of 60 women died from meningococcal disease. Regarding the 22 fatal cases of the (214) patients in Iceland (1975-9), there were 16 men (14%) against six (6%) women (difference not significant).

Discussion

The problem of meningococcal disease has not passed.³³ The five Scandinavian countries alone have experienced three epidemics in 10 years. The total number of cases during the epidemics in Finland, Iceland, and Norway exceeded 3300. Over 300 people have died despite the fact that the problem has been recognised, medical facilities have been readily available even in the remote northern areas, and treatment has been started promptly. With the non-epidemic incidence of meningococcal disease of 3/100 000/year or under (table I, figure) and case fatality rate of 5%,^{13,14} the three epidemics have resulted in at least 3000 extra cases with over 250 lost lives. If we calculated that each patient has been in hospital for an average of two weeks, often spending a few days in the intensive care unit, this totals 42 000 hospital days—that is, 115 years.

Where the epidemics have come from is a difficult question. Before the beginning of the group A epidemic in Finland in 1973, group A epidemics had been recently seen in Rumania,^{33,34} the Moscow area,³⁵ Mongolia,³⁶ the African meningitis belt,²³ and, at the same time, in the São Paulo area.³⁷ In most cases the epidemic strain had been resistant to sulphonamides. It would be reasonable to suggest that the infection came to Finland from the USSR, to where Finns travel quite often. Nevertheless, why has the same strain not spread further to Sweden when contacts between Finland and Sweden are much more common?

The Finnish epidemic lasted for under four years,³ probably to a large extent because of the extensive vaccination of the most susceptible age groups (those under 20).²⁵ In the Moscow area, where extensive vaccination has not taken place, the group A is still responsible for 61% of cases (V Pokrovski, presentation at International Congress of Meningococcal Disease and Rabies, Moscow, 1979), although the epidemic began over 10 years ago, in 1969.³⁸

The origin of the sulphonamide-resistant group B epidemic in northern Norway since 1974 is even more problematical. This group causes epidemics only exceptionally, and the latest reports have come from Belgium 1969-75,^{16,39} the Bolton area, Britain, 1971-4,²⁸ and Alabama, USA, 1975-6.⁴⁰ The time factor supports the view that the Norwegian epidemic could have a connection with that in Belgium and (just before) in Britain.

The epidemic strain in both the latter epidemics, however, was of serotype 2 whereas that in Norway is of type 15.¹⁴

The lack of an effective vaccination against the group B meningococci⁴¹ has necessitated evaluation of chemoprophylaxis. Sulphonamide sensitivity of the epidemic strain allowed effective mass prophylaxis with this drug in Alabama,⁴⁰ but the epidemic strain in Norway is highly resistant. The only other drugs that have been shown to be able to affect the carrier are rifampicin or minocycline,⁴²⁻⁴³ which, however, are not suitable for mass prophylaxis. An effective vaccine, perhaps the experimental outer membrane protein vaccines,⁴⁴⁻⁴⁵ would be essential. An additional problem, however, is that the Norwegian epidemic is not caused by the serotype 2 from which the protein vaccines have so far been prepared. Attempts to improve the immunogenicity of the group B capsular polysaccharide by increasing its molecular weight have so far not produced positive results.⁴¹

Currently a meningococcal epidemic is continuing in one Scandinavian country (Norway), and not much can be done to stop it; fortunately, its highest peak seems to be over (figure, table I). On the other hand, the high (12.8%) case fatality rate also in southern Norway is alarming because this part of the country has so far not belonged to the epidemic area. There is a fear that high mortality predicts an epidemic as was the case in Zaria, Nigeria: the gravest toll was paid in the beginning of the outbreak, whereafter the virulence of the (group A) epidemic strain seemed to decrease.²³ Whether this finding applies generally remains to be seen. A detailed surveillance is thus of paramount importance to find every major change in the epidemiological equilibrium. It requires very good international co-operation in the future.

