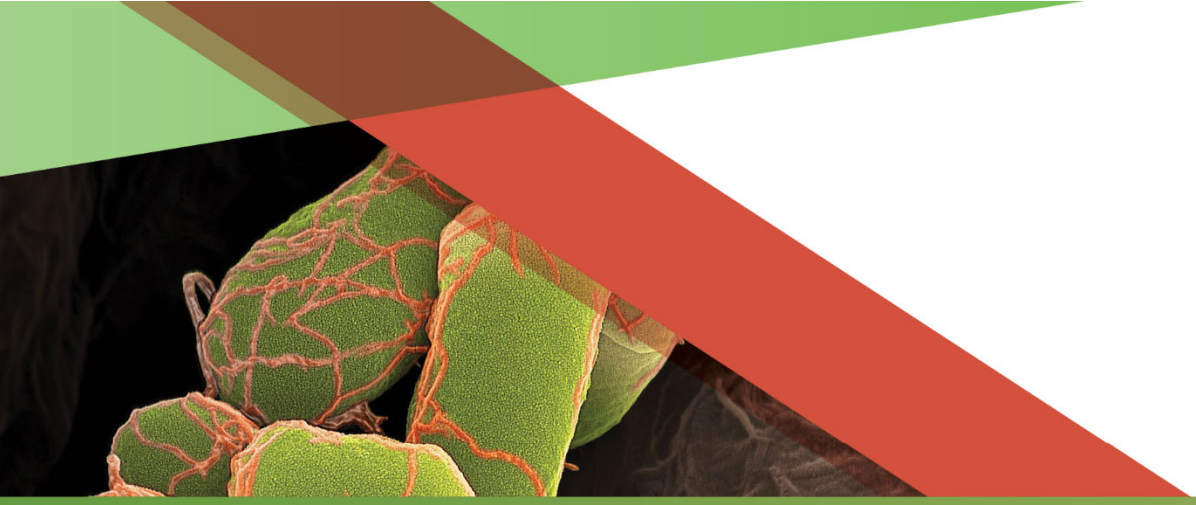


SURVEILLANCE REPORT

STEC infection

Annual Epidemiological Report for 2022

Key facts

- For 2022, 29 European Union/European Economic Area (EU/EEA) countries reported 8 565 confirmed cases of Shiga toxin-producing *Escherichia coli* (STEC) infection.
- The overall EU/EEA notification rate was 2.5 cases per 100 000 population, which exceeded the pre-pandemic level and represented a 25% increase compared to the notification rate in 2021.
- The STEC notification rate was highest in children under five years of age with 12.1 cases per 100 000 population for males and 11.3 cases per 100 000 population for females.
- The confirmed haemolytic-uremic syndrome (HUS) cases increased in 2022 after a stable trend of reported cases before and during the pandemic years in the EU/EEA. Among the 568 HUS cases reported, the majority were in the youngest age groups, from 0–4 years (60%) to 5–14 years (24%). However, the majority of the deceased cases with HUS were over 60 years old.

Introduction

Shiga toxin-producing *Escherichia coli* (STEC) are strains of the bacterium *Escherichia coli* that can produce Shiga toxins. These toxins affect small blood vessels, such as those found in the digestive tract and the kidneys. The main reservoir of STEC is grass-feeding animals, cattle in particular. STEC infection is regularly associated with the consumption of undercooked beef which has been contaminated with animal faeces due to poor processing methods during slaughter, or other contaminated food e.g. unpasteurised milk and dairy products, vegetables, and water. Direct contact with infected animals, for example in petting farms and zoos, is considered an important risk of STEC infection, especially in young children. STEC infection often causes gastroenteritis, enterocolitis, and bloody diarrhoea, and sometimes a severe complication called haemolytic-uremic syndrome (HUS), a progressive kidney failure.

Methods

This report is based on data for 2022 retrieved from The European Surveillance System (TESSy) on 11 October 2023. TESSy is a system for the collection, analysis and dissemination of data on communicable diseases.

For a detailed description of methods used to produce this report, please refer to the Methods chapter [1]. An overview of the national surveillance systems is available online [2].

A subset of the data used for this report is available through ECDC's online Surveillance Atlas of infectious diseases [3].

Suggested citation: European Centre for Disease Prevention and Control. STEC infection. In: ECDC. Annual epidemiological report for 2022. Stockholm: ECDC; 2024.

Stockholm, February 2024

For 2022, data on STEC infections were reported by 29 EU/EEA countries. The notification of STEC infections is mandatory in all but four EU/EEA countries, where notification is either voluntary (Belgium, France, and Luxembourg) or based on another type of system (Italy). Sixteen countries used the latest case definition (EU 2018) which consider a PCR positive finding as a laboratory confirmed case, three used the previous case definition from 2012, four reported in accordance with the one from 2008 and five reported using other or did not specify the case definitions used. The surveillance systems for STEC infections have national coverage in all EU/EEA countries except for three: France, Italy, and Spain. In France, STEC surveillance is based on paediatric HUS surveillance (coverage estimated at 85% from 2016–2017), and similarly in Italy, the surveillance is primarily based on the national registry for HUS [2]. Therefore, no notification rates are calculated for these two countries. The coverage of the surveillance system is estimated to be 97% in Spain in 2021–2022, so that proportion was used when calculating the national notification rate. For 2020, not all regions in Spain have reported and case numbers might therefore be lower than expected. No estimate of population coverage in Spain was provided prior to 2021, so notification rates were not calculated. All countries except Bulgaria reported case-based data. No data for 2020–2022 were reported by the United Kingdom due to withdrawal of the UK from the EU since 1 February 2020.

