SURVEILLANCE REPORT

Salmonellosis

Annual Epidemiological Report for 2021

Key facts

- Salmonellosis is the second most commonly reported gastrointestinal infection in the EU/EEA, and an important cause of food-borne outbreaks.
- In 2021, 60 494 laboratory-confirmed cases of salmonellosis were reported, out of which 73 were fatal.
- The EU/EEA notification rate for salmonellosis was 16.6 cases per 100 000 population.
- Salmonellosis notification rates in the five years preceding the COVID-19 pandemic have been stable. After a significant decline in cases in 2020, primarily as a consequence of the pandemic, the case numbers increased by 14% in 2021.
- The reported case rate was highest in young children (0–4 years) with 93.1 cases per 100 000 population, eleven times higher than in adults (25–64 years).
- Eggs and egg products continue to be the highest risk foods in *Salmonella* outbreaks, though in 2021, several of the largest outbreaks were linked to contaminated vegetables, fruits, seeds or products thereof.

Introduction

Enteric infections due to *Salmonella* are generally referred to by the term 'salmonellosis' when they are caused by *Salmonella* species other than *Salmonella* Typhi and *Salmonella* Paratyphi. Various animals (especially poultry, pigs, cattle and reptiles) can be reservoirs for *Salmonella*. Humans generally become infected by eating poorly cooked, contaminated food. The incubation period and the symptoms depend primarily on the amount of bacteria present in the food, and the immune status of the infected individual.

Methods

This report is based on data for 2021, retrieved from The European Surveillance System (TESSy) on 9 October 2022. 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, please refer to the 'Methods' chapter in the 'Introduction to the Annual Epidemiological Report' [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].

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Stockholm, December 2022

In 2021, 30 EU/EEA countries reported data on salmonellosis. Twenty-six countries reported data using either the 2008, 2012 or 2018 EU case definitions for salmonellosis. Compared with the 2008 and 2012 EU case definitions, the 2018 EU case definition allows nucleic acid determination for laboratory confirmation, and includes a requirement for antimicrobial susceptibility testing and reporting of results. Four countries used another case definition, which was not specified.

Notification of non-typhoidal salmonellosis is mandatory in most of the EU Member States as well as Iceland, Liechtenstein and Norway. In three Member States (Belgium, France, and the Netherlands), reporting is voluntary. The surveillance systems for salmonellosis have national coverage in all Member States except in three (France, the Netherlands and Spain). The population coverage in 2021 is estimated to be 48% in France and 64% in the Netherlands. The variation in coverage was taken into consideration when calculating the national notification rates. No information on estimated coverage was provided by Spain, and thus no notification rates were calculated. During the peak pandemic years 2020 and 2021, Spain did not receive data from all the regions that normally report cases, and the case numbers are therefore lower than expected. All countries reported case-based data except Bulgaria, which reported aggregated data. Both reporting formats were included to calculate number of cases, notification rates, disease trends, and age and gender distributions.

For 2020–2021, no data were reported by the United Kingdom (UK) due to its withdrawal from the EU on 31 January 2020.

Twenty-six EU/EEA countries reported antimicrobial resistance data for *Salmonella* for 2021. Twenty-five countries reported phenotypic resistance data – 21 as disk zones or minimum inhibitory concentration (MIC) values, and four as interpretation with clinical breakpoints. One country reported resistance predicted from whole genome sequencing (WGS).

In 2021, 15 countries provided WGS data for centralised analysis to support ongoing multi-country outbreak investigations.

Epidemiology

In 2021, 30 EU/EEA countries reported 61 236 salmonellosis cases, of which 60 494 were classified as laboratory-confirmed (Table 1). This was an increase of 14% in cases, compared to 2020. The number of cases per 100 000 population was 16.6, which was higher than in 2020 but still lower compared to pre-COVID-19 pandemic levels. Age-standardised notification rates did not differ substantially from crude rates.

The highest notification rates were reported by Czechia (93.7 cases per 100 000 population) and Slovakia (81.3), followed by Malta (48.2), Hungary (33.9) and France (28.7) – Table 1, Figure 1. The lowest rates were reported by Greece and Romania (2.7 cases per 100 000 population) and Bulgaria, Ireland and Portugal (3.5 cases per 100 000 population).

The hospitalisation status was reported for 31 357 salmonellosis cases in 2021 and of those, 38% had been hospitalised. The countries reporting the highest proportion of hospitalised cases were Cyprus, Greece and Lithuania (92%, 84% and 73%, respectively).

Specimen type can also be used as an indicator of severity of the infection. Among 45 105 cases with specimen type reported, 94% of *Salmonella* isolates were sampled from faeces, 2% from blood, 2% from urine and the remaining reported as 'other'. Out of 38 981 cases with known outcome, 73 were reported to have died, accounting for a case fatality of 0.19%.

