Research Article

National Program for the Control of Poultry Salmonellosis in Ukraine: Epizootiological Aspects and Monitoring of *Salmonella* spp. Pathogens in Poultry and Poultry Products Over 2010–2025

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Abstract | The safety of poultry products directly depends on controlling the spread of *Salmonella* spp. pathogens on poultry farms. The sustainable development of this sector in Ukraine is a critically important factor in ensuring the country's food security and also plays a significant role in exports. The poultry industry demonstrates high adaptability, developing in the direction of European integration and implementing principles of natural resource conservation. The aim of this study was to analyze reports on the results of laboratory diagnostic tests of samples subject to surveillance, in accordance with the National Program for the Control of Avian Salmonellosis, to assess the prevalence of *Salmonella enterica* at all stages of production (breeding, housing, production, and product distribution) on the commercial poultry operations, and to study the epizootiological aspects of avian salmonellosis monitoring in Ukraine. Authors analyzed non-confidential data. It was established that 94.6% of the planned studies were completed, with 941 *Salmonella* cultures isolated using standard bacteriological methods and identified by serotyping, representing a 0.03% detection rate in samples. The broiler testing plan was exceeded by 8.8%, while other categories were under-implemented by 4–12% (breeding and hatchery poultry – 93% and 91.8%, respectively). The most frequently isolated serovars were *Salmonella* Enteritidis (30.8%; 95% CI: 27.88–33.88%), *Salmonella* Pullorum and *Salmonella* Gallinarum (10.8%; 95% CI: 8.93–13.0%), *Salmonella* Eimsbuettel (11.1%; 95% CI: 9.12–13.23%), *Salmonella* Infantis (8.3%; 95% CI: 6.61–10.24%), and *Salmonella* Typhimurium (3.4%; 95% CI: 2.34–4.77%). The peak years for the isolation of various *Salmonella* strains were 2010 (95% CI: 10.49–14.83%), 2013 (95% CI: 12.86–17.54%), and 2018 (95% CI: 10.69–15.05%). Studies showed that isolates were most frequently detected in the samples from broilers (32.5%), commercial poultry (laying hens) (30.9%), and poultry products (egg products) (14.0%). At the same time, the highest number of isolates was detected predominantly in the southeastern regions of Ukraine. This review underscores the need for further refinement of the state control strategy throughout the entire production cycle to enhance the effectiveness of measures to combat avian salmonellosis, protect public health, and ensure food safety.

Keywords | *Salmonella* spp., Salmonellosis, Food Chain, Epizootic situation, Breeding poultry, Commercial poultry (laying hens), Broilers, Turkeys, Serological and bacteriological studies, Mapping

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INTRODUCTION

Salmonella enterica subsp. *enterica* is the primary foodborne zoonotic pathogen worldwide, accounting for 99% of all salmonellosis cases in humans and other mammals (Zizza *et al*., 2024). According to the European Food Safety Authority (EFSA), more than 350 000 cases of foodborne zoonoses are reported annually in the EU, where salmonellosis is the second most common gastrointestinal infection after campylobacteriosis and the leading cause of food poisoning outbreaks (Shchur *et al*., 2023; EFSA and ECDC, 2025; EFSA, 2026). Non-typhoidal *Salmonella* (NTS) – *Salmonella* Enteritidis, *Salmonella* Typhimurium, and monophasic *Salmonella* Typhimurium – are the most common serovars causing gastroenteritis in humans in the EU (EFSA and ECDC, 2025).

Livestock production is the primary source of *Salmonella* pathogens, and outbreaks of foodborne illness are most often linked to *Salmonella* infections among domestic poultry; therefore, control in poultry farming is a top priority due to its impact on human health and the economy (Siceloff *et al*., 2022; Marcu *et al*., 2026b). Annual financial losses from the consequences of NTS-associated infections linked to chickens are estimated at $2.8 billion (Scharff, 2020). Contaminated poultry products (meat and eggs) remain the primary sources of *Salmonella* transmission to humans. According to the Global Assessment of the Environmental Impact of Livestock (GLEAM) conducted by the Food and Agriculture Organization of the United Nations (FAO), egg production in 2016 was estimated at 73 million tons, while chicken meat production was estimated at 100 million tons. These figures are expected to rise in the coming years due to global population growth, increasing incomes, and rapid urbanization (Alexandratos and Bruinsma, 2012; Raut *et al*., 2023; Sammani *et al*., 2025). The rise in chicken and turkey meat consumption is driven by lower production costs, with feed accounting for up to 70% of poultry production expenses (OECD, 2022; Raut *et al*., 2023; Papp *et al*., 2023; Shchur *et al*., 2026).

With the rapid increase in the number of serotypes (approximately 3 000 are known), the identification of the pathogen has been simplified into three types, namely: non-typhoidal *Salmonella*, *Salmonella* Typhi, and *Salmonella* Paratyphi (Raut *et al*., 2023; Sharma *et al*., 2025). Domestic poultry is the primary reservoir of NTS among animals used for food production. Epidemiologically significant NTS serotypes include *Salmonella* Typhimurium, *Salmonella* Enteritidis, *Salmonella* Heidelberg, and *Salmonella* Newport. Domestic poultry can be infected with *Salmonella enterica* serovar Gallinarum, which includes two avian-adapted biovars, Gallinarum and Pullorum. Human infection with these biovars is extremely rare (Farhat *et al*., 2023; Tolooe *et al*., 2025). In contrast, the serovars *Salmonella* Enteritidis and *Salmonella* Typhimurium are among the most common in poultry and are the primary causes of salmonella-related foodborne illness in humans. The introduction and spread of *Salmonella* in poultry farming occur both vertically through an infected parent flock and horizontally between flocks due to breaches of biosecurity practices on the poultry farms (Shaji *et al*., 2023; Mahmood *et al*., 2025; Vougat Ngom *et al*., 2025). Therefore, controlling *Salmonella* spread and reducing contamination at the farm level is crucial for reducing the problem and protecting public health and food safety (Farhat *et al*., 2023; Tolooe *et al*., 2025).