In addition to case-based surveillance, ECDC coordinates centralised analysis of whole genome sequencing (WGS) data when needed to support multi-country outbreak investigations.

Epidemiology

Of the 29 EU/EEA countries reporting for 2022, 25 countries reported 8 565 confirmed cases of STEC infection (Table 1). The EU/EEA notification rate was 2.5 cases per 100 000 population. This was a 25% increase compared with 2021 and the rate and number of cases were higher than before the pandemic years in 2018–2019. The EU/EEA rate was higher, even though the data from Spain were included for the first time in 2021 and 2022, which lowered the EU/EEA rate due to the country's large population. Data from Spain were included as the estimated population coverage of the surveillance system was provided for 2021–2021.

The increase in 2022 was mainly due to a high increase in reported cases by one country (Denmark), which reported the highest numbers of confirmed cases in 2022, followed by Germany and Ireland. Together, these three countries accounted for 47.8% of all reported cases in the EU/EEA. The highest country-specific notification rates were observed in Denmark, Ireland, Malta, and Liechtenstein, with 22.6, 17.6, 15.0, and 10.2, cases per 100 000 population, respectively. A total of 12 southern and eastern EU/EEA countries reported ≤0.4 cases per 100 000 population (Table 1, Figure 1).

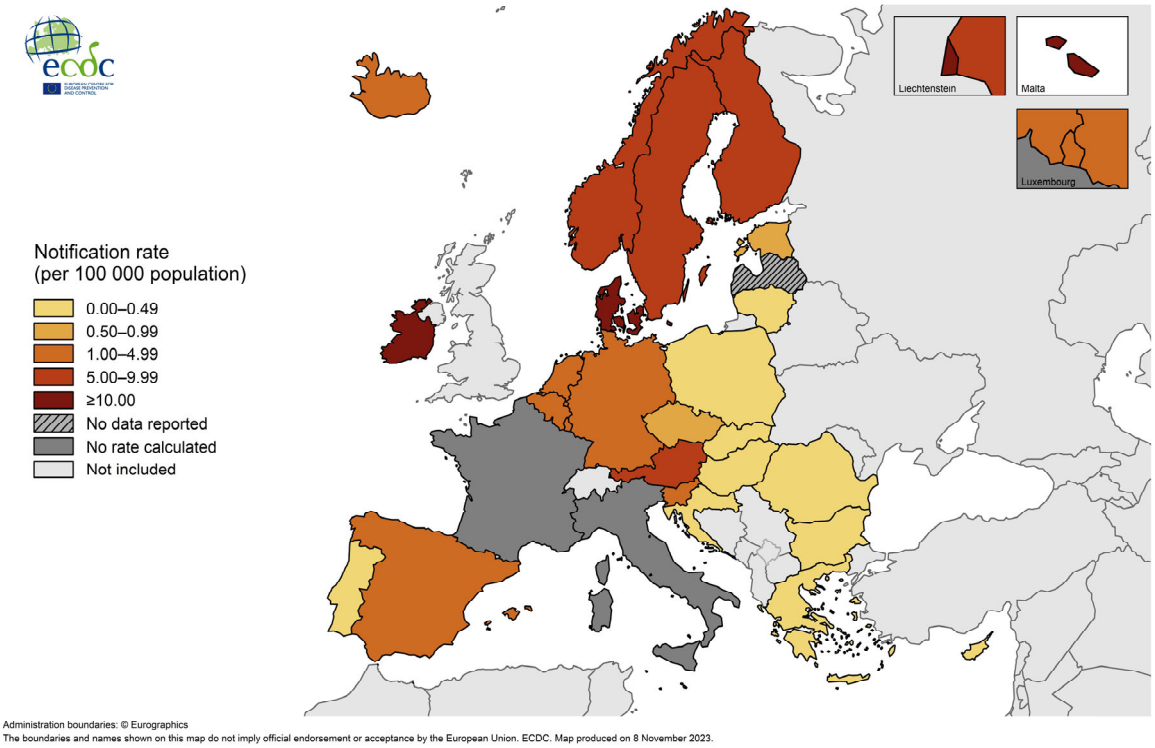
Thirty-seven percent of 3 462 STEC cases with known information were hospitalised. Twenty-eight of 6 044 cases with known outcome were reported to have died, resulting in a case fatality of 0.5%. Most of the deceased cases were over 60 years old (54%; 15/28) and the majority of them (71%; 20/28) had HUS.