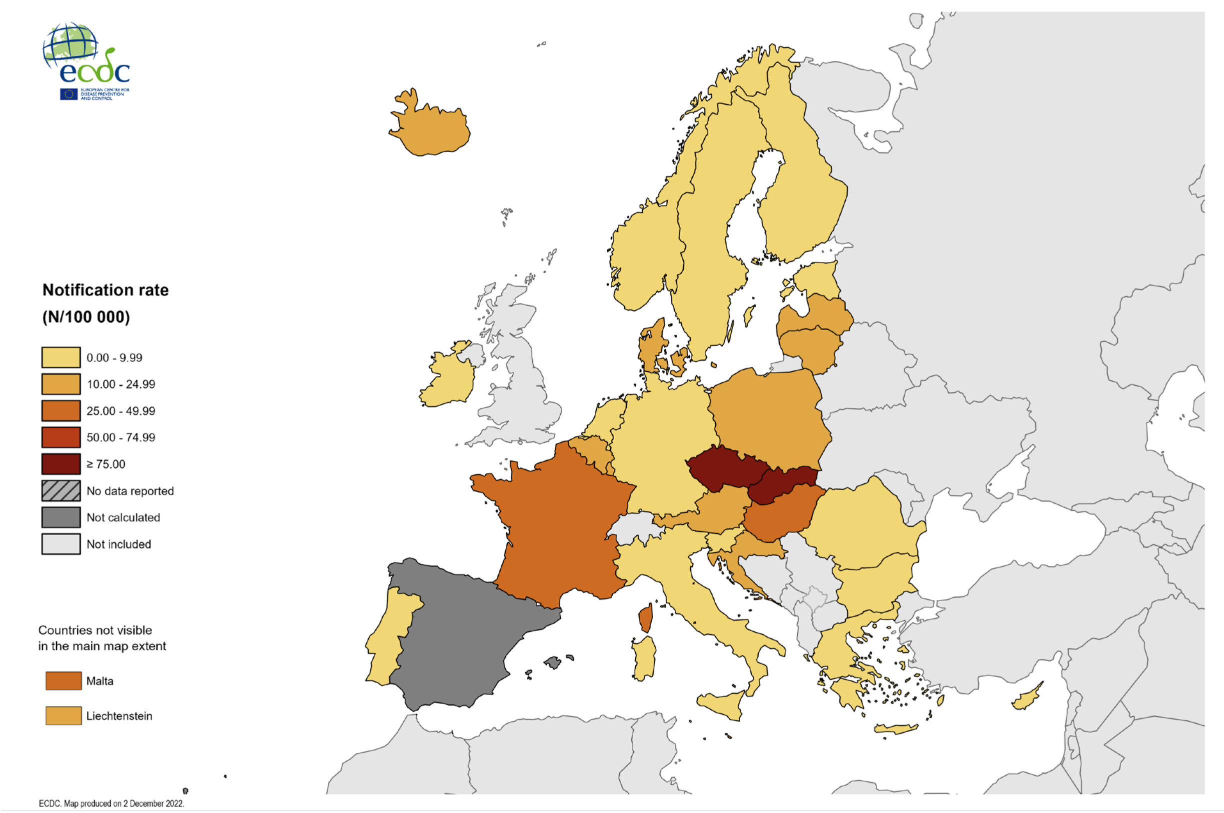
Table 1. Distribution of confirmed salmonellosis cases and rates per 100 000 population, by country and year, EU/EEA, 2017–2021

Country	2017		2018		2019		2020		2021		
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	ASR
Austria	1 667	19.0	1 538	17.4	1 866	21.1	817	9.2	993	11.1	11.5
Belgium	2 298	20.2	2 958	26.0	2 527	22.1	1 595	13.8	2 084	18.0	17.7
Bulgaria	796	11.2	586	8.3	594	8.5	187	2.7	241	3.5	3.8
Croatia	1 242	29.9	1 323	32.2	1 308	32.1	786	19.4	593	14.7	15.6
Cyprus	59	6.9	44	5.1	62	7.1	70	7.9	41	4.6	4.4
Czechia	11 473	108.5	10 901	102.7	13 009	122.2	10 516	98.3	10 032	93.7	95.3
Denmark	1 067	18.6	1 168	20.2	1 119	19.3	614	10.5	692	11.8	11.5

Country	2017		2018		2019		2020		2021		
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	ASR
Estonia	265	20.1	314	23.8	150	11.3	91	6.8	112	8.4	8.4
Finland	1 535	27.9	1 431	26.0	1 175	21.3	516	9.3	474	8.6	8.8
France	7 993	24.9	8 936	27.8	8 935	27.7	7 071	21.9	9 315	28.7	27.9
Germany	14 051	17.0	13 293	16.1	13 495	16.3	8 664	10.4	8 144	9.8	10.2
Greece	672	6.2	640	6.0	643	6.0	381	3.6	284	2.7	2.8
Hungary	3 922	40.0	4 161	42.6	4 452	45.6	2 964	30.3	3 298	33.9	34.7
Iceland	64	18.9	63	18.1	50	14.0	32	8.8	54	14.6	15.5
Ireland	379	7.9	352	7.3	347	7.1	214	4.3	173	3.5	3.5
Italy	3 347	5.5	3 635	6.0	3 256	5.4	2 713	4.5	3 768	6.4	6.9
Latvia	225	11.5	409	21.1	438	22.8	296	15.5	218	11.5	11.4
Liechtenstein	ND	ND	ND	ND	ND	ND	ND	ND	7	17.9	19.1
Lithuania	1 005	35.3	779	27.7	736	26.3	419	15.0	281	10.1	10.2
Luxembourg	118	20.0	135	22.4	131	21.3	93	14.9	133	21.0	21.3
Malta	107	23.2	116	24.4	131	26.5	176	34.2	249	48.2	47.7
Netherlands	954	8.7	1 061	9.6	1 197	10.8	695	6.2	862	7.7	7.6
Norway	992	18.9	961	18.1	1 092	20.5	441	8.2	389	7.2	7.1
Poland	8 921	23.5	9 064	23.9	8 373	22.0	5 192	13.7	7 708	20.4	21.0
Portugal	462	4.5	302	2.9	432	4.2	262	2.5	361	3.5	3.9
Romania	1 154	5.9	1 410	7.2	1 383	7.1	408	2.1	518	2.7	2.7
Slovakia	5 789	106.5	6 791	124.8	4 992	91.6	3 385	62.0	4 439	81.3	82.3
Slovenia	275	13.3	274	13.3	362	17.4	214	10.2	185	8.8	8.9
Spain	9 426	NR	8 730	NR	5 087	NR	3 526	NR	3 913	NR	NR
Sweden	2 280	22.8	2 041	20.2	1 990	19.5	825	8.0	933	9.0	8.7
United Kingdom	10 105	15.3	9 466	14.3	9 718	14.6	ND	ND	ND	ND	ND
EU/EEA	**92 643**	**19.6**	**92 882**	**20.0**	**89 050**	**20.0**	**53 163**	**14.2**	**60 494**	**16.6**	**16.7**

