

SURVEILLANCE REPORT

Invasive meningococcal disease

Annual Epidemiological Report for 2022

Key facts

- In 2022, 1 149 confirmed cases of invasive meningococcal disease (IMD), including 110 deaths, were reported in 30 European Union/European Economic Area Member States.
- France, Germany, Poland, and Spain accounted for 60% of all reported confirmed IMD cases.
- In 2022, the notification rate of IMD rose to 0.3 cases per 100 000 population, following a decline of the IMD incidence in 2020 and in 2021.
- Age-specific rates were highest in infants aged <1 year, followed by 1–4-year-olds and 15–24-year-olds.
- Serogroup B remains the major cause of IMD; it accounted for 62% of serogroup documented cases overall and was the dominating serogroup in all age groups below 65 years. The notification rate of serogroup B returned to that observed in 2018–19 or below in all age groups except for adolescents aged 15–24 years, where it increased beyond that observed in 2018–19.
- Serogroup Y was the second highest serogroup documented among cases (16%). It was the most reported documented serogroup in those aged 65 years and above, causing 46% of cases in this age group. The notification rate of serogroup Y of 2022 by age group never exceeded the level observed in 2018–19; however, it increased sharply in all age groups except in 25–49-year-olds compared to the level observed in 2021.
- Serogroup W was the third reported cause of IMD in 10% of documented serogroup cases, with the fourth cause being serogroup C (6%). The notification rate of serogroup C has continued to decrease since 2018.
- Case fatality was the highest among cases of serogroup W (17%) and C (20%).
- The continued strengthening of disease surveillance for IMD is essential to evaluate the impact of ongoing immunisation programmes and support decision-makers concerning the implementation or adaptation of vaccination strategies in the lifelong immunisation course.

Introduction

Invasive meningococcal disease (IMD) is a serious bacterial infection caused by the Gram-negative diplococcus *Neisseria meningitidis*. The bacterium is often detected in the nasopharynx without causing disease, described as asymptomatic carriage. It occasionally invades the body and causes meningococcal infection. IMD is a major cause of meningitis (37%–49% of cases) and septicaemia (18%–33% of cases) [1]. It is of public health concern because of its severe morbidity and relatively high case fatality rate (8–15%), especially in young children.

In the European Union/European Economic Area (EU/EEA), vaccines are available for primary prevention of disease caused by serogroups A, B, C, W, and Y. Antibiotics are administered for elimination of carriage and treatment of disease.

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Methods

This report is based on data for 2022 retrieved from The European Surveillance System (TESSy) on 9 February 2024. TESSy is a system for the collection, analysis and dissemination of data on communicable diseases.

For a detailed description of the methods used to produce this report, refer to the Methods chapter of the introduction to the 'ECDC Annual Epidemiological Report 2024' [2].

An overview of the national surveillance systems is available online [3].

A subset of the data used for this report is available through ECDC's online 'Surveillance Atlas of Infectious Diseases' [4].

Thirty EU/EEA countries reported data on invasive meningococcal disease (IMD) to ECDC. Most countries used the EU case definition [5] or a compatible case definition for confirmed cases [3].

Most countries reported data from comprehensive, passive surveillance systems with national coverage. Belgium reported data from a sentinel surveillance system. Bulgaria and Croatia reported aggregated data in 2022.

The United Kingdom (UK) contributed surveillance data up to 2019. No data were reported by the UK for 2020 or 2021 due to its withdrawal from the EU on 31 January 2020. The UK data that were reported up to 2019 are not included in the analysis of trends.

Epidemiology

In 2022, 1149 confirmed cases of IMD were reported in 30 EU/EEA countries (Table 1). The total number of reported confirmed cases remained below the total number observed in 2018-19, similar to the total number of cases reported in 2020, but has doubled compared to 2021. Four countries (France, Germany, Poland and Spain) accounted for 60% of all confirmed cases. Cyprus and Liechtenstein reported zero cases.

The overall EU/EEA notification rate was 0.3 cases per 100 000 population. By country, notification rates ranged from <0.1 cases (Bulgaria, Greece) to 0.6 cases per 100 000 population (Ireland, Luxembourg) (Table 1, Figure 1). The incidence in France, Lithuania and Slovakia reached 0.5 cases per 100 000 population, the second highest notification rate reported in 2022 after Ireland and Luxembourg.

All countries experienced an increased in notification rates (or in the number of cases) compared with 2021, except Cyprus, Estonia, Hungary, Liechtenstein, and Malta. In Malta and Hungary, the notification rate decreased compared to 2021 from 0.3 cases to 0.2 cases per 100 000 population and from 1.6 cases to 0.4 cases per 100 000 population, respectively. In other countries, although the number of cases increased it affected the notification rate at the margins (Bulgaria, Greece, Poland, Portugal, and Romania). In a few countries, the notification rate in 2022 again reached the same level as that observed in 2018–19 before the COVID-19 pandemic (Latvia, 0.4 cases per 100 000 population; Slovakia, 0.5 cases per 100 000 population) or was even higher (Iceland, 0.3 cases per 100 000 population; Luxembourg, 0.6 cases per 100 000 population).