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References

- Peltola H, Mäkelä PH, Elo O, Pettay O, Renkonen O-V, Sivonen A. Vaccination against meningococcal group A disease in Finland 1974-75. *Scand J Infect Dis* 1976;**8**:169-74.
- Bøvre K, Holten E, Vik-Mo H, et al. *Neisseria meningitidis* infections in northern Norway: an epidemic in 1974-1975 due mainly to group B organisms. *J Infect Dis* 1977;**135**:669-72.
- Peltola H. Group A meningococcal polysaccharide vaccine and course of the group A meningococcal epidemic in Finland. *Scand J Infect Dis* 1978;**10**:41-4.
- Artenstein MS, Gold R, Zimmerly JG, Wyle FA, Schneider H, Harkins C. Prevention of meningococcal disease by group C polysaccharide vaccine. *N Engl J Med* 1970;**282**:417-20.
- Wahdan MH, Rizk F, El-Akkad AM, et al. A controlled field trial of a serogroup A meningococcal polysaccharide vaccine. *Bull WHO* 1973;**48**:667-73.
- Peltola H, Mäkelä PH, Käyhty H, et al. Clinical efficacy of meningococcus group A capsular polysaccharide vaccine in children three months to five years of age. *N Engl J Med* 1977;**297**:686-91.
- Farquhar JD, Hankins WA, Desantis AN, Demeio JL, Metzgar DP. Clinical and serological evaluation of a meningococcal polysaccharide vaccine groups A, C, and Y. *Proc Soc Exp Biol Med* 1978;**157**:79-82.
- Virtanen M, Peltola H. Bacteremia and purulent meningitis in Finland. An analysis of positive blood and cerebrospinal fluid cultures in 1976-80. *Duodecim* (in press).
- Niklasson P-M. Kliniska manifestationer, koagulationsrubbingar och prognostisk bedömning vid meningokockinfektioner. Stockholm: 1975. (Thesis.)
- Bøvre K, Gedde-Dahl TW. Epidemiological patterns of meningococcal disease in Norway 1975-1979. *National Institute of Public Health (NIPH) Annals* 1980;**3**:9-22.
- Michaelsen H, Haslund R, Schirmer L, Steen-Johansen J. Purulent meningititt hos barn. Et 6-årsmateriale. *Tidsskr Nor Laegeforen* 1976;**96**:1776-800.
- Peltola H. Group A meningococcal and *Haemophilus influenzae* type b capsular polysaccharide vaccines in infants and children under school age. Helsinki: 1977. (Thesis.)
- Andersen BM. Mortality in meningococcal infections. *Scand J Infect Dis* 1978;**10**:277-82.
- Holten E. Serotypes of *Neisseria meningitidis* isolated from patients in Norway during the first six months of 1978. *J Clin Microbiol* 1979;**9**:186-7.
- Olcén P, Barr J, Kjellander J. Meningitis and bacteremia due to *Neisseria meningitidis*: clinical and laboratory findings in 69 cases from Örebro county 1965 to 1977. *Scand J Infect Dis* 1979;**11**:111-9.
- Anonymous. Meningococcal meningitis. *Weekly Epidemiological Record Belgium* 1976;**51**:333-40.
- Anonymous. Meningococcal surveillance. *Weekly Epidemiological Record Norway* 1978;**53**:40-1.
- Anonymous. Meningococcal surveillance. *Weekly Epidemiological Record Norway* 1979;**54**:279.
- Berild D, Gedde-Dahl TW, Abrahamsen T. Meningococcal disease in the Norwegian Armed Forces 1967-1979. Some epidemiological aspects. *National Institute of Public Health (NIPH) Annals* 1980;**3**:23-30.
- Helgason H, Magnússon J. Barnadaudi á Íslandi 1941-1975 (0-4 ára). *Laeknaneminn* 1976;**29**:5-23. (The medical students' periodical of Iceland.)
- Feldman HA. Meningococcal disease, 1965. *JAMA* 1966;**196**:391-3.
- Lapeyssonnie L. La méningite cérébro-spinale en Afrique. *Bull WHO* 1963;**28**:suppl.
- Greenwood BM, Bradley AK, Cleland PG, et al. An epidemic of meningococcal infection at Zaria, Northern Nigeria. 1. General epidemiological features. *Trans R Soc Trop Med Hyg* 1979;**73**:557-62.
- Salmi I, Pettay O, Simula I, Kallio A-K, Waltimo O. An epidemic due to sulphonamide-resistant group A meningococci in the Helsinki area (Finland). Epidemiological and clinical observations. *Scand J Infect Dis* 1976;**8**:249-54.