Source: country reports
ASR: age-standardised rate
ND: no data reported
NR: no rate calculated

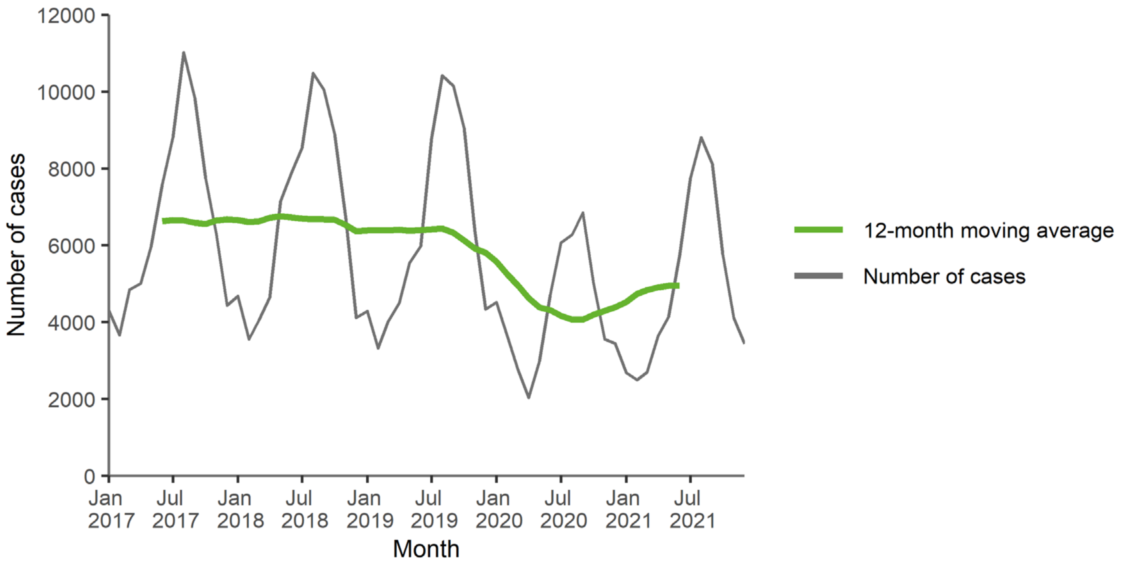
Figure 1. Distribution of confirmed salmonellosis cases per 100 000 population by country, EU/EEA, 2021



The number of reported cases of salmonellosis in the EU/EEA was stable in the period from 2017−2019 but in 2020, a marked decrease in the number of reported cases was seen on a monthly basis from March onward (Figures 2 and 3) compared to the previous years. All but two countries (Cyprus and Malta) reported a decrease in the number of cases in 2020. Case numbers increased again in 2021, but not to the same level as in 2017–2019 i.e. pre-pandemic levels.