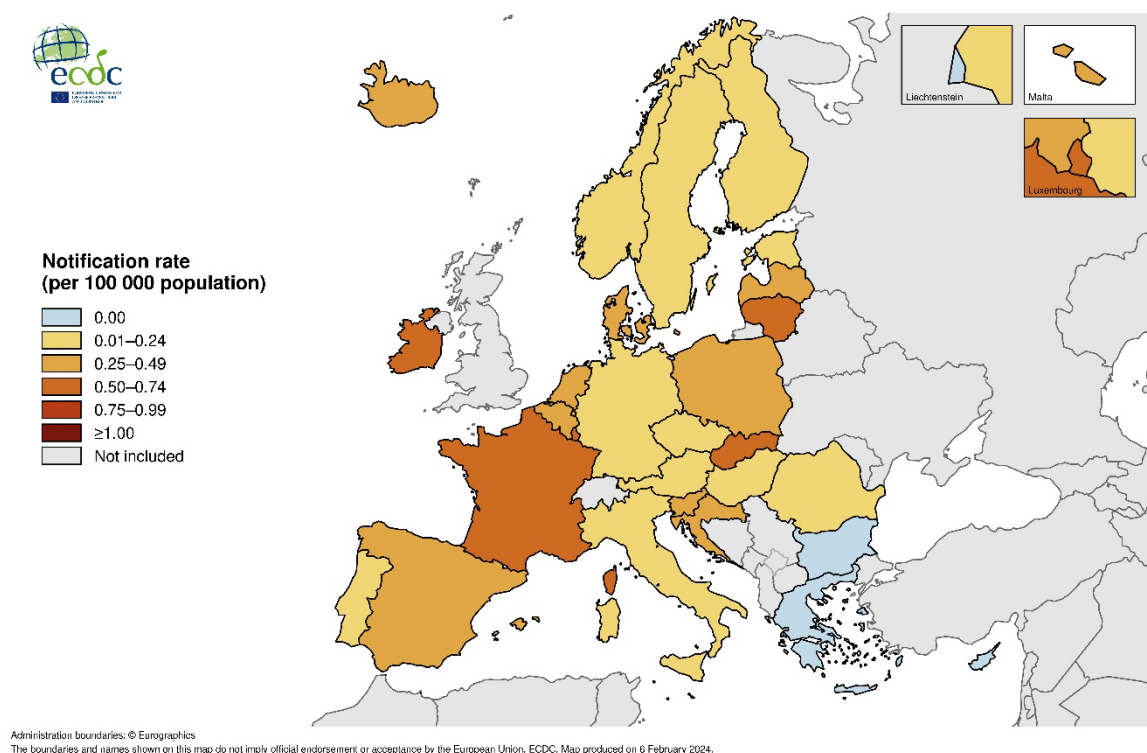
Table 1. Distribution of confirmed invasive meningococcal disease cases and notification rates per 100 000 population by country and year, EU/EEA, 2018–2022

Country	2018		2019		2020		2021		2022	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Austria	30	0.3	24	0.3	8	0.1	2	0.0	7	0.1
Belgium	116	1.0	107	0.9	55	0.5	24	0.2	43	0.4
Bulgaria	5	0.1	9	0.1	3	0.0	1	0.0	3	0.0
Croatia	31	0.8	34	0.8	14	0.3	6	0.1	17	0.4
Cyprus	1	0.1	2	0.2	0	0.0	0	0.0	0	0.0
Czechia	56	0.5	49	0.5	25	0.2	11	0.1	24	0.2
Denmark	38	0.7	50	0.9	16	0.3	9	0.2	15	0.3
Estonia	8	0.6	4	0.3	3	0.2	1	0.1	1	0.1
Finland	16	0.3	16	0.3	5	0.1	2	0.0	7	0.1
France	439	0.7	456	0.7	214	0.3	117	0.2	319	0.5
Germany	288	0.3	254	0.3	137	0.2	74	0.1	138	0.2
Greece	34	0.3	32	0.3	21	0.2	4	0.0	5	0.0
Hungary	40	0.4	46	0.5	32	0.3	30	0.3	24	0.2
Iceland	0	0.0	0	0.0	0	0.0	0	0.0	1	0.3
Ireland	88	1.8	67	1.4	20	0.4	10	0.2	29	0.6
Italy	170	0.3	189	0.3	73	0.1	25	0.0	57	0.1
Latvia	5	0.3	8	0.4	6	0.3	5	0.3	8	0.4
Liechtenstein	NDR	NRC	NDR	NRC	NDR	NRC	0	0.0	0	0.0
Lithuania	31	1.1	32	1.1	7	0.3	11	0.4	13	0.5
Luxembourg	2	0.3	2	0.3	4	0.6	1	0.2	4	0.6
Malta	4	0.8	33	6.7	17	3.3	8	1.6	2	0.4
Netherlands	206	1.2	159	0.9	68	0.4	37	0.2	79	0.4
Norway	26	0.5	16	0.3	5	0.1	5	0.1	10	0.2
Poland	199	0.5	193	0.5	106	0.3	107	0.3	117	0.3
Portugal	57	0.6	56	0.5	34	0.3	10	0.1	14	0.1
Romania	64	0.3	50	0.3	24	0.1	12	0.1	25	0.1
Slovakia	36	0.7	29	0.5	23	0.4	20	0.4	28	0.5
Slovenia	18	0.9	9	0.4	5	0.2	3	0.1	7	0.3
Spain	392	0.8	395	0.8	213	0.5	68	0.1	131	0.3
Sweden	56	0.6	65	0.6	28	0.3	9	0.1	21	0.2
EU/EEA (30 countries)	2 456	0.5	2 386	0.5	1 166	0.3	612	0.1	1 149	0.3
United Kingdom	772	1.2	582	0.9	NDR	NRC	NA	NA	NA	NA
EU/EEA (31 countries)	3 228	0.6	2 968	0.6	1 166	0.3	NA	NA	NA	NA

Source: country reports; NDR: no data reported; NRC: no rate calculated; NA: not applicable.

No data from 2020 onwards were reported by the United Kingdom, due to its withdrawal from the EU on 31 January 2020.