Table 1. Confirmed cases of STEC infection and 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	305	3.5	284	3.2	288	3.2	383	4.3	469	5.2
Belgium	112	1.0	131	1.1	84	0.7	124	1.1	187	1.6
Bulgaria	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Croatia	10	0.2	22	0.5	8	0.2	12	0.3	16	0.4
Cyprus	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Czechia	26	0.2	33	0.3	32	0.3	36	0.3	58	0.6
Denmark	493	8.5	623	10.7	445	7.6	928	15.9	1 329	22.6
Estonia	7	0.5	6	0.5	10	0.8	7	0.5	11	0.8
Finland	210	3.8	311	5.6	175	3.2	288	5.2	291	5.2
France	259	NRC	335	NRC	262	NRC	298	NRC	473	NRC
Germany	2 226	2.7	1 907	2.3	1 409	1.7	1 635	2.0	1 873	2.3
Greece	1	0.0	5	0.0	3	0.0	10	0.1	14	0.1
Hungary	14	0.1	23	0.2	8	0.1	24	0.2	26	0.3
Iceland	3	0.9	27	7.6	4	1.1	7	1.9	4	1.1
Ireland	966	20.0	798	16.3	734	14.8	878	17.5	892	17.6
Italy	73	NRC	62	NRC	45	NRC	65	NRC	118	NRC
Latvia	3	0.2	48	2.5	2	0.1	13	0.7	NDR	NRC
Liechtenstein	NDR	NRC	NDR	NRC	NDR	NRC	7	17.9	4	10.2
Lithuania	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Luxembourg	3	0.5	4	0.7	0	0.0	10	1.6	9	1.4
Malta	41	8.6	53	10.7	43	8.4	68	13.2	78	15.0
Netherlands	488	2.8	459	2.7	323	1.9	484	2.8	585	3.3
Norway	494	9.3	511	9.6	331	6.2	437	8.1	518	9.5
Poland	6	0.0	14	0.0	3	0.0	7	0.0	34	0.1
Portugal	2	0.0	1	0.0	5	0.0	2	0.0	6	0.1
Romania	20	0.1	36	0.2	14	0.1	6	0.0	28	0.1
Slovakia	12	0.2	3	0.1	1	0.0	5	0.1	4	0.1
Slovenia	32	1.5	31	1.5	30	1.4	48	2.3	58	2.8
Spain	126	NRC	269	NRC	74	NRC	422	0.9	623	1.4
Sweden	892	8.8	756	7.4	491	4.8	653	6.3	857	8.2
EU/EEA (30 countries)	**6 824**	**2.3**	**6 752**	**2.2**	**4 824**	**1.6**	**6 857**	**2.0**	**8 565**	**2.5**
United Kingdom	1 840	2.8	1 587	2.4	NDR	NRC	NA	NA	NA	NA
EU/EEA (31 countries)	**8 664**	**2.4**	**8 339**	**2.2**	**4 824**	**1.6**	**NA**	**NA**	**NA**	**NA**

Source: Country reports.
NDR: No data reported.
NRC: No rate calculated.
NA: Not applicable.
No data for 2020, 2021 and 2022 were reported by the United Kingdom, due to its withdrawal from the EU on 31 January 2020.

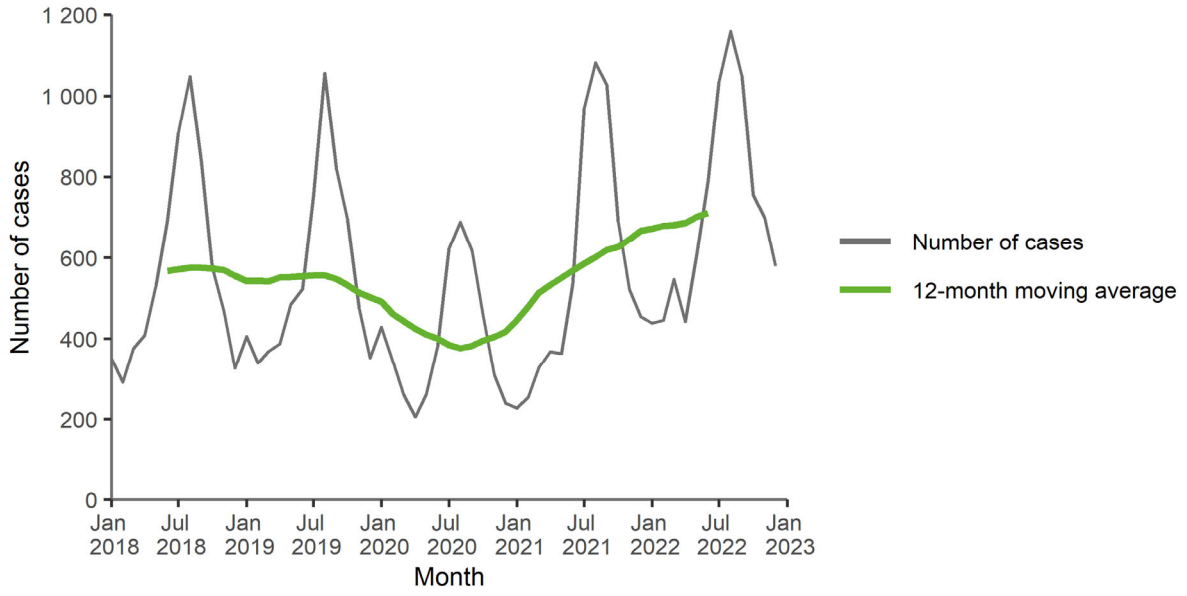
Figure 1. Confirmed cases of STEC infection per 100 000 population by country, EU/EEA, 2022



Source: Country reports.

The number of cases with STEC infection increased in 2021–2022 after a decrease in 2020 due to the COVID-19 pandemic (Figure 2). The overall trend for STEC in 2018–2022 did not show any significant increase or decrease. Four countries (Austria, France, Malta, and Spain) reported a significant increasing ($p < 0.05$) trend in the same time period. No countries reported decreasing trends from 2018 to 2022 [5].