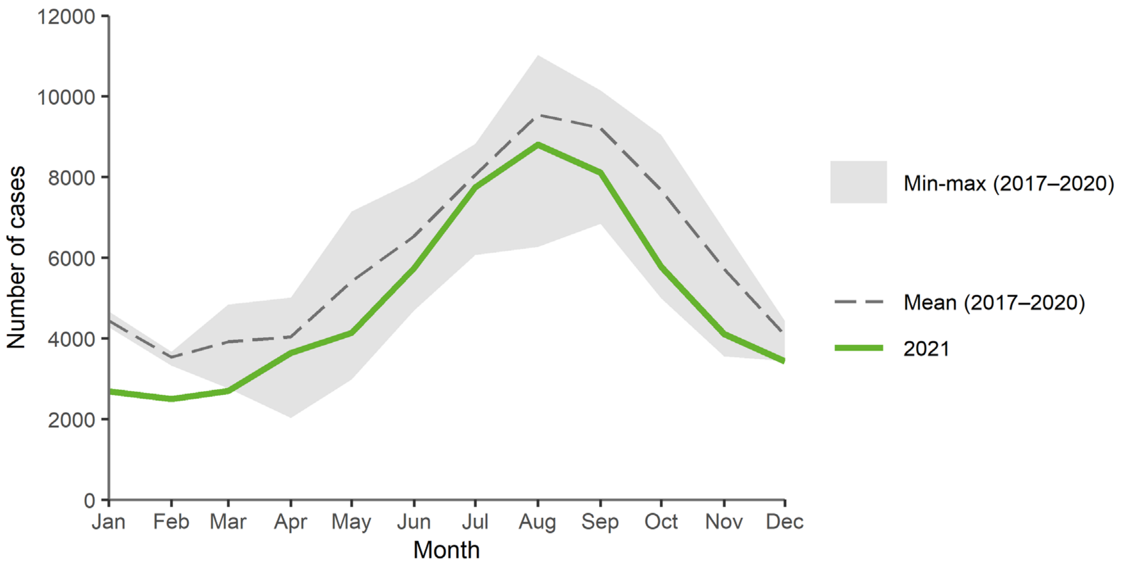
There is a clear seasonal distribution of salmonellosis cases by month of reporting, with a peak in July to September (Figures 2, 3). The smaller peak normally observed in January was not visible in 2021.

Figure 2. Distribution of confirmed salmonellosis cases by month, EU/EEA, 2017–2021



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

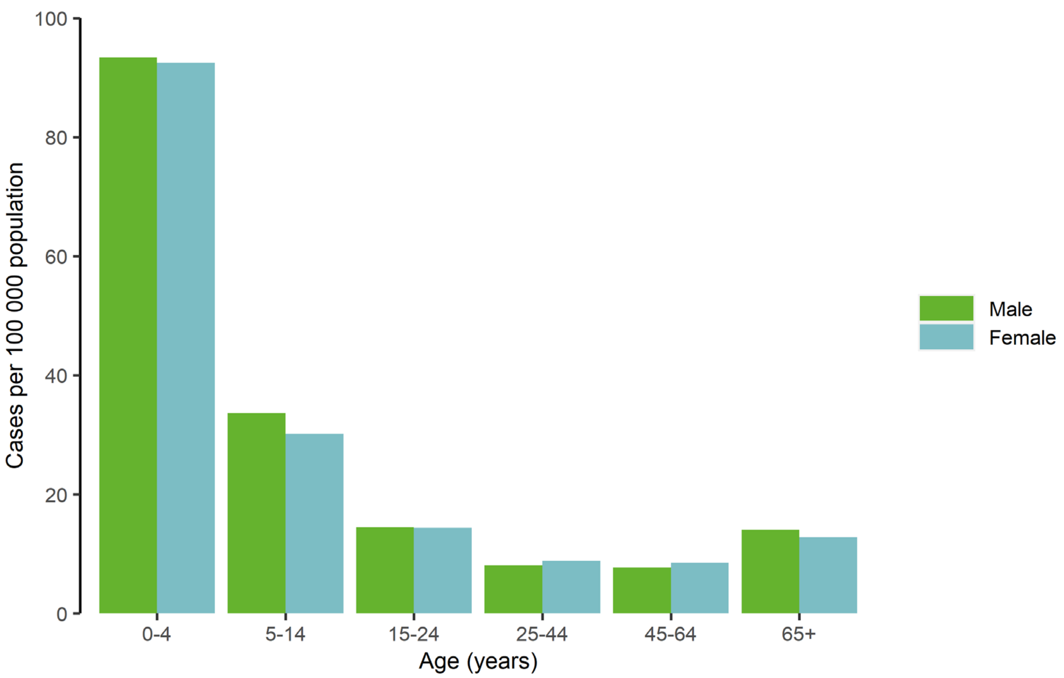
Figure 3. Distribution of confirmed salmonellosis cases by month, EU/EEA, 2017–2020 and 2021



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

There was no difference in salmonellosis notification rates by gender in the EU/EEA (male-female ratio 1:1). By age, the highest notification rate was observed among young children (0–4 years), with 93.1 cases per 100 000 population (Figure 4). The rate in young children was three times higher than in older children, and 11 times higher than in adults (25–64 years). The countries with the largest difference in the rates between young children in the 0–4-year age group and adults in the 25–44-year age group (the rates were 25–50 times higher in children) were: Slovenia, Italy, Lithuania, Cyprus, Romania, Greece, Bulgaria, Poland and Portugal (by increasing order of magnitude).

Figure 4. Distribution of confirmed salmonellosis cases per 100 000 population, by age and gender, EU/EEA, 2021



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

Out of 45 177 cases with known travel history, 1 591 (3.5%) were reported as travel-associated, the lowest rate ever reported to TESSy. The EU average in 2017–2019 was 15.6% and in 2020, 4.4%. In the Nordic countries, travel-related infections usually account for about 60–80% of salmonellosis cases, but in 2021, this proportion was only 12–21%. The highest proportion of travel-related cases was observed in France, Iceland, Sweden and Slovenia (19–21%).