- Mäkelä PH, Peltola H. Group-specific meningococcal vaccination and epidemics caused by other groups of meningococci. *Lancet* 1978;iii:780-1.
- Frasch CE, Chapman SS. Classification of *Neisseria meningitidis* group B into distinct serotypes. I. Serological typing by a microbactericidal method. *Infect Immun* 1972;**5**:98-102.
- Gold R, Winkelhake JL, Mars RS, Artenstein MS. Identification of an epidemic strain of group C *Neisseria meningitidis* by bactericidal serotyping. *J Infect Dis* 1971;**124**:593-7.
- Farries JS, Dickson W, Greenwood W, Malhotra TR, Abbot JD, Jones DM. Meningococcal infections in Bolton 1971-1974. *Lancet* 1975;iii:118-21.
- Frasch CE. Role of serotype antigens in protection against disease due to *Neisseria meningitidis*. *J Infect Dis* 1977;**136**:S84-S90.
- Mäkelä PH, Peltola H, Käyhty H, et al. Polysaccharide vaccines of group A *Neisseria meningitidis* and *Haemophilus influenzae* type b: A field trial in Finland. *J Infect Dis* 1977;**136**:S43-S50.
- Moberg I. Sulfaresistenta meningokocker i Sverige—förekomst, vaccination och kemoprofylax. *Läkartidningen* 1975;**72**:971-3.
- Mäkelä PH, Käyhty H, Weckström P, Sivonen A, Renkonen O-V. Effect of group-A meningococcal vaccine in army recruits in Finland. *Lancet* 1975;iii:883-6.
- Peltola H. Meningococcal disease—still with us. *Review of Infectious Diseases* (in press).
- Mihalcu F, Pasolescu O, Coban V, Cuciureanu G, Dumitrescu S. Aspects actuels de la méningite cérébro-spinale épidémique en Roumanie. *Arch Roum Path Exp Microbiol* 1972;**31**:125-34.
- Favorova LA, Teleshvskaya EA, Troshina LD, Vinnitshek ND, Ershova GA, Salnikova GP. Epidemiology and prevention of meningococcal infections (in Russia). *Sov Med* 1971;**11**:113-8.
- Jamba G, Bytchenko B, Causse G, et al. Immunization during a cerebrospinal meningitis epidemic in the Mongolian People's Republic, 1974-75. *Bull WHO* 1979;**57**:943-6.
- Lima G Jr. *Discours de Monsieur le Ministre de la Santé du Brésil. Séminaire international sur les vaccinations en Afrique*. Lyon: Edition Mérieux, 1974:124-8.
- Kostyukova NN, Mironova TK, Leschinskaya EV. Microbiological characteristics of meningococcus infection in Moscow during a periodic rise in morbidity (1968-1971) (in Russia). *Zh Microbiol Epidemiol Immunobiol* 1974;**5**:29-32.
- De Maeyer S, Seba JM, Reginster G. Epidemiology of meningococcal meningitis in Belgium. *Journal of Infection* 1981;**3**:S63-S70.
- Jacobson JA, Chester TJ, Fraser DW. An epidemic of disease due to serogroup B *Neisseria meningitidis* in Alabama. Report of an investigation and community wide prophylaxis with a sulfonamide. *J Infect Dis* 1977;**136**:104-8.
- Frøholm LO. Review of meningococcal vaccines with emphasis on possible immunoprophylaxis of group B disease. *National Institute of Public Health (NIPH) Annals* 1980;**3**:67-74.
- Devine LF, Pollard RB, Krumpe PE, et al. Field trial of the efficacy of a previously proposed regimen using minocycline and rifampicin sequentially for the elimination of meningococci from health carriers. *Am J Epidemiol* 1973;**97**:394-401.
- Sivonen A, Renkonen O-V, Weckström P, Koskenvuo K, Raunio V, Mäkelä PH. The effect of chemoprophylactic use of rifampicin and minocycline on meningococcal carrier rates in army recruits in Finland. *J Infect Dis* 1978;**137**:238-44.
- Frasch CE, Robbins JD. Protection against group B meningococcal disease. III. Immunogenicity of serotype 2 vaccines and specificity of protection in a guinea pig model. *J Exp Med* 1978;**147**:629-44.
- Zollinger WD, Mandrell RE, Altieri P, Berman S, Lowenthal J, Artenstein MS. Safety and immunogenicity of a *Neisseria meningitidis* type 2 protein vaccine in animals and humans. *J Infect Dis* 1978;**137**:728-39.

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