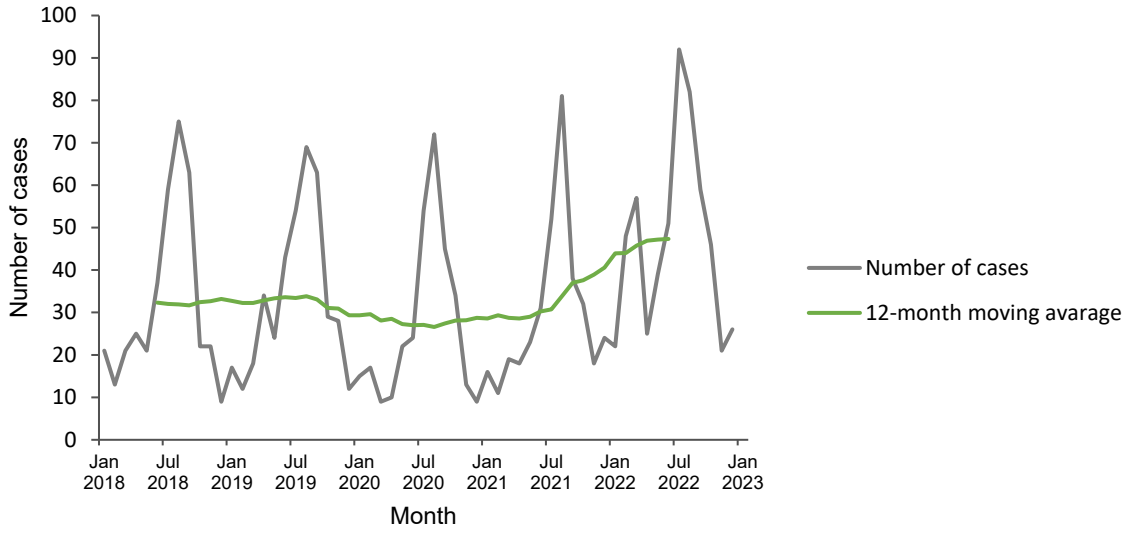
Figure 2. Confirmed cases of STEC infection by month, EU/EEA, 2018–2022



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

The number of confirmed STEC cases with HUS increased in 2022 (Figure 3). The EU/EEA trend of HUS cases was stable during the pandemic years and the number of reported HUS cases did not decrease in 2020 as did the STEC cases. In 2022, cases peaked in July–August similarly than in previous years, but a smaller peak was detected in February–March due to a large outbreak in France (Figure 3). Among the 568 HUS cases reported, the majority were in the youngest age groups, from 0–4 years (60%) to 5–14 years (24%).

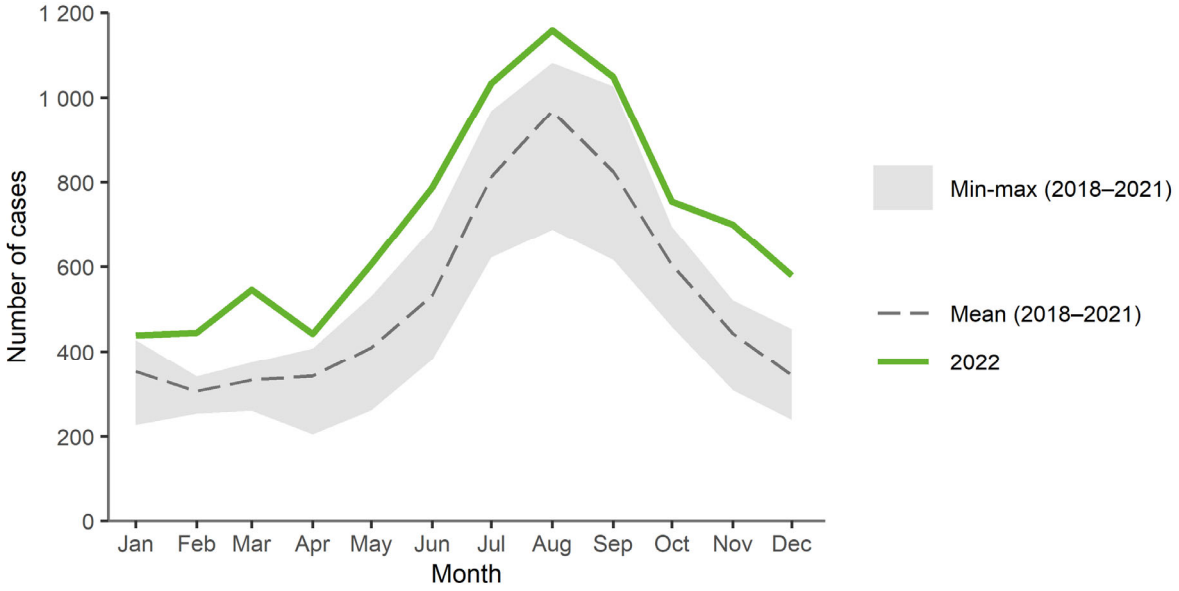
Figure 3. Confirmed STEC cases with HUS by month, EU/EEA, 2018–2022



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

A clear seasonal trend in the number of confirmed STEC cases was observed between 2017 and 2022, with more cases reported during the summer months from June to September. In 2022, the number of reported cases was higher than the average in all months compared to 2018–2021 (Figure 4).