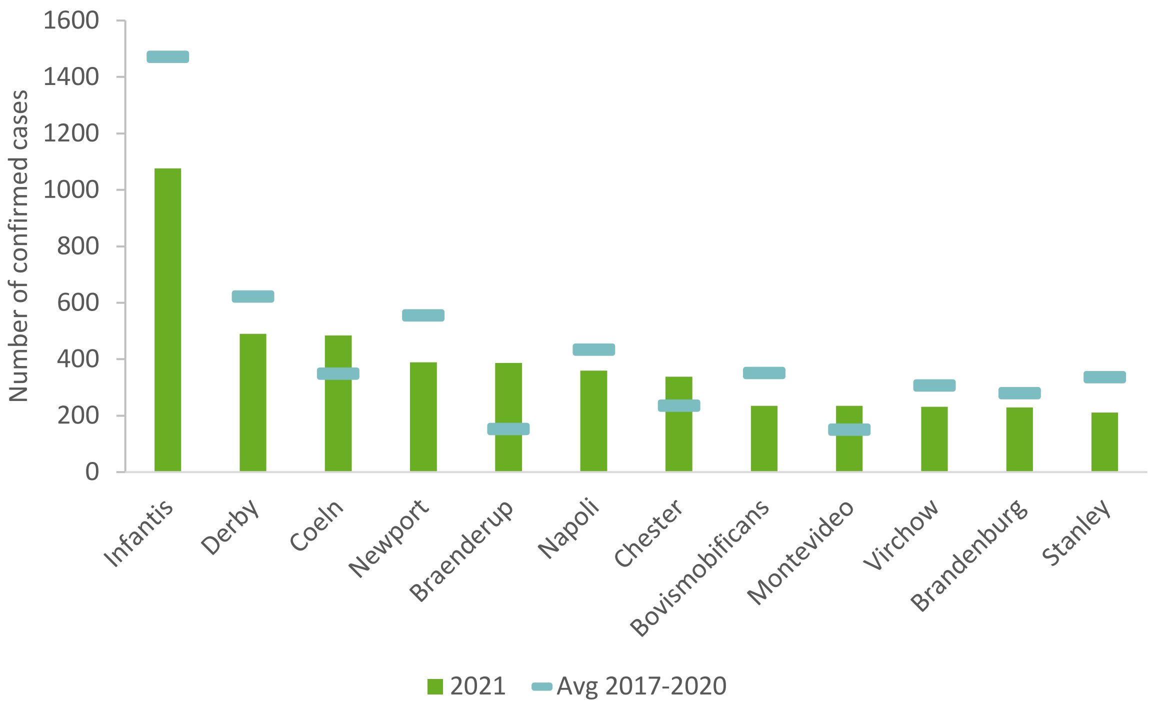
Among the 1 495 travel-associated cases with information on the probable country of infection, Türkiye, Spain and Italy were the most frequently reported travel destinations (accounting for 12%, 7% and 5% of travel-related cases, respectively).

Microbiological surveillance

Serovars

Information on *Salmonella* serovars and serogroups was available for 87% of the confirmed cases from the EU/EEA countries (Bulgaria and Poland did not report case-based serovar data). As in previous years, the three most commonly reported *Salmonella* serovars in 2021 were *S.* Enteritidis (54%), *S.* Typhimurium (11%) and monophasic *S.* Typhimurium 1,4,[5],12:i:- (9%). The proportions of these three serovars were at a similar level as 2019 but with lower case numbers. The number of cases of the 4th–15th most common serovars in 2021 are presented in Figure 5. During the last five years (2017–2021), 102 different serovars were identified in over 100 cases each. Nine of these serovars had their highest case numbers reported in 2021 (Coeln, Chester, Braenderup, Montevideo, Oranienburg, Anatum, Kedougo, Hessarek and Blockley). For four of these (Coeln, Braenderup, Chester and Montevideo), multi-country or national outbreaks were reported in the European surveillance portal for infectious diseases – EpiPulse (see the section, 'Outbreaks and other threats'). In comparison, for the serovars with more than 100 cases in 2017–2021, 33 serovars were reported at their lowest level in 2021.

Figure 5. Number of confirmed salmonellosis cases for the 4th–15th most common serovars in 2021, and comparison with 2017–2020, EU/EEA



Antimicrobial resistance

[Note that the analysis in this section has been done using epidemiological cut-off values (ECOFFs) and thus describes microbiological/acquired resistance which does not take dosing into account. The clinical resistance is usually lower.]

Antimicrobial resistance (AMR) was commonly observed in *Salmonella* isolates from humans in 2021 with multidrug resistance in 23% of the isolates (resistance to at least three of the nine monitored antimicrobial classes). Among the investigated serovars, multidrug resistance was most common in monophasic *S.* Typhimurium (78%), *S.* Kentucky (55%) and *S.* Infantis (38%).

However, only a smaller fraction (0.8%) of the bacteria was resistant to both the critically important antimicrobial classes for treatment – fluoroquinolones and third-generation cephalosporins. An increasing proportion of isolates was observed to be resistant to fluoroquinolones in 12 countries in the period 2017–2021, particularly visible in *S.* Enteritidis. Decreasing trends in resistance to ampicillin and tetracycline were observed in nine and 10 EU/EEA countries, respectively. For ampicillin, the decrease was most evident in *S.* Typhimurium and *S.* Enteritidis, and for tetracycline, in *S.* Typhimurium. The proportion of extended-spectrum β-lactamase (ESBL)-producing *Salmonella* isolates was at a low but stable level in 2017–2021 (identified in 0.8% of tested isolates, except in 2020 when it was identified in 0.6% of tested isolates).