Salmonella carriage, the subsequent development of antimicrobial resistance, and the emergence of new serovars pose an additional public health challenge for the poultry industry worldwide (Scallan *et al*., 2011; Abraham *et al*., 2022; Song *et al*., 2022; Wigley, 2024). Given the emergence of multidrug-resistant foodborne pathogens, which pose serious challenges for the public regarding the consumption of safe and high-quality food of animal origin, effective natural alternatives to traditional antibiotics are becoming increasingly important in the poultry sector, as they demonstrate a broad spectrum of antimicrobial activity and hold promise for improving food safety (Shchur *et al*., 2024; Marcu *et al*., 2026a). With the rise in poultry consumption worldwide, the prevalence, incidence, and transmission of *Salmonella* in agricultural settings and at various poultry processing facilities are major public health concerns requiring integrated control measures throughout the food chain (Mkangara, 2023; Raut *et al*., 2023). Several pre- and post-slaughter intervention strategies have been developed to ensure poultry safety and hygiene. These strategies include activities during carcass slaughter and meat processing, as well as the implementation of Hazard Analysis and Critical Control Points (HACCP) plans (Shaji *et al*., 2023).

In Ukraine, thousands of salmonellosis cases are reported each year. The highest incidence is observed among children, who are highly susceptible to infection due to the immaturity of their immune systems and the high pathogenicity of *Salmonella*, which can cause disease even at low infectious doses. Among the identified serovars, 67.8% are *Salmonella* Enteritidis, 24.5% – *Salmonella* Typhimurium, and 3.5% – *Salmonella* Infantis (Lusta *et al*., 2024). The main sources of the pathogen are eggs, chicken meat, and meat and dairy products. Analysis shows that frequent outbreaks are associated with poor food storage conditions (Podavalenko *et al*., 2021). During the period 2014–2023, the average annual incidence of salmonellosis in Ukraine was approximately 15.02 cases per 100,000 population. In total, there were approximately 64 108 confirmed cases over 10 years (Boiko *et al*., 2025).

In Ukraine, there are few literary sources describing poultry salmonellosis in separate regions of the country, however, there are no statistics on the prevalence of these pathogens in poultry farming at the national level. The main objectives of the strategy to combat avian salmonellosis in Ukraine are to monitor the disease; test feed; control the production of poultry meat and other poultry products at all stages of production, which must include the detection of infection with all serotypes of *Salmonella* that affect human health; assess the epizootic situation; determining strategies and tactics for action in the event of pathogen detection. However, a large-scale and systematic evaluation of such measures has not yet been conducted.

In light of the above, the authors set out to analyze the effectiveness of the State Control system for salmonellosis and to study the epizootiological aspects of monitoring salmonellosis in poultry in Ukraine over a 16-year period (from the time of the introduction of the National Program for the Control of Salmonellosis in Poultry, 2010–2025).

MATERIALS AND METHODS

Study design

To analyze the State Control system for salmonellosis in Ukrainian poultry farms and the epizootic situation regarding this disease, the following were used: reports on the work of the State Veterinary Laboratories of the State Service of Ukraine for Food Safety and Consumer Protection over 2010–2025, reports from the State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise (SSRILDVSE), and data from the State Statistics Service of Ukraine.

SSRILDVSE is authorized to process such reports, as it is the state coordinator of regional veterinary medicine laboratories in Ukraine. The authors obtained permission to use these data and analyzed data are not confidential.

Ukrainian national program for the control of salmonellosis in poultry

To ensure timely monitoring of salmonellosis in poultry on the commercial operations, detect the presence of *Salmonella* in all poultry products at the initial stages of production, to ensure continued public health protection, and facilitate the entry of Ukrainian poultry producers into the international market, Order No. 147 of November 30, 2009, was signed No. 147 "On the Approval of the Programs for the Control of Salmonellosis in Poultry in Ukraine for 2009–2013". In 2016, Ukraine approved new Instructions on the Prevention and Eradication of Salmonellosis in Poultry (Order of the Ministry of Agriculture and Forestry dated September 19, 2016, No. 310). The purpose of these Instructions is to ensure the application of appropriate and effective veterinary and sanitary measures aimed at detecting and controlling *Salmonella* at all stages of production and distribution of poultry and poultry products (including in feed), to reduce the prevalence of these pathogens and the risk it poses to the health of poultry and humans.

Bacteriological methods for detecting *Salmonella* pathogens

The studies were conducted in 24 authorized regional laboratories, accredited by the National Accreditation Agency of Ukraine in accordance with the international standard EN ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories" used the following methods recommended in the national Poultry Salmonellosis Control Programs for the detection and identification of *Salmonella* isolates:

- DSTU 4769:2007 Bacteriological examination of pathological material from animals. Methods for the detection of *Salmonella*.
- DSTU EN 12824:2004 Microbiology of food and animal feed. Horizontal method for the detection of *Salmonella*.

All of these laboratories underwent re-accreditation every 5 years and an annual assessment of the professional level of laboratories regarding the qualitative detection of *Salmonella* spp. in control samples provided by the provider. This testing includes:

- Verification of the correctness of the use of microbiological research methods by laboratories;
- Assessment of the ability of laboratories to obtain reliable and reproducible test results;
- Ensuring quality control and increasing the reliability of microbiological test results.

In case of discrepancies between the results obtained by laboratories and the assigned value of the control sample for the *Salmonella* spp. indicator in 25 g, corrective actions and re-testing are carried out.

Serotyping of the isolates was performed using sera specific for O-somatic antigens and H-flagellar antigens, including cilia phases I and II (Sifin, Berlin, Germany), in accordance with the White-Kauffmann-Le-Minor scheme ISO/TR 6579-3:2014 "Microbiology of the food chain – Horizontal method for the detection, enumeration, and serotyping of *Salmonella* – Part 3: Guidelines for serotyping of *Salmonella* spp."

The laboratory protocols included the following steps: first, the samples were pre-enriched in buffered peptone water for 16–20 hours at 37°C. Then, they were selectively enriched in two liquid media, Rappaport-Vassiliadis tetrathionate and Mueller-Kaufman, or selenite-cysteine broth at 37°C for 24 hours. In the case of processing swabs from poultry houses and poultry droppings, samples were enriched in Rappaport-Vassiliadis semi-solid medium with novobiocin at 42°C for 24–48 hours. Subsequently, subcultures from the enrichment media were isolated on two selective solid media: xylose-lysine-deoxycholate agar (XLD) and differential agar for *Salmonella* (SDA) at 37°C for 18–48 hours. Biochemical identification of the isolated bacterial colonies was performed using commercial reagents and specialized media. Identification included tests such as the determination of oxidase, catalase, the Foge Proskauer test, the methyl red test, citrate salt assimilation (on Simmons agar), detection of lysine decarboxylase, urea, indole, and hydrogen sulfide (on triple sugar agar (TSI), as well as fermentation of sugars (glucose, mannitol, sucrose, and lactose).