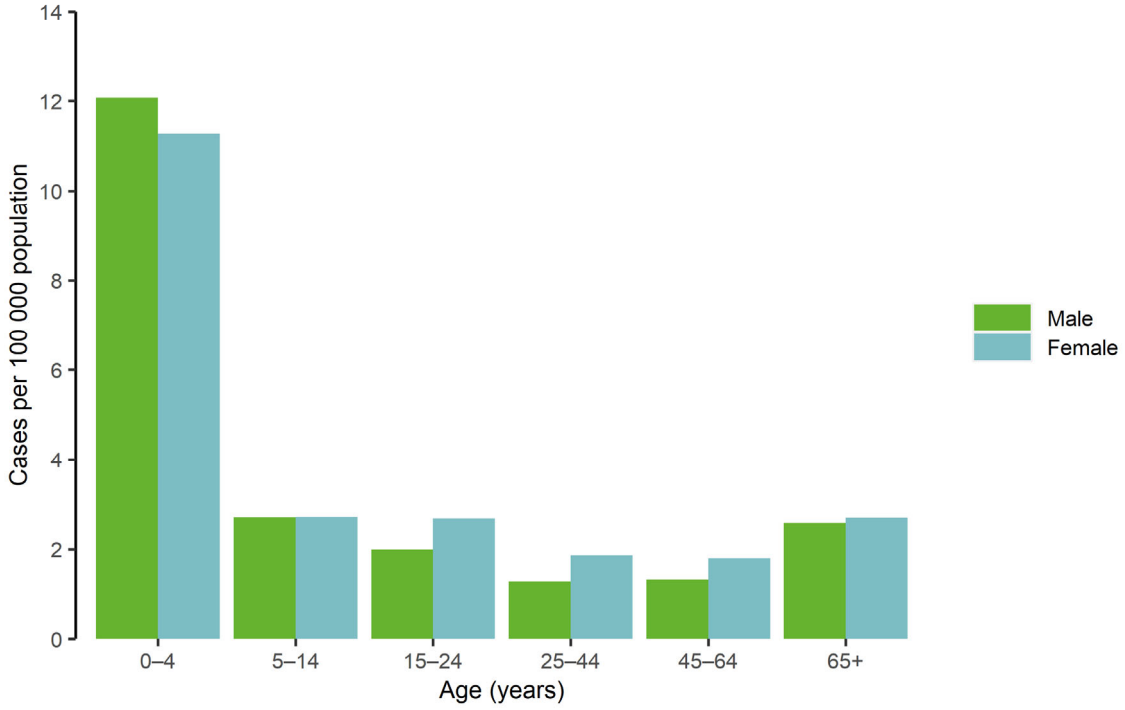
Figure 4. Confirmed cases of STEC infection by month, EU/EEA, 2022 and 2018–2021



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

Among the 8 539 (99.7%) confirmed STEC cases for which gender was reported, 46% were males and 54% were females, with a male-to-female ratio of 0.9:1. The highest notification rate per 100 000 population was observed in the age group 0–4 years (12.1 for males and 11.3 for females). This age group accounted for 2 091 (24%) of the 8 556 cases for whom information on age was available. The notification rate decreased with age and was lowest (0.9 and 1.3 per 100 000 population) in the age group of 25–44 and 45–64 years for males and females, respectively (Figure 5).

Figure 5. Confirmed cases of STEC infection per 100 000 population, by age and gender, EU/EEA, 2022



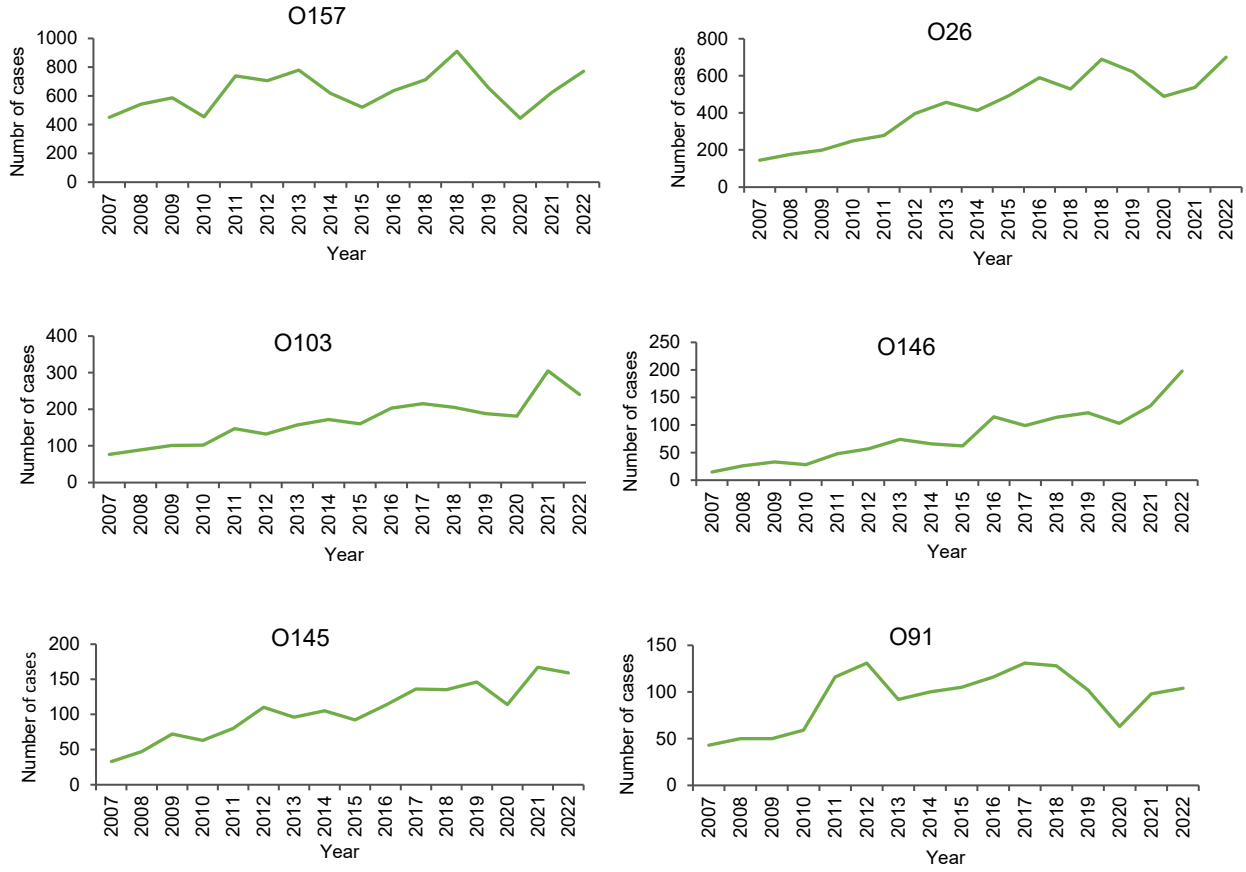
Source: Country reports from Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Liechtenstein, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.