Figure 1. Distribution of confirmed invasive meningococcal disease cases per 100 000 population by country, EU/EEA, 2022



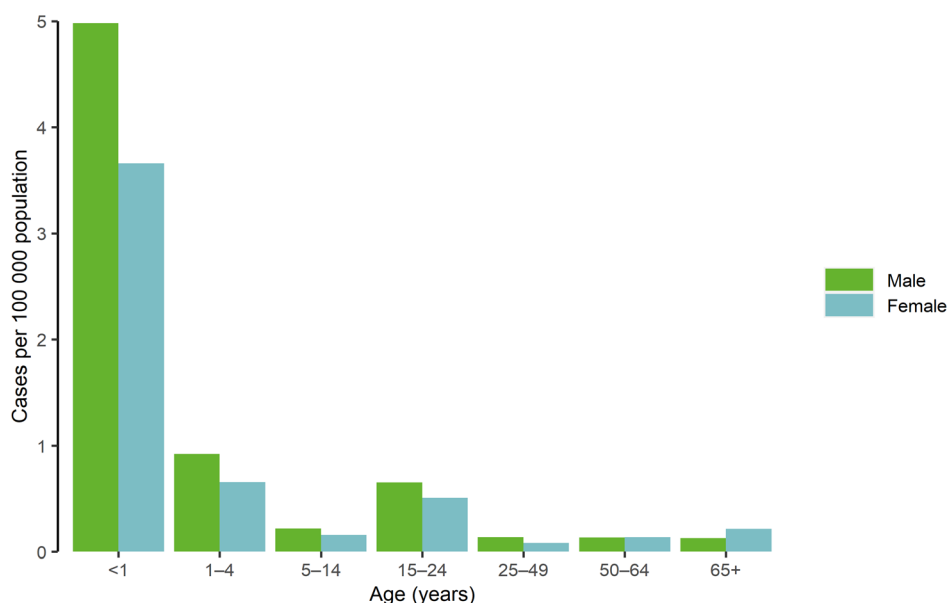
Age and gender

In 2022, the pattern of notification rates in the different age groups was similar to what observed in previous years, with highest notification rates observed in infants, followed by young children and adolescents. The notification rate was 4.3 confirmed cases per 100 000 population in infants (under one year of age) and 0.8 confirmed cases per 100 000 population in children 1–4-year-olds (Figure 2). The notification rate in 15–24-year-olds (0.6 per 100 000 population) was slightly higher than in 5–14-year-olds (0.2 per 100 000 population). The notification rate in individuals aged 65 years and older was 0.2 confirmed cases per 100 000 population.

Notification rates were higher in males compared to females: 0.3 versus 0.2 confirmed cases per 100 000 population. Notification rates were higher in males in all age groups except in those 65 years and older, where male and female notification rates were respectively 0.2 and 0.1 confirmed cases per 100 000 population. In infants (under one year of age), the notification rate was much higher in male infants (5.0 confirmed cases per 100 000 population) than female infants (3.7 confirmed cases per 100 000 population).

The overall male-to-female ratio of IMD cases was 1.18:1.

Figure 2. Distribution of confirmed invasive meningococcal disease cases per 100 000 population by age and gender, EU/EEA, 2022

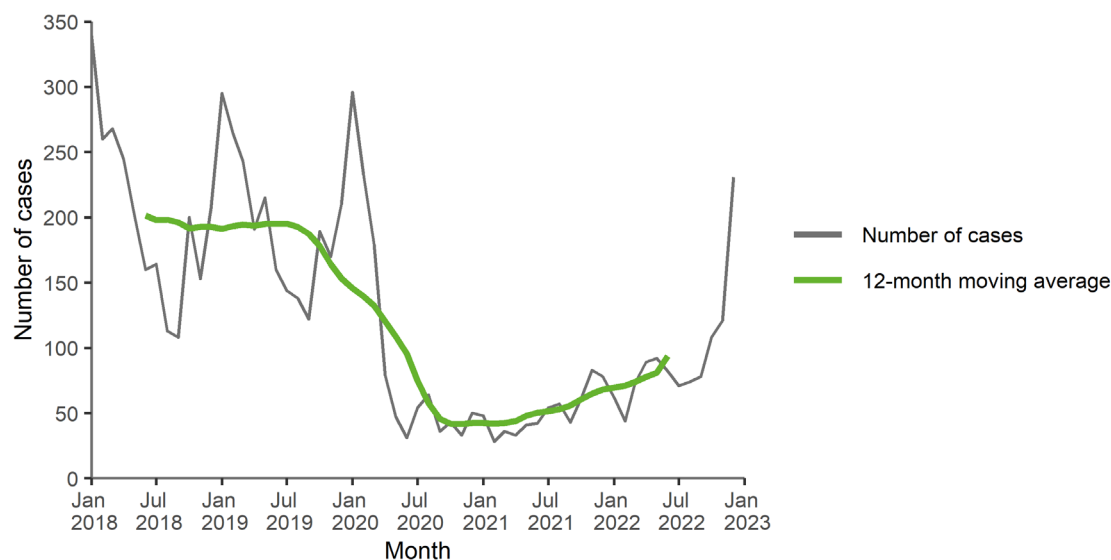


Source: country reports from Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