Statistical analysis of the study results

Statistical data were performed by the binomial confidence intervals (BCI, 95% CI) that were calculated to assess a seroprevalence using the Clopper-Pearson exact method with a confidence level of 0.95 using the R epitools software package (Ausvet, version 2020, Australia) (https://epitools.ausvet.com.au/). Mapping was presented in the software Quantum GIS 3.16.0 (International Quantum GIS Project, 2020, Germany), which is free on the website (https://www.qgis.org/ru/site/forusers/download.html). The vector layers for the borders of Ukraine's regions were downloaded from the site https://www.diva-gis.org/Data. Quantile classification with 5 classes of the data was chosen. With this classification, an equal count of oblasts fall into each class.

The nonparametric Mann–Kendall trend test was used to assess temporal trends in the number of *Salmonella* serovars detected for 2010–2025. The test was used to detect the presence of a statistically significant monotonic trend (increase or decrease) in the time series without assuming normal distribution of the data. Differences were considered statistically significant at P < 0.05.

The prevalence of *Salmonella* Enteritidis was compared with that of other serovars using Pearson's chi-square test for 2×2 contingency tables. Differences were considered statistically significant at P < 0.05.

To assess the dynamics of the proportion of positive results of studies for salmonellosis in 2010–2025, the χ^2-test for trend analysis was used. The analysis was performed based on the annual number of positive results and the total number of studies conducted. Additionally, the presence of a linear component of the trend and deviations from linearity were assessed. Differences were considered statistically significant at P < 0.05.

RESULTS

Dynamics of poultry farms and the poultry population in Ukraine during the study period

In the Program for the Control of Salmonellosis in Poultry in Ukraine, the approximate breakdown of the poultry tested by species was as follows (as a percentage of the total number of tested): broilers approximately 65–70%; laying hens – 20–25%; turkeys – 5–7%; other poultry species (ducks, geese, etc.) about 2–3%. The Program covered poultry farms throughout Ukraine and provided for monitoring at all stages of poultry production.

Figures 1–3 show trends in the number of farms and poultry over the analyzed period.

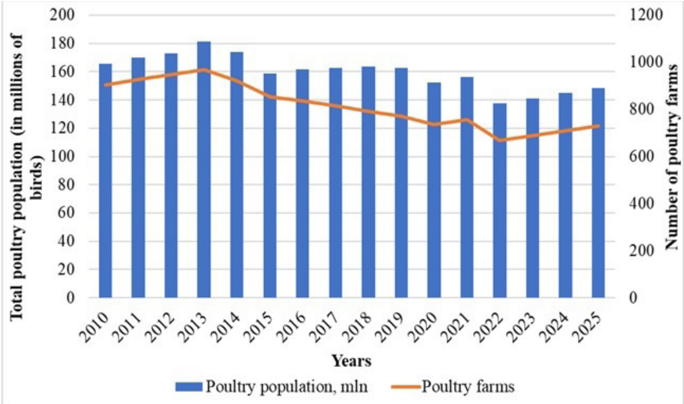

Figure 1: Temporal trends in poultry population and number of poultry farms in Ukraine, 2010–2025. The left y-axis shows the total poultry population (in millions of birds), and the right y-axis shows the number of poultry farms. Data are presented as annual counts.

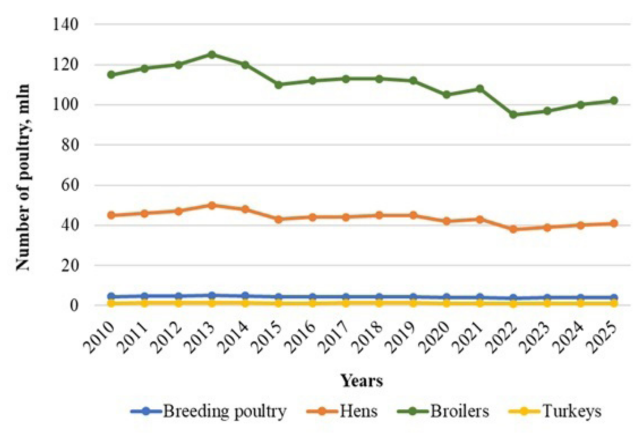

Figure 2: Population dynamics of different poultry species on farms in Ukraine, 2010–2025. Values are shown in millions of birds for breeding poultry, hens, broilers, and turkeys.

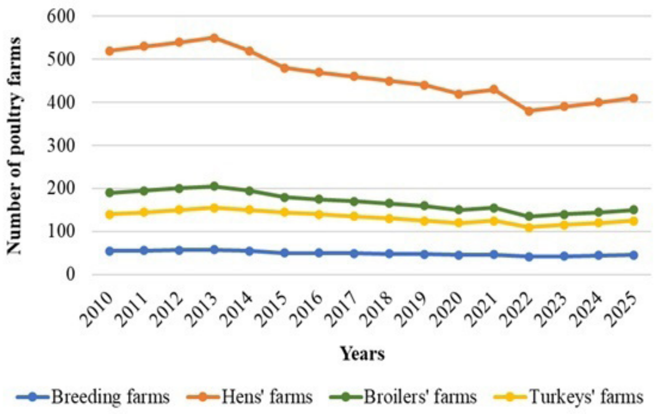

Figure 3: Number of poultry farms by production sector in Ukraine, 2010–2025. Data are shown for breeding farms, layer hen farms, broiler farms, and turkey farms.

An analysis of the data in Figures 1–3 shows that Ukraine maintains a fairly large poultry population, which is estimated at approximately 148 million birds as of 2025. In terms of species, broilers and laying hens dominate (in 2025, 41 and 102 million, respectively; 95% CI: 92.2–98.9% of the total population). At the same time, looking back, there was a trend of rapid growth in the numbers of these species from 2010 to 2013 (the broilers number increased by 8.7% and laying hens – by 11.1%). A downward trend began in 2014 due to the economic crisis caused by the loss of parts of the eastern and southern territories, which subsequently stabilized during 2017–2021. In 2022, there was a sharp decline in the number of poultry population due to the outbreak of hostilities (by 13.6% and 13.1%, respectively). As for the number of breeding poultry and turkeys, throughout the entire period under review, their numbers were recorded at approximately 4.2 and 1.2 million, respectively.

Data on the number of poultry farms also indicates a downward trend in their numbers in 2014 and 2022 due to the loss of some enterprises in the eastern and southern regions of Ukraine. At the same time, during 2017–2021, production consolidation occurred due to an increase in the size of poultry farms. Overall, the compiled data indicate that in 2023–2025 there was a gradual increase in the number of farms and, accordingly, a recovery in poultry production. Overall, as of 2025, there are 730 poultry farms operating in Ukraine, specifically: 410 with laying hens (56.2%), 150 broiler farms (20.5%), 125 turkey farms (17.1%), and 45 breeding farms (6.2%).