Microbial surveillance

Information on STEC serogroups was reported by 22 countries for 3 617 confirmed cases (42.2%) in the EU/EEA in 2022. The numbers reported are affected by outbreaks and countries' possibility for characterisation of STEC isolates. The six most frequently reported serogroups were O157 (21.3%), O26 (19.4%), O103 (6.6%), O146 (5.5%), O145 (4.4%), and O91 (2.9%) (Figure 6). These serogroups together accounted for over 60% of the total number of confirmed STEC cases with known serogroups in 2022. During the last 15 years, since the start of EU-level surveillance of STEC, a continuous increase had been seen, especially for four of the most common serogroups reported: O26, O146, O145, and O103. For 2022, the highest number ever reported could be seen for O146 and O26 (Figure 6). For 2 414 cases (28.2%) the full serotype was reported, i.e. both the O type and the H type. The most common serotype was O157:H7 (18.4%) followed by O26:H11 (18.1%) and O103:H2 (7.6%). For cases with STEC-associated HUS, serogroup was reported for 393 cases; O26 was most frequently reported (51.4%) followed by O157 (14.5%), O80 (6.0%) and O145 (5.8%).

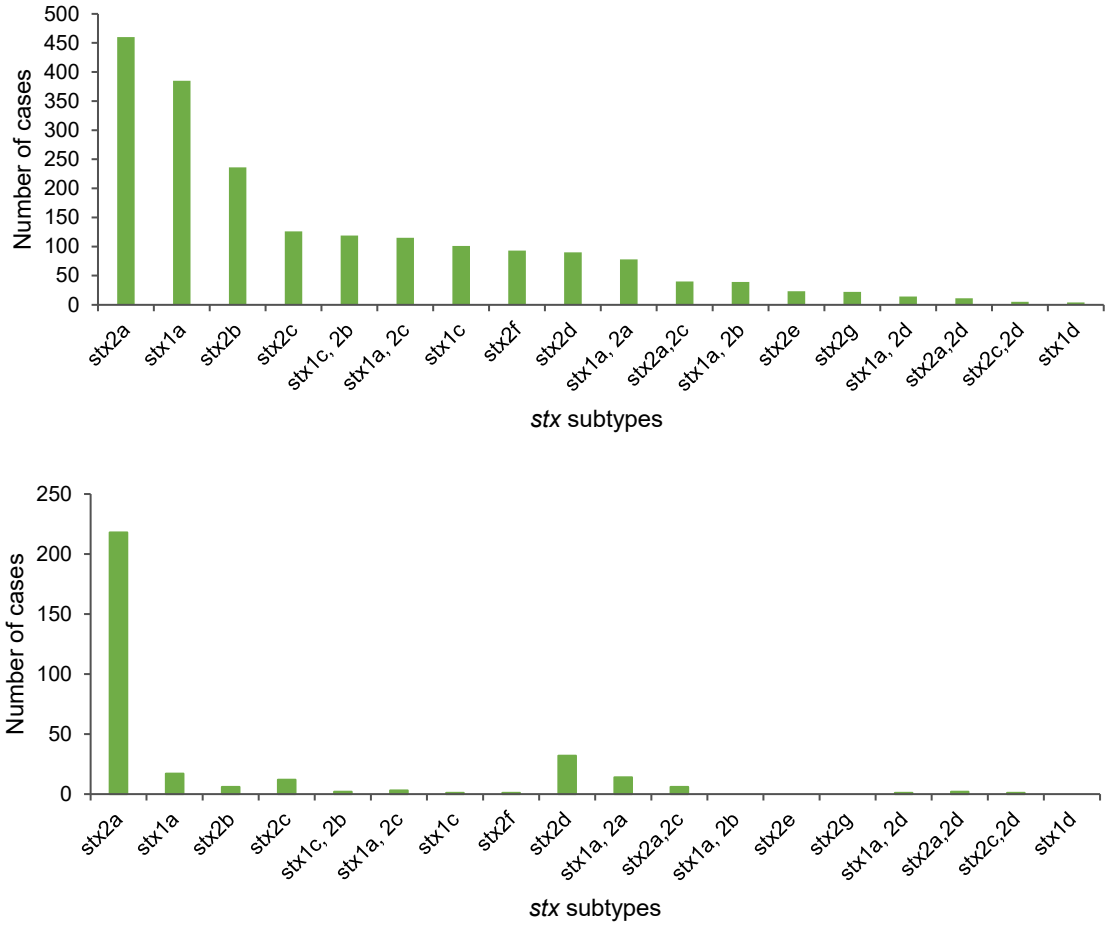
Data on virulence gene combinations (based on shiga toxin-coding genes *stx1*, *stx2* and intimin-coding gene *eae*) were provided for 3 285 (38.4%) STEC cases. The most frequently reported virulence gene combination was *stx2* and *eae*-positive (30%) and *stx2* positive and *eae*-negative (18.5%). In strains isolated from severe cases (HUS, bloody diarrhoea and/or hospitalised cases), 44.8% were positive for *stx2* and *eae*. For 1 968 cases, *stx* gene subtypes were reported. The most common *stx* subtypes were *stx2a* (23.4%), *stx1a* (19.6%), *stx2b* (12.0%), and *stx2c* (6.4%). For cases with HUS with *stx* gene subtyping data (n=316), *stx2a* was the most commonly reported (69.0%) followed by *stx2d* (10.1%) (Figure 7).