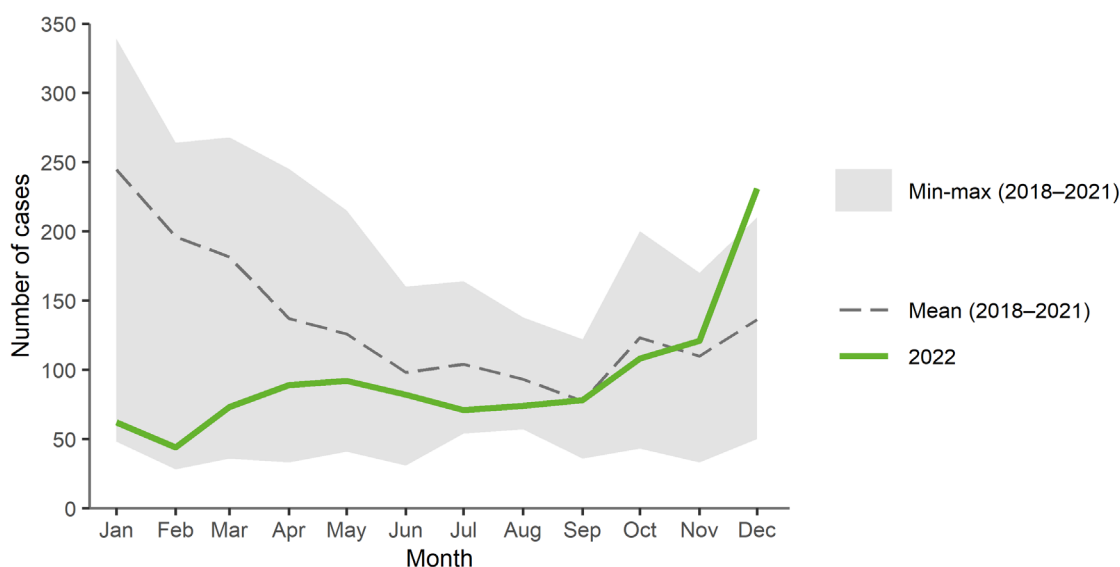
Seasonality and trend

Between 2018 and early 2020, the seasonality of IMD followed a pattern similar to previous years. IMD occurred primarily in the winter months, while the number of cases was lowest in summer (Figure 3). The number of reported confirmed cases sharply decreased in 2020–22 (Figure 3) with an attenuated seasonality pattern. The strong rise in the number of cases observed in December 2022 might mark the restart of a more common seasonality pattern similar to prior to the COVID-19 pandemic (Figure 4).

Figure 3. Distribution of confirmed invasive meningococcal disease cases by month, EU/EEA, 2022 and 2018–2021



Source: country reports from Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

Figure 4. Distribution of confirmed invasive meningococcal disease cases by month, EU/EEA, 2022 and 2018–2021

Source: country reports from Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

Serogroup

Out of 1149 confirmed IMD cases reported in 2022, 991 (86%) had a documented serogroup (Table 2). Most cases with a documented serogroup belonged to serogroup B (62%), followed by serogroups Y (16%), W (10%) and C (6%). As the proportion of cases with unknown serogroup remained high (14%), the observed serogroup distribution should be interpreted with caution.

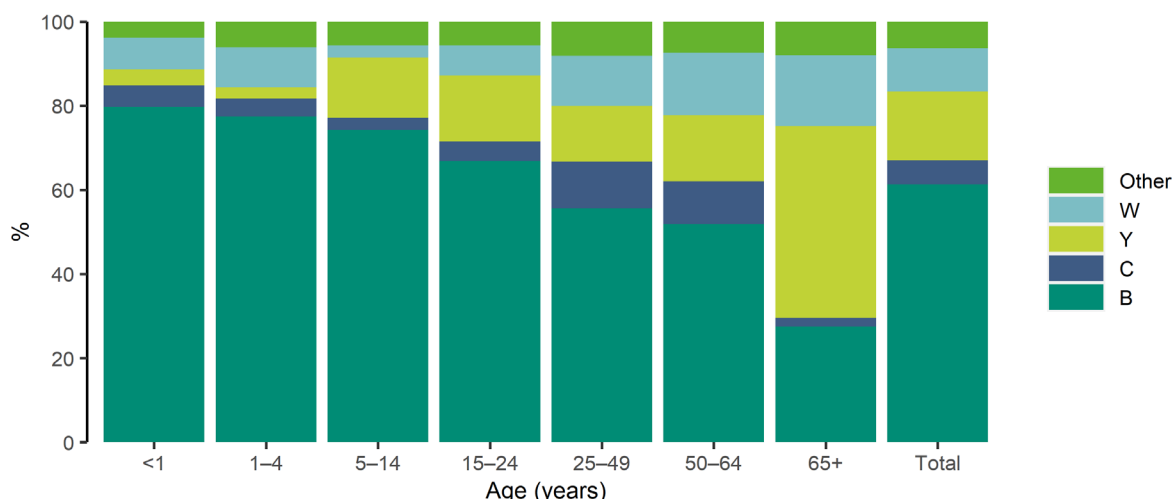
Serogroup B was predominant in all age groups aged below 65-year-olds (Figure 5). In total, serogroup B accounted for 80% of cases aged less than one year. This proportion decreased in older age groups and reached 27% in individuals aged 65 years and above. Serogroup Y was mostly documented in those aged 65 years and above, causing 46% of cases in this age group. The proportion of serogroup Y cases was the lowest in infants <1 year (3.8%) and in 1–4-year-olds (2.6%). Serogroup W was most common in the 65 years and above age group, causing 17% of cases, and was the second most common serotype identified in this age group. In other age groups, the proportion fluctuated between 6.6% (15–24-year-olds) and 14.8% (50–64-year-olds). Serogroup C was the third serogroup reported in <1 year (5%) and in 1–4-year-olds (4.3%), age groups where serogroup B was dominant. In 25–49-year-old and in 50–64-year-olds, the proportion of serogroup C was respectively 11% and 10% and it was the serogroup less commonly reported in these age groups.