Implementation of the research plan at under the national program for the control of *Salmonellosis* in poultry

An analysis of reports on the implementation of the poultry salmonellosis testing plan for the period 2010–2025 shows that, overall, 2 773 989 of the planned 2 932 165 tests were performed, or 94.6% (95% CI: 94.58–94.63%). At the same time, the plan for testing breeding poultry was fulfilled by 93% (95% CI: 92.92–93.08%); for hatchery poultry, by 91.8% (95% CI: 91.76–91.89%); commercial poultry (laying hens) – by 93.6% (95% CI: 93.52–93.67%); poultry products (egg products) and sanitary-hygienic inspections by 92.7% (95% CI: 92.64–92.75%); broilers the plan was exceeded by 8.8%; poultry products from broiler meat and sanitary and hygienic inspections of facilities related to their handling by 87.6% (95% CI: 87.55–87.63%); turkeys – by 96.9% (95% CI: 96.71–97.18%); turkey meat products and sanitary-hygienic inspections by 90.4% (95% CI: 90.24–90.61%).

Figure 4 presents systematized data covering a 16-year period regarding the number of laboratory diagnostic tests for salmonellosis in various types of poultry. Since 2014, there has been a downward trend in the number of tests, and from 2018 to 2021, a near return to pre-crisis levels. At the same time, starting in 2022, with the onset of full-scale war, another decline has been recorded. These results logically align with the decrease in poultry populations and poultry farms. The war's impact on logistics and laboratory capacity (low levels of material support and a shortage of human resources) has led to a decrease in the number and quality of studies, particularly the absence of serotyping.

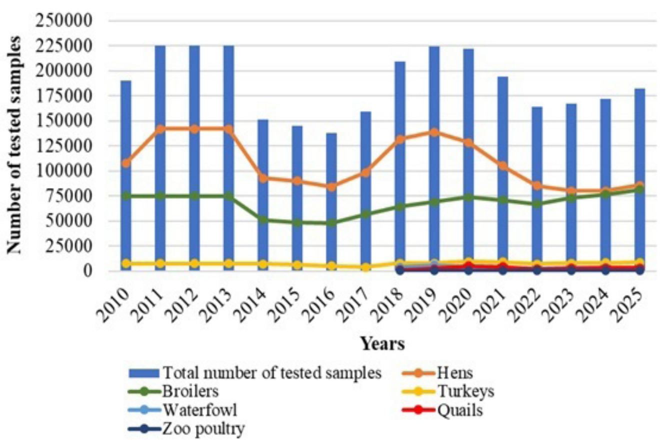

Figure 4: Annual number of laboratory tests conducted under the National Program for the Control of *Salmonella* in Poultry, Ukraine, 2010–2025. Data are shown for all poultry categories combined and by species.

During the period under review, the largest number of tests was conducted on chicken flocks (95% CI: 57.89–58%) and broilers (95% CI: 36.02–36.13%). Nearly 10 times fewer tests were conducted on turkeys (95% CI: 4.0–4.04%), and about 1% of the tests were performed on waterfowl (95% CI: 1.0–1.03%) and quail (95% CI: 0.81–0.83%). The smallest number of samples was tested from zoo birds (95% CI: 0.12–0.13%). It should be noted, however, that samples from waterfowl, quail, and zoo birds have only been tested since 2018.

Overall, the testing plan was fully implemented only in the "broilers" category; the remaining items of the plan were under-implemented by 4–12%. It should be noted that the testing plan was implemented in Vinnytsia, Volyn, Dnipropetrovsk, Zakarpattia, Kyiv, and Chernihiv regions.

Positive cases of *Salmonella* isolation under the program during the 2010-2025 period

During the study period, 2,773,989 laboratory diagnostic tests were conducted, and 941 positive cases were identified, representing a 0.03% detection rate in samples. The largest positivity rates of samples were obtained in Luhanska (0.194%), Khmelnytska (0.184%), Khersonska (0.15%) and Zaporizka (0.133%) regions. At the same time, the largest number of studies was conducted in Kyivska, Vinnytska, Cherkaska and Dnipropetrovska regions (more than 200 thousand studies in each). It is shown, that no isolates were detected in the Kharkivska, Odeska, Chernivetska, and Rivnenska regions, although about 40 thousand samples were examined in each (Figure 5). In total, positives were registered in 21 regions of Ukraine.

From the 941 *Salmonella* spp. isolates, 52 were isolated from biological samples taken from breeding poultry (95% CI: 4.15–7.18%), 64 from incubators (95% CI: 5.28–8.6%), and 291 from samples taken from commercial poultry (laying hens) (95% CI: 27.98–33.99%), 132 were obtained from poultry products (egg products) and during sanitary and hygienic inspections of these facilities (95% CI: 11.87–16.41%), 190 isolates were confirmed in broilers (95% CI: 17.67–22.90%), 116 were detected during testing of broiler meat products and during related sanitary and hygienic inspections (95% CI: 10.29–14.60%), 12 were isolated during testing of samples from turkeys (95% CI: 0.66–2.22%) and 27 during testing of turkey meat products and during sanitary and hygienic studies related to turkey meat production (95% CI: 1.9–4.15%). From other materials (other poultry species and feed), 57 isolates were obtained (95% CI: 4.62–7.78%) (Figure 6).

On Figure 6 is shown the regions of Ukraine and indicated the materials from which *Salmonella* spp. were isolated. Overall, the highest number of positive samples was found among the material collected from commercial poultry (laying hens) in the Sumy, Poltava, Luhansk, Donetsk, Zaporizhzhia, Kherson, Dnipropetrovsk, Kirovohrad, Khmelnytskyi, Mykolaiv, Cherkasy, Kyiv, and Chernihiv regions, as well as in Crimea.