Figure 6. The six most common STEC serogroups in the EU/EEA, 2007–2022



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

Figure 7. *Stx* gene subtypes for confirmed STEC cases with complete subtyping data (n=1 968) (top panel) and for STEC associated HUS cases (n=316) (bottom panel), in EU/EEA, 2022



Note: subtypes with < 5 isolates not included.
Source: Country reports from Austria, Belgium, Czechia, Denmark, France, Italy, Norway, Romania, Slovenia, Spain, Sweden.

Outbreaks and other threats

In 2022, 12 events on STEC infection were reported through ECDC's EpiPulse platform. Five genetically related multi-country STEC clusters, all due to serogroup O157:H7, involved at least 11 countries, with almost 120 cases in total. In one cluster, ground beef in hamburgers was a suspected vehicle of infection. The largest STEC outbreak in 2022 was reported by France, with 50 cases of HUS. The source of infection was frozen pizza. This was a multi-strain outbreak in which the majority of cases were infected with O26:H11, positive for *stx2a* and *eae*. The outbreak strains could also be isolated from food samples [4].

According to the European Union One Health 2023 Zoonoses report, 71 foodborne STEC outbreaks were reported by 14 countries (Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Malta, the Netherlands, Norway, Poland, Spain, Sweden, and the United Kingdom (Northern Ireland)) to the European Food Safety Authority (EFSA) annual zoonoses data collection in 2022 [5]. This was 40 more (129% increase) than the number of foodborne outbreaks reported in 2021. This was mainly due to France reporting 37 outbreaks, accounting for more than half of the of STEC outbreaks in the EU. Information on the STEC serogroup was available for 14 outbreaks, and of those serogroup O157 was the most common (seven outbreaks), and the remaining outbreaks were with serogroups O26, O104, O111, O113, O145, and O178. A food vehicle was reported in one strong-evidence foodborne outbreak; an outbreak of STEC O157 was caused by bovine meat intended to be eaten raw. Poland reported one weak evidence outbreak without known source of infection caused by STEC O104, involving 16 human cases, including five hospitalisations and one death. This is the first time that this STEC serogroup has been reported as the causative agent of a foodborne outbreak in Europe since 2011 [5].

Discussion

In 2022, STEC was the third most commonly reported foodborne zoonotic disease in the EU/EEA [3]. It was also the third most frequent bacterial pathogen detected in food- and waterborne outbreaks in the EU [5]. In 2022, the highest number of cases and the highest notification rate was reported since STEC surveillance started in the EU in 2007. This was mainly due to the high increase in reported cases in one country (Denmark). Without the increase in Denmark, the EU notification rate was comparable to the rate in 2021. In Denmark, there has been a sharp increase in reported confirmed STEC cases since 2018 (except in 2020, possibly due to the COVID-19 pandemic) because of changes in laboratory techniques, such as the increasing use of diagnostic PCR panels in clinical laboratories. In 2020, the EU trend of STEC infections decreased notably, most likely due to the pandemic, but in 2021 increased to the pre-pandemic (2017–2019) level. The general increase in STEC cases is due to the shift in diagnostic methods, with PCR amplification of Shiga toxin-coding genes (*stx*) being more commonly used for the detection of STEC cases in several countries instead of diagnosis based on cultivation [6]. Using PCR panels allow for more samples to be tested for STEC, and not only selected samples from certain patient groups (e.g. children), or only bloody stools. In addition, all strain variants can be detected, since it is not dependent upon selective media. On the contrary, the number of reported HUS cases did not decrease in 2020 and the trend of HUS was stable during the pandemic years. This probably indicates that cases with STEC infection were underdiagnosed and underreported during the pandemic, whereas the most severe cases of the disease were unlikely to remain undiagnosed.

In 2022, the most frequently reported serogroup identified in STEC cases was O157, followed by O26, although the two proportions diverged by only 2%. There has been an increasing proportion in the number of STEC O26 cases observed since the start of the serogroup surveillance, while those assigned to STEC O157 do not show this pattern. The continuous increase seen for the non-O157 serogroups is possibly due to the development of selective media for isolation and further typing of not only the classical STEC O157, but also many other serogroups, and an increased awareness that additional serogroups other than O157 are important and should be tested for. Other factors like new sources or routes for transmission could have contributed to the increase: the large HUS-associated outbreak caused by pizza dough is one example [4]. The change in diagnostics could also have the effect that more samples are screened for STEC, as the traditional phenotypic methods demand different selective plates in order to isolate different STEC serotypes, a process more demanding than, for example, isolation for *Salmonella*. It is also shown on the EU level that the proportion of STEC cases with no information on serogroup has been steadily increasing in the last five years, which could be an indication of a higher proportion of notifications based on PCR based on virulence genes not distinguishing between serogroups.