Table 2. Serogroup distribution of confirmed cases of invasive meningococcal disease, EU/EEA, 2022

Serogroup	Cases	%
B	613	62
C	55	6
Y	161	16
W	99	10
Other	63	6
Total	991	100

'Other' refers to all cases reported as serogroup A, X, Z, 29E, non-groupable or 'other'.

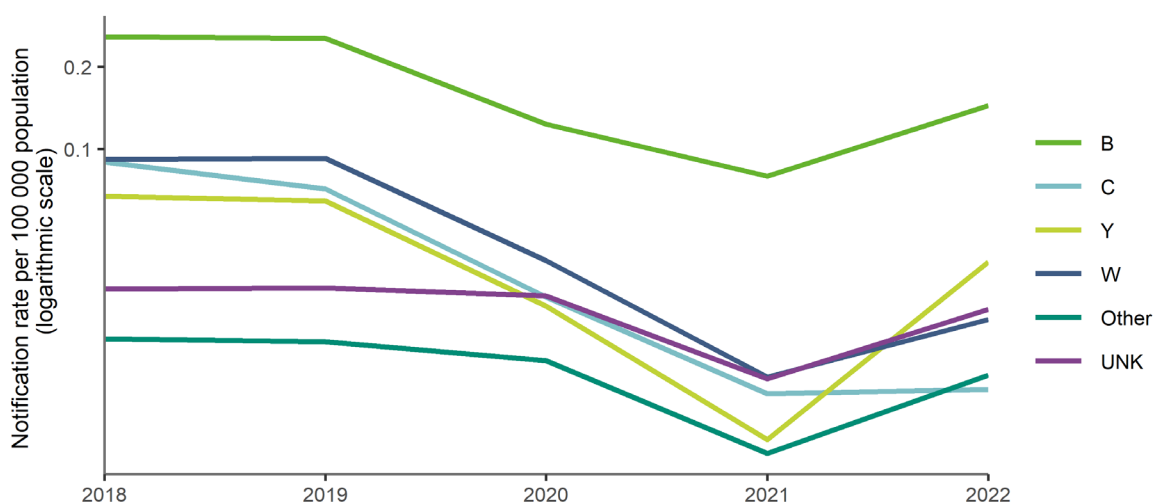
Figure 5. Serogroup distribution of confirmed cases of invasive meningococcal disease by age group, EU/EEA, 2022



'Other' refers to all cases reported as serogroup A, X, Z, 29E, non-groupable or 'other'.

Among 23 countries that consistently reported IMD confirmed cases with serogroup data between 2018 and 2022, there was an overall increase in the notification rate of IMD of serogroups B, W and Y in 2022 compared to 2021, while the incidence of serogroup C has been decreasing and remained at the same low level as 2021 and lower than the level observed in 2018–19 (0.01 case per 100 000 population) (Figure 6). The incidence of serogroup Y increased sharply in 2022 compared to 2021 and it was the second highest serogroup reported overall (0.04 case per 100 000 population).

Figure 6. Notification rates of confirmed cases of invasive meningococcal disease by serogroup and year, EU/EEA, 2018–2022



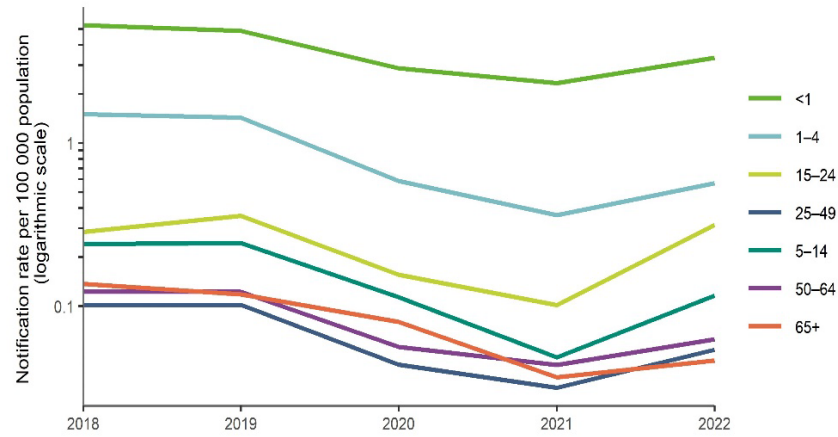
Source: country reports from Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden.

The notification rate of IMD confirmed cases by serogroup and by age group for 2022 showed an increase compared to 2021 in all age groups for serogroup B, W, and Y (Figure 7).

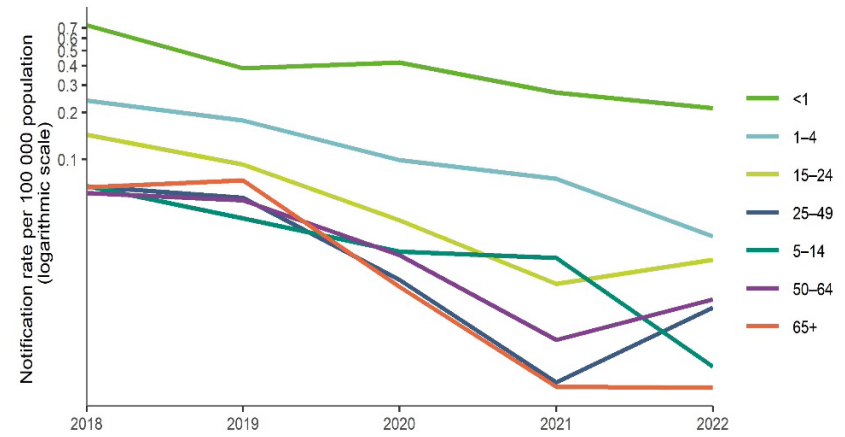
The notification rate of serogroup B returned to what observed in 2018–19 or below in all age groups, except adolescents aged 15–24 years, where in 2022 it increased beyond what observed in 2018–19. For serogroup Y, the notification rate of 2022 by age group never exceeded the level observed in 2018–19; however, it increased sharply in all age groups except in 25–49 years, when compared to level observed in 2021. There was a slow increase in IMD incidence of serogroup W in all age groups especially in those younger than five years old and in older individuals aged 65 years and above. In all age groups, the serogroup W IMD incidence remained below the level of incidence observed during the 2018–19 period. There was a decrease in serogroup C IMD cases aged below 15-year-olds and in 65-year-olds and above while it increased in all age groups between 15–65-year-olds, without returning to levels seen in 2018–2020.