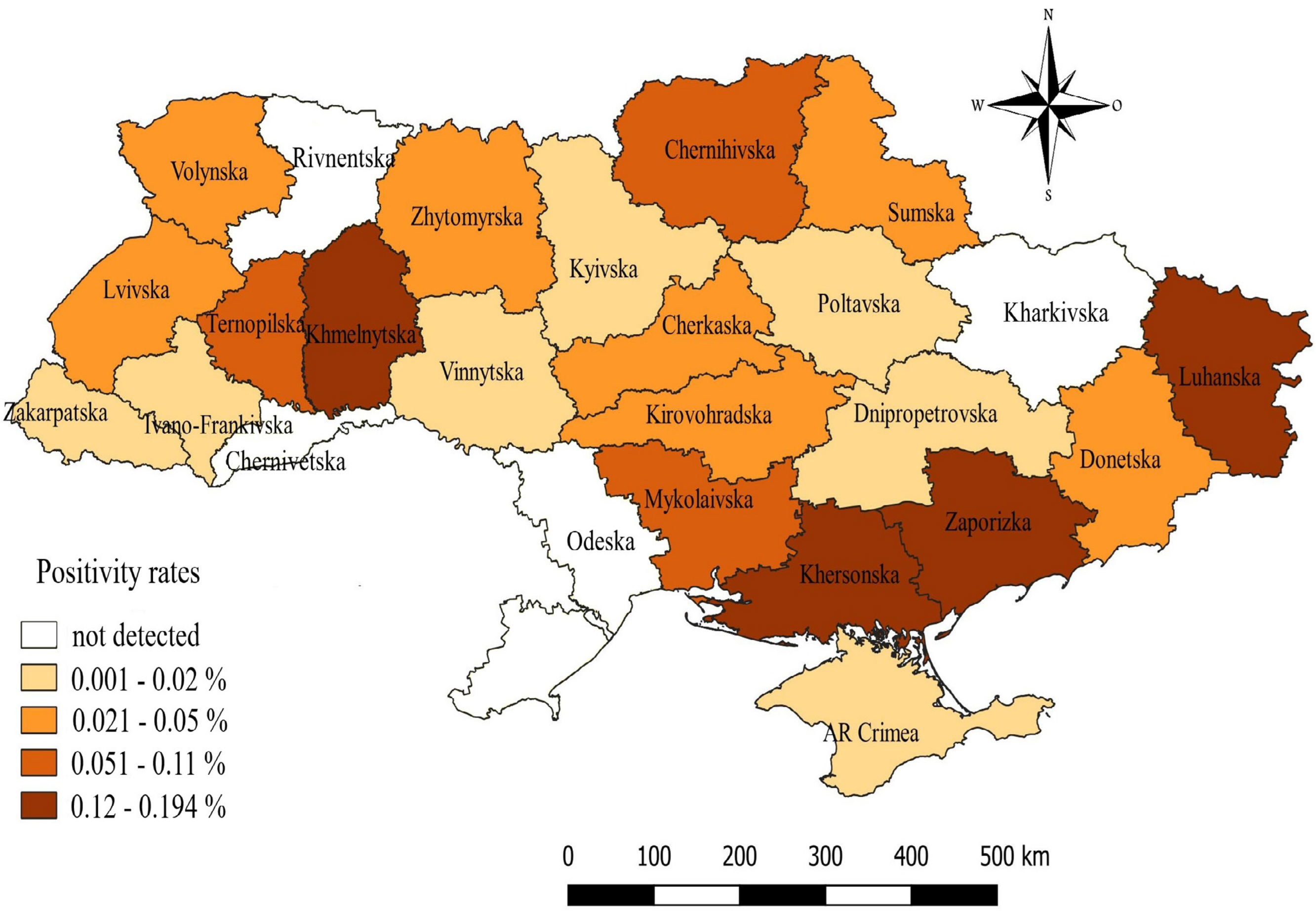

Figure 5: Geographic distribution of *Salmonella* spp. isolation rates by region in Ukraine, 2010–2025. Rates are expressed as the percentage of positive samples per total tests conducted in each region. Darker colors indicate higher positivity rates.

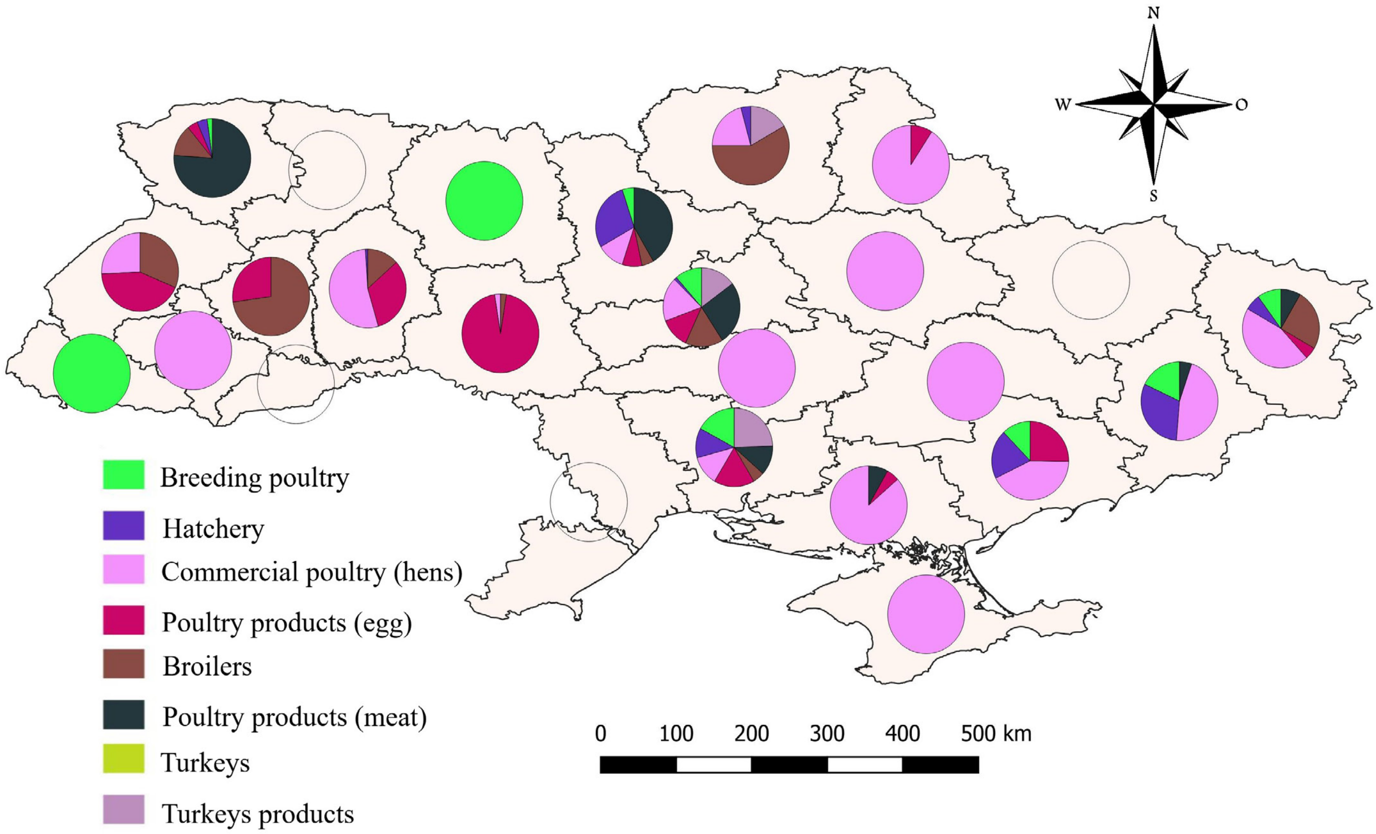

Figure 6: Regional distribution of *Salmonella* spp. isolates by sample type in Ukraine, 2010–2025. Positive samples are categorized by source: breeding poultry, commercial poultry, broilers, turkeys, and poultry products.