In 2022, STEC O26 was the most reported serogroup among HUS cases, as observed since 2016. Most of the HUS cases caused by this serogroup were reported by three countries (France, Italy, and Denmark), two of which base their surveillance of STEC infections mainly on the detection of HUS cases (France and Italy). In 2022, the highest number of HUS cases ever was reported at the EU- evel. This was partly, but not entirely, due to the large outbreak in France [4]. The HUS cases reported by France doubled compared to the previous years, and more than half were caused by serogroup O26. Serogroup O80 was the third most common serogroup to cause HUS in 2022, and the majority was reported by France. The majority of these isolates carried the *stx2d* gene, which is known to cause more severe disease. In general, the high proportion of HUS cases due to non-O157 serogroups points towards an emerging risk of severe infections caused by serogroups other than O157 [7].

Although a recent pathogenicity assessment of STEC affirms that serogroup is not a marker of pathogenicity, it still has some importance as an epidemiological marker, and it is still useful to observe the circulation of the different STEC serogroups in food and human cases of disease [8]. Analysis of the virulence gene combinations (*stx* and *eae*), particularly the subtyping of the *stx* genes, allows identifying STEC virulotypes that have a higher frequency of association to severe disease in humans (hospitalised cases, bloody diarrhoea, and HUS cases). Since 2012, there has been a steady increase in the reporting of *stx* and *eae* virulence genes to TESSy. The majority (>90%) of severe human cases were reported with information on *stx* gene subtypes; *stx2a* and *stx2d* are clearly associated with more severe disease, and specifically HUS, as also shown in 2022. In general, subtyping of shiga toxin genes is still far from being comprehensive enough for food and animal isolates to allow risk assessment of STEC circulating in the vehicles of infections [5].

Ruminants are the main natural reservoir of STEC. Over the years, several STEC outbreaks among children have been reported in petting farms and zoos due to direct contact with STEC-positive animals. Undercooked ground beef or other meats were found to be a significant risk factor for acquiring sporadic foodborne STEC infection, most often caused by serogroup O157 [9]. Beef and fresh produce (fruit and vegetables) were incriminated as the most important sources of STEC infections in Europe in a source attribution study, each estimated to account for 30% of the cases [10]. Reported outbreaks also highlight a risk of STEC infections associated with raw milk and cheese made from unpasteurised milk [6]. The majority of STEC isolates from food belonged to the top 20 STEC serogroups reported in human infections in EU [5].

Public health implications

STEC infection is mainly acquired through the consumption of contaminated food or water and contact with animals and/or their faeces. Good hygiene practices in food processing and good handling practices in premises dealing with animals as well as guidance on hand hygiene for visitors in petting farms and zoos can decrease the risk of infections and further outbreaks. Adequate cooking of food at home, particularly beef, and the use of pasteurised dairy products may reduce the risk of foodborne STEC infections. The STEC serogroups most frequently found in food samples are also those most commonly reported in human infections, highlighting the role of contaminated food as a source of human infections.

References

1. European Centre for Disease Prevention and Control (ECDC). Introduction to the Annual Epidemiological Report. Stockholm: ECDC. Available at: http://ecdc.europa.eu/annual-epidemiological-reports/methods
2. European Centre for Disease Prevention and Control (ECDC). Surveillance systems overview for 2022. Stockholm: ECDC. Available at: Surveillance systems overview for 2022 (europa.eu)
3. European Centre for Disease Prevention and Control (ECDC). Surveillance Atlas of Infectious Diseases. Stockholm: ECDC. Available at: http://atlas.ecdc.europa.eu/public/index.aspx?Dataset=27&HealthTopic=59
4. Nestlé allowed to restart pizza plant linked to deadly *E. coli* outbreak. Food Safety News. 19 December 2022. Available at: https://www.foodsafetynews.com/2022/12/nestle-allowed-to-restart-pizza-plant-linked-to-deadly-e-coli-outbreak/
5. European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC). European Union One Health 2022 Zoonoses Report. EFSA Journal 2023. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/EFS2_8442.pdf
6. Berenger B.M, Chui L, Ferrato C, Loyd T, Li V, Pillai D.R. Performance of four commercial real-time PCR assays for the detection of bacterial enteric pathogens in clinical samples. IJID.2022 Jan;114:195-201.
7. Gabrielle Jones et al. Outbreak of Shiga toxin-producing *Escherichia coli* (STEC) O26 paediatric haemolytic uraemic syndrome (HUS) cases associated with the consumption of soft raw cow's milk cheeses, France, March to May 2019. Euro Surveill. 2019 May; 30:24(22). Available at: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2019.24.22.1900305
8. European Food Safety Authority Panel on Biological Hazards (EFSA BIOHAZ Panel). Pathogenicity assessment of Shiga toxin-producing Escherichia coli (STEC) and the public health risk posed by contamination of food with STEC. EFSA Journal 2020; 18(1):5967.
9. Kintz E, Brainard J, Hooper L, Hunter P. Transmission pathways for sporadic Shiga-toxin producing *E. coli* infections: A systematic review and meta-analysis. Int J Hyg Environ Health. 2017 Jan; 220(1):57-67.
10. Pires SM, Majowicz S, Gill A, Devleesschauwer B. Global and regional source attribution of Shiga toxin-producing *Escherichia coli* infections using analysis of outbreak surveillance data. Epidemiology and Infection. 2019 Jan;147.