Figure 7. Notification rates of confirmed cases of invasive meningococcal disease by serogroup, age group and year, EU/EEA, 2018–2022

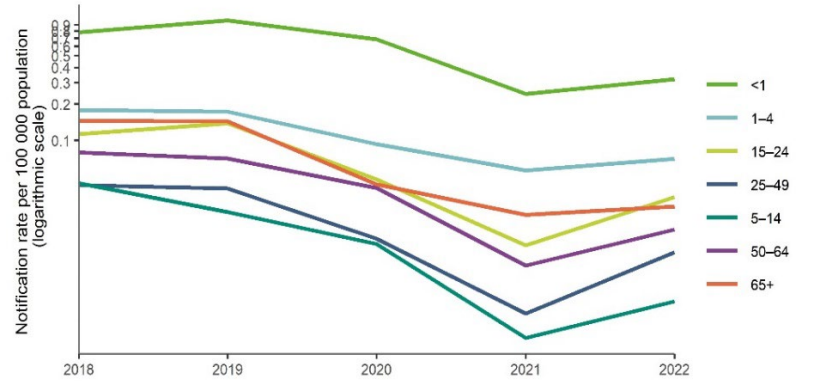
Serogroup B



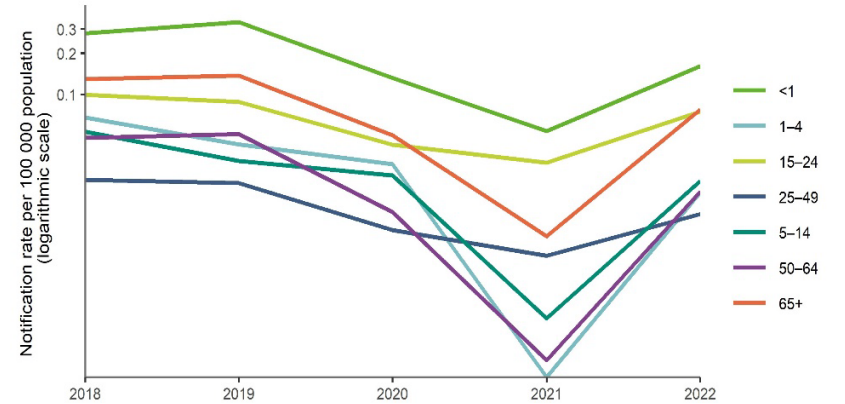
Serogroup C



Serogroup W



Serogroup Y



Clinical presentation and outcome

In 2022, clinical presentation was reported for 624 confirmed IMD cases (54%). Meningitis was the most common reported clinical presentation (46%) associated with septicaemia (16%). Septicaemia only was the second most common clinical pattern (26%). Pneumonia (2%) and 'other' clinical presentations (9%) were reported in the remaining cases. A total of 55% and 39% of serogroup W and Y cases respectively presented with septicaemia. The outcome was reported for 1 052 confirmed IMD cases (91%). There were 110 fatal cases reported, e.g. a case fatality of 10% among cases with known outcome. Case fatality was the highest among cases of serogroup W (17%) and C (20%). Fatality ratio was 15% among serogroup C, 10% among serogroup B, and 8% among serogroup Y.

Case fatality was the highest in cases aged 50–64 years (19%). High case fatality was also reported in <1-year-olds (10%), in 1–4-year-olds (12%) and in 25–49-year-olds. Although lower in other age groups, it remained high and was 7% in 15–24-year-olds and 5% in 5–14-year-olds.

Vaccination status

In 2022, the vaccination status was reported for 372 cases (21%). Most cases were unvaccinated (93%).

Discussion

Invasive meningococcal disease (IMD) remains rare in EU/EEA countries but is a severe and life-threatening disease in all age groups. This report covers an overview of cases with laboratory confirmation.

In 2020–2021, the total number of notified cases and the notification rates across all age groups sharply decreased compared to 2018–2019. In 2021, the IMD incidence was low. The containment measures implemented in EU/EEA countries to tackle the circulation of SARS-Cov-2 from March 2020 onwards impacted on the transmission of respiratory pathogens transmitted by droplets including *Neisseria meningitidis* [6-7], and contributes to the explanation of the drop in the notification rates of IMD observed between 2020 and 2021. In 2022, compared to 2021, there was an overall upsurge in the number of cases reported and the notification rate of all serogroups of IMD except for serogroup C, for which both the proportion and the incidence of IMD cases remained low. Meanwhile serogroup B remained the dominant serogroup increasing in all age group. The notification rate of IMD confirmed cases of serogroup B increased beyond the level observed in 2018–19 in 15–24-year-olds. There was a sharp increase of serogroup Y IMD incidence and a moderate increase in IMD serogroup W incidence without reaching the level of incidence observed in 2018–19. Of note, the notification rate of serogroup Y IMD incidence increased in all age groups.