The trends in the isolation of cultures from biological materials within Ukraine for the period 2010–2025 are shown on Figure 7. The peak values (more than 100 isolates each year) were observed in 2010 (95% CI: 10.49–14.83%), 2013 (95% CI: 12.86–17.54%), and 2018 (95% CI: 10.69–15.05%). Since 2019, the number of identified serovars has been less than 50 each year. Statistical analysis shows that the significant decreasing trend in the number of detected *Salmonella* serovars was observed during 2010–2025 (Mann–Kendall test, $P < 0.05$).

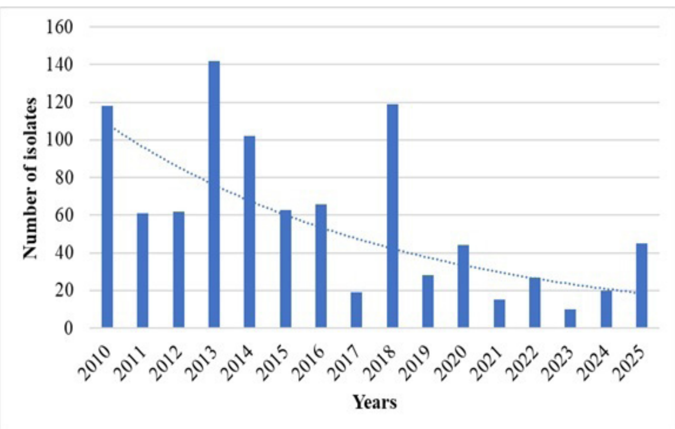

Figure 7: Annual number of *Salmonella* spp. isolates identified in Ukraine, 2010–2025. Error bars represent 95% binomial confidence intervals.

Analysis of positivity rates indicates that the proportion of positive samples has also decreased since 2019. Thus, during 2010–2018, positives were detected in the range of 0.01–0.11%, and since 2019 – 0.006–0.02%. In general, they were recorded throughout the study period in the form of sporadic outbreaks (Table 1).

Statistical analysis of the systematized results of studies on salmonellosis over 2010–2025 showed statistically significant differences between years (Pearson's $\chi^2 = 513.61$; df = 15; $P < 0.0001$). Analysis of the linear trend showed the presence of statistically significant changes in the indicator over time ($\chi^2 = 236.10$; df= 1; $P < 0.0001$). At the same time, the test for deviation from linearity was also statistically significant ($\chi^2 = 277.51$; df = 14; $P < 0.0001$), which indicates the nonlinear nature of the dynamics of the proportion of positive results. Thus, the level of detection of salmonellosis during the studied period changed significantly, but these changes did not have the character of a uniform linear increase or decrease.

Identified serovars of *Salmonella enterica* subsp. *enterica* during the implementation of the program

Overall, during the analyzed period, from the examined objects subject to control, namely: Biological and pathological material from poultry, poultry products

Table 1: Systematized salmonellosis positivity rates by region and by year.

Years	Positivity rates by year, %	Positivity rates by region, %																						
		Vinnytska	Volynska	Dnipropetrovska	Donetska	Zhytomyrska	Zakarpatska	Zaporizka	Ivano-Frankivs-ka	Kyivska	Kirovohradska	Luhanska	Lvivska	Mykolaivska	Poltavska	Sumska	Ternopilska	Khersonska	Khmelnytska	Cherkaska	Chernihivska	AR Crimea
2010	0.11				1.2			0.01				1.5								0.2	1.4	
2011	0.04								0.02	0.06		0.1	0.01	0.02					0.25	0.03		0.02
2012	0.03							0.3				0.03				0.4			0.06	0.1		
2013	0.06							0.6		0.03		0.02	0.08		0.14				0.46	0.02		
2014	0.07							0.13		0.08		0.33							0.71	0.2		
2015	0.04	0.01						0.23		0.01	0.2							0.5	0.46	0.02		
2016	0.05													0.12		0.04			1.2	0.02		
2017	0.01					0.23											0.53	0.33		0.04		
2018	0.06		0.03				0.07	0.21		0.03			0.04	1.19					0.04	0.12		
2019	0.01									0.01			0.05	0.21			0.07	0.39	0.08	0.003		
2020	0.02							0.34					0.04	0.26				0.9	0.02	0.08		
2021	0.008		0.03						0.03				0.09					0.22	0.02			
2022	0.02		0.34																0.04			
2023	0.006	0.005	0.06														0.13			0.007		
2024	0.01	0.03																	0.06	0.02		
2025	0.02	0.08	0.03	0.04															0.04	0.01		

Empty cells indicate no positive samples, but investigations were conducted annually in all indicated regions.

(commercial eggs, egg powder, egg mass for processing, poultry carcasses, semi-finished products, mechanically deboned poultry meat, poultry meat), feed, and swabs from equipment in egg storage facilities, poultry houses, feed mills, slaughter and processing facilities, and cold storage and freezer rooms, 44 different serological variants were identified. In addition, it was detected untyped serovars identified to the genus *Salmonella* by biochemical and serological properties (group B, C_1, and Q) (Figure 8).

The prevalence of *Salmonella* Enteritidis was significantly higher than other identified serovars (χ^2 test, $P < 0.001$). Thus, it was isolated in 290 cases (30.8%; 95% CI: 27.88–33.88%). *Salmonella* Eimsbuettel and *Salmonella* Infantis were isolated in 104 (11.1%; 95% CI: 9.12–13.23%) and 78 cases (8.3%; 95% CI: 6.61–10.24%), respectively, and *Salmonella* Typhimurium– 32 (3.4%; 95% CI: 2.34–4.77%). Two distinct groups *Salmonella* Pullorum and *Salmonella* Gallinarum were often reported together and accounted for 102 cases (10.9%; 95% CI: 8.93–13.0%). The proportion of untyped *Salmonella* spp. isolates was 19.2% (95% CI: 16.76–21.90%).