The clones of multidrug resistant and ESBL-producing *Salmonella* that have been under special observation at the EU-level in the last years – *S.* Infantis with $bla_{CTX\text{-}M\text{-}1}$, *S.* Kentucky with $bla_{CTX\text{-}M\text{-}14b}$ and *S.* Infantis with $bla_{CTX\text{-}M\text{-}65}$ – did not seem to expand their spread in 2021, being reported by only one, two and one country each, respectively. However, incomplete genotyping results from some countries prevents a full assessment. No carbapenem-resistant isolates were detected in 2021, and levels of azithromycin resistance were low (<1%).

Molecular typing data collection for outbreak support

In four of the multinational outbreak investigations coordinated by ECDC, Member States submitted sequences to ECDC which were analysed to assess the relatedness between isolates from cases and suspected food items. Three of these were communicated by Rapid Outbreak Assessments (ROAs) as a probable source could be identified (see the next section, 'Outbreaks and other threats').

Outbreaks and other threats

In the summer of 2021, there was a transition from the Epidemic Intelligence Information System for Food and Waterborne Diseases (FWD-EPIS) to the new EpiPulse system for the reporting of outbreaks/unusual events of food- or waterborne diseases. In the entire year, 44 events with *Salmonella* infections were reported in FWD-EPIS/EpiPulse. These were launched by nine EU/EEA countries (35 events) and two non-EU countries (the United States and New Zealand) (9 events). Of these, 18 were multi-country events, and three resulted in a joint ECDC-EFSA Rapid Outbreak Assessment.

The largest multi-country outbreak detected in the EU/EEA in 2021 involved 348 confirmed cases with *S.* Braenderup sequence type 22 (ST22) which were reported by 12 EU/EEA countries and the United Kingdom (UK) between mid-March and early July 2021. The cases were spread throughout the countries and only two reported travels. A total of 68 cases were hospitalised. The case interviews and an analytical epidemiological study suggested small melons (in particular, Galia melons) as the possible vehicle of infection. *S.* Braenderup ST22 matching the outbreak strain was isolated in the UK in two imported Galia melons from Honduras (that belonged to the same batch), and in Austria from a pooled sample of melons (unknown origin) including Galia melons. The outbreak investigation led to the implementation of control measures for imported melons in circulation in the EU market [4, 5].

A prolonged outbreak with 121 confirmed cases was reported from January 2019 to October 2021. It involved six different serovars of *Salmonella* enterica (*S.* Havana, *S.* Mbandaka, *S.* Orion, *S.* Kintambo, *S.* Senftenberg and *S.* Amsterdam), and was found linked to sesame-based products from Syria. Cases were reported in five EU/EEA countries (plus Canada and the United States), and case interviews revealed the consumption of different types of sesame-based products (halva or tahini) prior to illness. Almost half of the cases were children ≤10 years, who also represented over half of the hospitalised cases. Despite the control measures implemented in August 2020 after the findings of *Salmonella*-positive sesame-based products, cases continued to occur in 2021. This could partly be explained by the long shelf-lives of the products [6].

In September 2021, France reported an increase in *Salmonella* Enteritidis ST11 infections to EpiPulse. By January 2022, 272 confirmed cases had been reported in five EU/EEA countries and the UK, with the majority of cases (216) in France. Twenty-five cases were hospitalised and two deaths were recorded. Outbreak investigations identified a link to the consumption of eggs/egg products, and via trace back of eggs from a restaurant visited by some of the cases, one packing centre in Spain and a specific farm testing positive for the outbreak strain could be identified. Not all cases could however be linked to the specific farm or the packing centre [7].

Two other multi-country outbreaks involving four EU/EEA countries each were identified via EpiPulse. They were related to *S.* Chester (cases falling in from mid-July throughout August) and *S.* Montevideo (a prolonged outbreak with sporadic cases occurring from January 2021 to January 2022), respectively, but no single source could be identified.

Among the national salmonellosis outbreaks reported to EpiPulse, the largest was detected in Finland in June, where a total of 620 children and 108 employees at day-care centres across three cities fell ill with *Salmonella* Typhimurium. All facilities were served by the same central kitchen and the outbreak strain was identified in the vegetables served at lunch [8].

Finland also reported another *S.* Typhimurium outbreak in February, related to vegetables where 49 cases fell ill after consuming salad containing contaminated tomato cubes that were sold frozen and had not been heated before use [9].

Sweden identified an outbreak of *S.* Coeln with 52 cases from 14 regions reported from end of August to October 2021. A national case-case study identified a link to the consumption of sprouts, further supported by an investigation in one of the regions. No microbiological confirmation could be done in the suspected food item, as it was a fresh produce thought to have been delivered to food stores, wholesalers and commercial kitchens at the same point of time in August [10].

Discussion

Salmonellosis remains the second most common food-borne infection in the EU/EEA. After the significant decrease in salmonellosis cases observed from 2007 to 2014, following targeted control measures in poultry production, a stable incidence was observed at the EU/EEA level from 2015 to 2019. In 2020, a significant drop in cases was observed, primarily as a consequence of the COVID-19 pandemic. All except two countries reported a decrease in the number of cases. Factors mentioned by countries resulting in lower case numbers were: people avoiding seeking medical care for mild symptoms due to risk of exposure to COVID-19 in healthcare facilities, limited laboratory capacity due to reallocation of resources to SARS-CoV-2, fewer restaurant visits, increased hand washing, less travel due to travel restrictions, etc.