The post-pandemic epidemiology of meningococcal disease should be interpreted taking into consideration the recent changes in the meningococcal vaccination programmes and the short period of observation following the pandemic period. In addition, multiple factors contribute to explain the constant changing epidemiology of meningococcal disease and its serogroup distribution – these include vaccination programmes [8, 9], secular trends, the emergence of hypervirulent clones, population immunity, environmental and behavioural risk factors [10].

Since the beginning of the monitoring of IMD cases in the EU/EEA, serogroup B has been responsible for most cases in infants and young children, with the notification rates declining since 2014 [10] and even more during the COVID-19 pandemic period [15]. The immunisation strategy with 4CMenB aims to impact on the incidence of IMB [11,12] by providing direct individual protection against IMD serogroup B in the vaccinees [12], as the vaccine does not have any effect on serogroup B meningococcal carriage [13].

Since the deployment of Men-C conjugate vaccination programmes in infants across the EU/EEA in the early 2000s, young children with catch-up campaigns in adolescents have been associated with the decrease of IMD Serogroup C [14]. The slight increase of notification rates in young adults (15–24 years) observed in 2022 compared with 2021 needs to be further monitored. It might be the consequence of lower vaccination coverage in this age group, but could also be due to other factors.

The observed increase of notification rates for IMD cases of serogroup W and serogroup Y requires close monitoring. Before the COVID-19 pandemic, changing increasing trends in the incidence of IMD serogroup W and at a less extend serogroup Y had already been reported for several years [14,15]. The epidemiology of serogroup W is changing quickly. Among factors that explained the resurgence of serogroup W before the pandemic of COVID-19, there was the report of the circulation of strains belonging to sequence type (ST) 11 in several countries including the Netherlands, in Sweden and in France [16–18] and the report on the emergence of a distinct genotype from CC11 (ST-9316) [19]. In 2018, there was an increased both in the incidence and in the proportion of reported serogroup Y IMD cases [10,14,20,21]. The resurgence of this serogroup in all age groups is of concern and requires a close monitoring including the need to integrate microbiological data, genomic and epidemiological data.

As of January 2023, 20 countries have adopted meningococcal vaccine recommendations [8-9] with the conjugate monovalent Meningococcal-C (Men-C) and/or the four-component Men-B protein-based vaccine (4CMen-B) and/or the quadrivalent Meningococcal ACWY (Men-ACWY). Recommendations differed across countries in terms of targeted age group(s) (infants, adolescents, adults), targeted serogroup(s) (different vaccine products recommended covering different serogroup(s)), mandatory versus voluntary vaccine policies and funding scheme. Men-C and Men-B vaccine recommendations mostly target infants while recommendations with Men-ACWY mostly target the adolescents with a shift in recent years toward primary vaccination of young children (instead of primary Men-C vaccination). None of the EU/EEA countries has universal recommendation in place against IMD in adults. In that age group, the proportion of different serogroups varied depending on the age. The proportion of the serogroup W and Y was the highest among individuals aged ≥ 65 years old as compared to younger age groups; they also had the highest case fatality rate. Before the pandemic, the incidence of IMD continued to increase in adults [20]. Lifelong vaccination against IMD should also be considered in light of the unpredictable clinical pattern of IMD, the high mortality rates, the cost of hospital care and the potential for severe life-long sequelae at any age of life [1].

Public health implications

Several vaccines targeting different serogroups are available for the prevention of IMD. The choice of introducing a vaccine into the national routine immunisation programme depends on multiple factors, such as vaccine efficacy and expected coverage, disease and serogroup burden, cost effectiveness, and feasibility of the programme.

The epidemiology of IMD after the COVID-19 pandemic is characterised by the resurgence of serogroup B and Y, which are dominant, followed by serogroup W, while serogroup C remained at very low levels of circulation.

The pattern of resurgence of IMD-confirmed cases after the COVID-19 pandemic could partly be explained by the different vaccine strategies adopted in the EU/EEA; further enhanced analysis is required to better understand the effect of the different vaccine strategies implemented, including the long-term vaccination strategy against serogroup C.

The dynamic nature of meningococcal disease epidemiology, increasing trends in certain serogroups in some countries, and the rapid expansion of hypervirulent clones highlight the need for continued high-quality surveillance, including molecular methods, to accurately detect and assess changes in the epidemiology of IMD, as well as the effectiveness and impact of implemented vaccines. ECDC has established a pilot for an integrated genomic and epidemiological surveillance of IMD, whose objectives include the understanding of multi-country outbreaks and long-term monitoring to inform vaccination strategies. This approach has now been taken in 2024 by ECDC.