In general, the heat map analysis revealed substantial temporal variability in the distribution of *Salmonella* serovars during the study period. Thus, *Salmonella* Enteritidis predominated in most years and was particularly prevalent in 2014–2016 and 2022, accounting for 57.8–74.1% of all isolates identified in those years. In contrast, the proportion of untyped *Salmonella* spp. increased markedly in certain years, reaching 52.6% and 59.7% in 2017 and 2018, respectively.

Several serovars demonstrated sporadic occurrence and were associated with specific periods. *Salmonella* Eimsbuettel was predominantly detected in 2013, when it accounted for 73.2% of all isolates, but was not identified in other years. *Salmonella* Gallinarum was more frequently isolated during the first half of the observation period, whereas *Salmonella* Infantis became increasingly important after 2018 and represented 45.0% and 63.6% of all isolates in 2024 and 2025, respectively. *Salmonella* Typhimurium was detected irregularly throughout the study period and never exceeded 26.3% of annual isolates.

Overall, the heat map demonstrates a heterogeneous serovar composition characterized by the long-term dominance of *Salmonella* Enteritidis, periodic emergence of individual serovars, and marked year-to-year fluctuations in the relative prevalence of less common serotypes.

In Ukraine, the problem of salmonellosis acquired significant epidemiological importance in the 20th century. As part of the USSR, Ukraine participated in the all Union system of sanitary and epidemiological control. Key measures included state veterinary control at meat

No	Serovars of *Salmonella*	Years of observation																TOTAL, % (2010-2025)
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
1	Enteritidis	43,2	3,3	3,2	9,2	57,8	68,3	66,7	5,3	25,2	25,0	4,4	40,0	74,1	40,0	15,0	6,8	30,80
2	*Salmonella* spp.	7,6	13,1	22,6	1,4	2,9	7,9	33,3	52,6	59,7	32,1	15,6	33,3	7,4	20,0	0,0	27,3	19,20
3	Eimsbuettel	0,0	0,0	0,0	73,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	11,10
4	Gallinarum	22,9	14,8	24,2	7,7	5,9	0,0	0,0	0,0	3,4	21,4	0,0	0,0	0,0	0,0	0,0	0,0	8,30
5	Infantis	0,0	32,8	0,0	0,0	3,9	0,0	0,0	0,0	6,7	10,7	2,2	6,7	7,4	20,0	45,0	63,6	8,30
6	Typhimurium	1,7	0,0	3,2	0,0	10,8	14,3	0,0	26,3	0,0	0,0	2,2	0,0	0,0	0,0	10,0	0,0	3,40
7	Pullorum	10,2	18,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,60
8	Give	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	46,7	0,0	0,0	0,0	0,0	0,0	2,30
9	Muenchen	0,0	0,0	16,1	0,7	8,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,10
10	Stanley	0,0	0,0	19,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,30
11	Isangi	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,4	13,3	0,0	0,0	30,0	2,3	1,20
12	Thompson	0,0	0,0	0,0	7,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,10
13	Virchow	0,0	4,9	1,6	0,0	3,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,90
14	Derby	2,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,70
15	Anatum	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	11,1	0,0	0,0	0,0	0,0	0,0	0,60
16	Essen	3,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,6	0,0	0,0	0,0	0,0	0,0	0,0	0,50
17	Suberu	0,0	0,0	0,0	0,0	0,0	7,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,50
18	Muenster	0,8	4,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,40
19	Oranienburg	0,0	1,6	4,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,40
20	Kambole	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	11,1	0,0	0,0	0,0	0,40
21	London	0,8	0,0	0,0	0,0	0,0	0,0	0,0	10,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,30
22	Sinstorf	0,0	4,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,30
23	Sendai	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,20
24	Paratyphi B	0,0	0,0	1,6	0,0	0,0	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,20
25	Montevideo	0,0	0,0	0,0	0,0	2,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,20
26	Easboume	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	7,1	0,0	0,0	0,0	0,0	0,0	0,0	0,20
27	Djugu	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	6,7	0,0	0,0	0,0	0,0	0,20
28	Portland	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,4	0,0	0,0	0,0	0,0	0,0	0,20
29	Kisii	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	20,0	0,0	0,0	0,20
30	Westhampton	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
31	Simba	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
32	Panama	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
33	Edinburgh	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
34	Lomita	0,0	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
35	Canada	0,0	0,0	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
36	Nigeria	0,0	0,0	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
37	Irumu	0,0	0,0	0,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
38	Haifa	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
39	Hindmarsh	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
40	Hamburg	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
41	Potsdam	0,0	0,0	0,0	0,0	0,0	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
42	Dublin	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
43	Indiana	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,10
44	Livingstone	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	0,0	0,0	0,0	0,0	0,10
45	Agona	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	0,0	0,0	0,0	0,0	0,10
	TOTAL isolates	118	61	62	142	102	63	66	19	119	28	44	15	27	10	20	45	n=941 / 100%

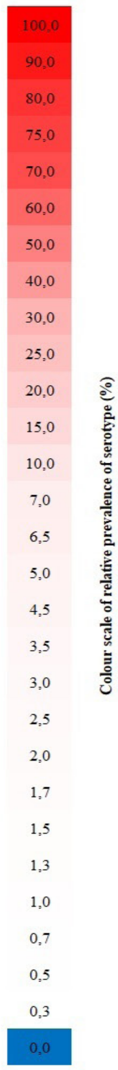

Figure 8: Heat map showing the temporal distribution of *Salmonella* enterica subsp. enterica serovars isolated from poultry, poultry products, feed, and environmental samples in Ukraine, 2010-2025. Each cell represents the proportion (%) of a specific serovar among all isolates in a given year. Untyped *Salmonella* spp. are included as a separate category. *Salmonella* Pullorum and *Salmonella* Gallinarum are grouped together due to their similar epidemiological significance.

processing plants, sanitary supervision of food service establishments, mandatory reporting of cases of intestinal infections, and bacteriological monitoring of animal-derived products. Particular attention was paid to poultry farming, as eggs and chicken meat were the primary sources of the *Salmonella* Enteritidis pathogen. After 1991, the epidemiological surveillance system in Ukraine was reformed. Key stages of the reform included the creation of a National sanitary Control system, harmonization of standards with EU requirements, implementation of the HACCP (Hazard Analysis and Critical Control Points) system, and strengthening of laboratory diagnostics. In 2016, the sanitary and epidemiological stations were abolished, and the State Service of Ukraine for Food Safety and Consumer Protection was established, which currently coordinates the monitoring of salmonellosis in animal husbandry and food products. There is also currently a system of epidemiological surveillance in place through the Public Health Center of the Ministry of Health of Ukraine.