Notification rates for salmonellosis in humans vary between Member States, reflecting variations in, for example, quality, coverage and disease-severity focus of the surveillance systems, practices in sampling and testing, prevalence in the food-producing animal population, food and animal trade between Member States, and the proportion of travel-associated cases. In 2021, the proportion of travel-associated cases was the lowest ever reported to TESSy. This was most likely an effect of the travel restrictions during the pandemic, particularly evident in the countries that normally report a very high proportion of travel-associated cases.

The fact that the salmonellosis rate in young children is eleven times higher compared with adults may be explained by a higher proportion of symptomatic infections among young children, an increased likelihood of parents taking children to see a doctor on getting sick, and for doctors to take samples. Certain countries with very large differences between the rates of young children and adults also reported high proportions of hospitalised cases. This indicates that surveillance systems in those countries may mainly capture the most severe infections.

Among the food-borne outbreaks reported to the European Food Safety Agency (EFSA) in 2021, *Salmonella* accounted for the largest proportion, 19%, as in previous years [11]. The majority (80%) of the reported salmonellosis food-borne outbreaks were caused by *S.* Enteritidis. The most frequently implicated food vehicles in strong-evidence salmonellosis food-borne outbreaks were, 'eggs and egg products', followed by 'mixed foods', 'bakery products', 'pig meat and products thereof', 'vegetables and juices and other products thereof', 'broiler meat and products thereof' and 'cheese'.

Among the *Salmonella* outbreaks reported to EpiPulse in 2021, the largest ones were mostly caused by contaminated vegetables, fruits or seeds or products thereof (melons, sesame products, salads, tomatoes, sprouts), as described in the section, 'Outbreaks and other threats'. A similar conclusion was made by EFSA as they found that among the strong-evidence salmonella outbreaks, 'vegetables and juices and other products thereof' caused the most number of cases in 2021, and the proportion of this category among causative agents increased considerably compared with both 2020 and the pre-pandemic years [11].

The year 2021 was the last year for reporting multi-locus variable-number tandem repeat analysis (MLVA) typing data via isolate-based reporting. The typing method has continuously been replaced by WGS in individual Member States. This is also reflected in the outbreak reports and the events reported in EpiPulse. The benefits of using WGS in facilitating the identification of linked cases in different countries and suspected food sources is promoted by ECDC, PulseNet International and World Health Organization (WHO) [12, 13]. National examples of WGS systems allowing comparison of sequences between sectors in a 'One Health' approach exists, for e.g., in the US and Germany [14, 15].

Mild infections with *Salmonella* should be treated with fluid and electrolyte replacement, and not with antimicrobials. Some infections might however become more severe. In 2% of cases reported to the EU/EEA in 2021, the infection had resulted in bacteraemia. Fluoroquinolones and macrolides (azithromycin) are the primary treatment for severe infections in adults (for children, cephalosporins would be used instead of fluoroquinolones). In case of invasive infections, intravenous cephalosporins are recommended [16]. Fluoroquinolone resistance in non-typhoidal *Salmonella* subspecies. from humans have increased in the last few years in the EU/EEA, particularly observed in *S.* Enteritidis which is a serovar mainly associated with eggs and poultry. In 2020, high to very high resistance to fluoroquinolones was observed in isolates recovered from broilers, fattening turkeys and poultry carcasses/meat [17]. Resistance to third-generation cephalosporins and macrolides however remain low in isolates from both humans and poultry.

Since 2019, it is possible to report antimicrobial resistance predicted from WGS-derived resistance determinants for *Salmonella* via isolate-based data collection. Testing of the quality of predicted resistance has also become a part of the EQA (external quality assessment) panels for *Salmonella*, which are offered to laboratories with national reference functions within the EU/EEA with support from ECDC.

In 2021, one country (Sweden) reported predicted resistance data to TESSy for *Salmonella*. With the increasing use of WGS in many Member States as the method of choice for serotype determination and cluster analysis, the resistance determinants could also be derived from the WGS data, specifically for countries with limited data from phenotypic testing. The methodology also has the benefit of allowing harmonised data analysis and interpretation between both countries and sectors (for example, the food sector). It could be an efficient tool for antimicrobial resistance (AMR) surveillance within the EU/EEA, not the least for the monitoring of emerging antimicrobial resistances of relevance to public health.

Public health implications

The rates of non-typhoidal salmonellosis vary between EU/EEA countries, reflecting differences in prevalence in food and animals used for food production, animal trade between countries, the proportion of travel-associated cases, and the quality and coverage of surveillance systems.

Eggs and egg products continue to be the highest risk foods in *Salmonella* outbreaks [11], although several larger outbreaks from non-animal food sources were identified in 2021. Proper *Salmonella*-control measures at the primary production level and sufficient laboratory capacity are prerequisites to reduce *Salmonella* prevalence in food-producing animals.