References

1. Pardo de Santayana C, Tin Tin Htar M, Findlow J, Balmer P. Epidemiology of invasive meningococcal disease worldwide from 2010-2019: a literature review. *Epidemiol Infect.* 2023;151:e57. doi: 10.1017/S0950268823000328.
2. European Centre for Disease Prevention and Control (ECDC). Introduction to the Annual Epidemiological Report. In: ECDC. Introduction to the Annual epidemiological report]. Stockholm: ECDC; 2024 [cited 14 March 2024]. Available at: <http://ecdc.europa.eu/annual-epidemiological-reports/methods>
3. European Centre for Disease Prevention and Control (ECDC). Surveillance systems overview 2022 [downloadable spreadsheet]. Stockholm: ECDC; 2024 [cited 4 March 2024]. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Table-surveillance_systems_overview_2022_20240119.xlsx
4. European Centre for Disease Prevention and Control (ECDC). Surveillance atlas of infectious diseases. Stockholm: ECDC; 2024 [cited 4 March 2024]. Available at: <http://atlas.ecdc.europa.eu/public/index.aspx?Dataset=27&HealthTopic=40>
5. European Centre for Disease Prevention and Control (ECDC). EU case definitions. Stockholm: ECDC; 2024 [cited 4 March 2024]. Available at: http://ecdc.europa.eu/en/aboutus/what-we-do/surveillance/Pages/case_definitions.aspx
6. Brueggemann AB, Jansen van Rensburg MJ, Shaw D, McCarthy ND, Jolley KA, Maiden MC, et al. Changes in the incidence of invasive disease due to *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* during the COVID-19 pandemic in 26 countries and territories in the Invasive Respiratory Infection Surveillance Initiative: a prospective analysis of surveillance data. *Lancet Digit Health.* 2021 Jun;3(6):e360-e370. doi: 10.1016/S2589-7500(21)00077-7. Erratum in: *Lancet Digit Health.* 2021 Jul;3(7):e413. doi: 10.1016/S2589-7500(21)00103-5. Epub 2021 May 26.
7. Nicolay N, Mirinaviciute G, Mollet T, Celentano LP, Bacci S. Epidemiology of measles during the COVID-19 pandemic, a description of the surveillance data, 29 EU/EEA countries and the United Kingdom, January to May 2020. *Euro Surveill.* 2020 Aug;25(31):2001390. doi: 10.2807/1560-7917.ES.2020.25.31.2001390. Available at: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.31.2001390>
8. European Centre for Disease Prevention and Control (ECDC). Vaccine Scheduler. Stockholm: ECDC; 2019. Available at: <http://vaccine-schedule.ecdc.europa.eu>
9. Ladhani SN, Andrews N, Parikh SR, Campbell H, White J, Edelstein M et al. Vaccination of Infants with Meningococcal Group B Vaccine (4CMenB) in England. *N Engl J Med.* 2020 Jan 23;382(4):309-317. doi: 10.1056/NEJMoa1901229.
10. Whittaker R, Dias JG, Ramliden M, Ködmön C, Economopoulou A, Beer N et al. The epidemiology of invasive meningococcal disease in EU/EEA countries, 2004-2014. *Vaccine.* 2017;35(16):2034-2041. doi: 10.1016/j.vaccine.2017.03.007.
11. Ladhani SN, Borrow R, Andrews NJ. Growing evidence supports 4CMenB effectiveness. *Lancet Infect Dis.* 2018 Apr;18(4):370-371.
12. McMillan M, Marshall HS, Richmond P. 4CMenB vaccine and its role in preventing transmission and inducing herd immunity. *Expert Rev Vaccines.* 2022 Jan;21(1):103-114. doi: 10.1080/14760584.2022.2003708.
13. Marshall HS, McMillan M, Koehler AP, et al. Meningococcal B vaccine and meningococcal carriage in adolescents in Australia. *N Engl J Med* 2020;382:318-327.
14. Nuttens C, Findlow J, Balmer P, Swerdlow DL, Tin Tin Htar M. Evolution of invasive meningococcal disease epidemiology in Europe, 2008 to 2017. *Euro Surveill.* 2022 Jan;27(3):2002075. doi: 10.2807/1560-7917.
15. European Centre for Disease Prevention and Control (ECDC). Invasive meningococcal disease. In: ECDC. Annual epidemiological report for 2021. Stockholm: ECDC; 2023. Available at: <https://www.ecdc.europa.eu/sites/default/files/documents/MEN%20AER%202021.pdf>
16. Knol MJ, Hahné SJM, Lucidarme J, Campbell H, de Melker HE, Gray SJ, et al. Temporal associations between national outbreaks of meningococcal serogroup W and C disease in the Netherlands and England: an observational cohort study. *Lancet Public Health.* 2017 Oct;2(10):e473-e482.
17. Lucidarme J, Scott KJ, Ure R, Smith A, Lindsay, Stenmark B, et al. An international invasive meningococcal disease outbreak due to a novel and rapidly expanding serogroup W strain, Scotland and Sweden, July to August 2015. *Euro Surveill.* 2016 Nov 10;21(45). Available at: <http://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2016.21.45.30395>
18. Hong E, Barret AS, Terrade A, Denizon M, Antona D, Aouiti-Trabelsi M, Deghmane AE, Parent du Chatelet I, Levy-Bruhl D, Taha MK. Clonal replacement and expansion among invasive meningococcal isolates of serogroup W in France. *J Infect.* 2018;76:149–58. doi:10.1016/j.jinf.2017.10.015

19. Deghmane AE, Haeghebaert S, Hong E, Jousset A, Barret AS, Taha MK. Emergence of new genetic lineage, ST-9316, of *Neisseria meningitidis* group W in Hauts-de-France region, France 2013-2018. *J Infect.* 2020 Feb 4. pii: S0163-4453(20)30060-8. doi: 10.1016/j.jinf.2020.01.020.
20. European Centre for Disease Prevention and Control (ECDC). Invasive meningococcal disease. In: ECDC. Annual epidemiological report for 2018. Stockholm: ECDC; 2022. Available at: <https://www.ecdc.europa.eu/sites/default/files/documents/AER-Invasive-meningococcal-disease-2018.pdf>
21. Bröker M, Emonet S, Fazio C, Jacobsson S, Koliou M, Kuusi M, et al. Meningococcal serogroup Y disease in Europe: Continuation of high importance in some European regions in 2013. *Hum Vaccin Immunother.* 2015;11(9):2281-6.