References

1. European Centre for Disease Prevention and Control (ECDC). Introduction to the Annual Epidemiological Report. Stockholm: ECDC; 2020. Available at: https://ecdc.europa.eu/en/annual-epidemiological-reports/methods

2. European Centre for Disease Prevention and Control (ECDC). Surveillance systems overview for 2021. Stockholm: ECDC; 2022. Available at: https://www.ecdc.europa.eu/en/publications-data/surveillance-systems-overview-2021

3. European Centre for Disease Prevention and Control (ECDC). Surveillance Atlas of Infectious Diseases. Stockholm: ECDC; 2021. Available at: http://atlas.ecdc.europa.eu

4. European Centre for Disease Prevention and Control (ECDC) and European Food Safety Authority (EFSA). Rapid Outbreak Assessment: Multi-country outbreak of *Salmonella* Braenderup ST22, presumed to be linked to imported melons. Stockholm/Parma: ECDC/EFSA; 20 July 2021. Available at: https://www.ecdc.europa.eu/en/publications-data/rapid-outbreak-assessment-multi-country-outbreak-salmonella-braenderup-st22

5. Chan Y-W, Hoban A, Moore H, Greig DR, Painset A, Jorgensen F, et al., on behalf of the Incident Management Teams. Two outbreaks of foodborne gastrointestinal infection linked to consumption of imported melons, United Kingdom, March to August 2021. Journal of Food Protection. 13 December 2022. Available at: https://doi.org/10.1016/j.jfp.2022.100027.

6. European Centre for Disease Prevention and Control (ECDC) and European Food Safety Authority (EFSA). Rapid Outbreak Assessment: Multi-country outbreak of multiple *Salmonella* enterica serotypes linked to imported sesame-based products. Stockholm/Parma: ECDC/EFSA; 14 October 2021. Available at: https://www.ecdc.europa.eu/en/publications-data/rapid-outbreak-assessment-multi-country-outbreak-multiple-salmonella-enterica

7. European Centre for Disease Prevention and Control (ECDC) and European Food Safety Authority (EFSA). Rapid Outbreak Assessment: Multi-country outbreak of *Salmonella* Enteritidis sequence type (ST)11 infections linked to eggs and egg products. Stockholm/Parma: ECDC/EFSA; 8 February 2022. Available at: https://www.ecdc.europa.eu/en/publications-data/multi-country-outbreak-salmonella-enteritidis-sequence-type-st11-infections

8. Terveyden ja hyvinvoinnin laitos (THL, The Finnish Institute for Health and Welfare). Elintarvike- ja vesivälitteisten epidemioiden esiintyvyys (Prevalence of food-borne and waterborne epidemics), (*in Finnish*). Helsinki: THL; 2021. Available at: Prevalence of foodborne and waterborne epidemics - THL

9. Kääriäinen S, Obach D, Paspaliari D , Tofferi M, Nieminen A, Pihlajasaari A, Kuronen H, Vainio A, Rimhanen-Finne R. *Salmonella* Typhimurium outbreak associated with frozen tomato cubes at a restaurant in western Finland, January to February 2021. Euro Surveill. 2022;27(41):pii=2200316. Available at: https://doi.org/10.2807/1560-7917.ES.2022.27.41.2200316

10. Folkhälsomyndigheten. Salmonella (Sverige, augusti-okbotber 2021) (*in Swedish*). 18 November 2021. Available at: https://www.folkhalsomyndigheten.se/smittskydd-beredskap/utbrott/utbrottsarkiv/salmonella-sverige-augusti-oktober-2021/

11. European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC). The European Union One Health 2021 Zoonoses Report. EFSA Journal 2022;20(12):7666, 273 pp. Available at: https://doi.org/10.2903/j.efsa.2022.7666

12. Nadon C, Van Walle I, Gerner-Smidt P, Campos J, Chinen I, Concepcion-Acevedo J, et al. PulseNet International: Vision for the implementation of whole genome sequencing (WGS) for global food-borne disease surveillance. Euro Surveill. June 2017, 22(23): 30544. Available at: http://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2017.22.23.30544

13. World Health Organization (WHO). Whole genome sequencing for foodborne disease surveillance: landscape paper. Geneva: WHO; 2018. Available at: https://www.who.int/publications/i/item/789241513869

14. Stevens EL, Carleton HA, Bael J, Tillman GE, Lindsey RL, Lauer AC et al. Use of Whole Genome Sequencing by the Federal Interagency Collaboration for Genomics for Food and Feed Safety in the United States. J Food Prot. March 2022; 85(5): 755–772. Available at: https://meridian.allenpress.com/jfp/article/85/5/755/478841/Use-of-Whole-Genome-Sequencing-by-the-Federal

15. Uelze L, Becker N, Borowiak M, Busch U, Dangel A, Deneke C, et al. Toward an Integrated Genome-Based Surveillance of *Salmonella enterica* in Germany. Front Microbiol. 2021; 12:626941. Available at: https://www.frontiersin.org/articles/10.3389/fmicb.2021.626941/full

16. Gilbert DN, Chambers HF, Saag MS, Pavia AT, and Boucher HW (ed.) The Sanford Guide to Antimicrobial Therapy 2022. 52nd edition. Sperryville, VA, USA: Antimicrobial Therapy, Inc.; 2022.

17. European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC). The European Union Summary Report on Antimicrobial Resistance in zoonotic and indicator bacteria from humans, animals and food in 2019–2020. EFSA Journal. March 2022, 20(3):7209. Available at: https://doi.org/10.2903/j.efsa.2022.7209