DISCUSSION

A special official Salmonellosis Control Program was developed in Ukraine and adopted in 2009 by Order No. 147 “On the Approval of the Program for the Control of Salmonellosis in Poultry in Ukraine for 2009–2013.” This official government document defined a set of measures for state veterinary and sanitary control of *Salmonella* pathogens in poultry products and live poultry. The Program was developed in accordance with EU requirements (directives and regulations, in particular Reg. 2160/2003 and 1177/2006), but was not part of a single mandatory European mechanism. The Program was based on state veterinary supervision, monitoring, and control of serotypes affecting human health (primarily *Salmonella* Enteritidis and *Salmonella* Typhimurium). Monitoring was conducted at all stages: poultry husbandry, production, equipment, and feed. The main focus was on the state sanitary supervision, laboratory testing, sampling, and epizootic control measures. This Program was aimed at reducing risks to humans and meeting EU export requirements, but data on systematic reductions in epizootic indicators over the entire period were not always publicly disclosed. The 2009–2013 Ukrainian Program was a significant step toward harmonization with international standards, particularly in the context of the EU, but it was not a standalone EU Program.

It comprised four components, creating a comprehensive control plan, namely:

1. Monitoring and detection. This component included continuous monitoring of salmonellosis incidence in poultry, laboratory testing for the presence of these pathogens in laying hens, broilers, breeding poultry, and turkeys, as well as control of feed, equipment, and facilities.
2. Control of production processes. Control was envisaged at all stages of poultry production (including meat and eggs) taking into account key serotypes that pose a risk to humans (*Salmonella* Enteritidis, *Salmonella* Typhimurium, *Salmonella* Hadar, *Salmonella* Infantis, *Salmonella* Virchow, etc.).
3. Organizational and operational measures. These were based on assessing the epizootic situation, determining a course of action upon detection of the pathogen, conducting unannounced sampling at production facilities, and imposing quarantine restrictions on affected farms. All these measures were consistent with the “farm-to table” approach applied in EU countries.
4. Laboratory methods and standards. These primarily involved bacteriological testing in accordance with standards, determining the number and frequency of sample collection, and the use of modern methods for detecting *Salmonella* spp. in products and the environment. All these measures were essential for a reliable assessment of control and for reducing the risk of infected products entering the market.

The program mandated control at the breeding flock level, which included regular sampling of feces and litter, bacteriological testing, culling upon detection of an infected flock, and a ban on the sale of hatching eggs from the sick poultry. A key feature of control at the breeding flock level was the emphasis on state laboratory testing. Control at the broiler/layer level involved routine pre-slaughter monitoring, testing for *Salmonella* Enteritidis and *Salmonella* Typhimurium, and sanitization of facilities after each batch of poultry. Control at the processing level (at slaughterhouses) was based on carcass inspection, bacteriological analysis of swabs, and veterinary and sanitary examination. Control at the market/consumer level included sanitary surveillance and investigations of outbreaks among the population. Thus, the Program harmonized standards and facilitated export preparation, but lacked strict supranational control and a unified reporting system, as is the case, for example, in the EU (Korniienko et al., 2025).

In 2016, Ukraine adopted a new Instruction for the Prevention and Control of Salmonellosis in Poultry, which update certain provisions of the Program in line with current international standards. This reflects the ongoing development of science-based control measures of salmonellosis in Ukraine. The Instructions on the Prevention and Eradication of Salmonellosis in Poultry, developed in accordance with the requirements of the OIE Terrestrial Animal Health Code, the Law of Ukraine “On Veterinary

Medicine and Animal Welfare," taking into account the requirements of Directive 2003/99/EC, EU Regulations No. 2160/2003 (consolidated version as of April 21, 2021) and No. 1177/2006, is aimed at implementing appropriate and effective measures to detect and control salmonellosis at all stages of breeding and keeping poultry, as well as reducing risks that pose a threat to humans. The provisions of the Instruction apply to laying hens, broiler chicks, breeding poultry, turkeys; risk assessments are conducted, the epizootic situation in the poultry farm and the region is studied, and the results of laboratory tests are taken into account; in addition, state territorial competent authorities may also develop and implement Control Programs for other poultry species as well.

Today, salmonellosis remains a serious global, national, and regional public health problem (Kumar *et al*., 2019; Abd El-Ghany, 2020; Podavalenko *et al*., 2021; Polishchuck *et al*., 2023; Boiko *et al*., 2025).

Outbreaks of foodborne illness associated with *Salmonella* spp. are quite common and cause serious concern (Antunes *et al*., 2016; Dieye *et al*., 2022), including in Ukraine (Boiko *et al*., 2025; Korniienko *et al*., 2025). Salmonellosis outbreaks usually occur as a result of the consumption of animal products, with chicken being one of the main sources (Klishchova and Nazarenko, 2021).

Ukrainian researchers note that during outbreaks, the serovars *Salmonella* Enteritidis and *Salmonella* Typhimurium predominate (Podavalenko *et al*., 2021). Our studies showed the isolation of *Salmonella enterica* serovar Enteritidis in 30.8% of all isolated cultures (290 out of 941), and *Salmonella* Typhimurium in a slightly lower proportion 3.4% (32 out of 941) which confirms the findings of other authors and, at the same time, highlights the danger of this pathogen to humans. Therefore, veterinary specialists in Ukraine are paying close attention to this issue as well, since cross-sectoral collaboration between veterinary services and medicine representatives is essential in this regard.

As early as the late 20th century, outbreaks caused by *Salmonella* Gallinarum were reported on commercial farms worldwide (Raut *et al*., 2023). Subsequently, outbreaks caused by *Salmonella* Typhimurium and *Salmonella* Enteritidis began to be reported in poultry flocks and food products (chicken meat and eggs, turkey meat) (Oakley *et al*., 2014). In the 1990s, *Salmonella* Enteritidis predominated over all other serovars in poultry farming, and foodborne outbreaks were reported in many countries (Raut *et al*., 2023). According to previously conducted studies, our colleagues have established that in poultry farming in the North-Eastern region of Ukraine, Gallinarum and Pullorum were mainly isolated – 26.9%, Enteritidis – 20.1%, Typhimurium – 30.3%, *Salmonella* Infantis – 1.5% and such an exotic serovar as Arizona - 6.0% (Klishchova and Nazarenko, 2021). Recently, during outbreaks, more exotic serovars of *Salmonella* – Heidelberg, Minnesota, Montevideo, Tennessee, and Kentucky – have been detected, and the latter continue to increase in percentage terms in poultry food chains and food products worldwide (Voss-Rech *et al*., 2015). In our country, during the period of our study, the following serovars were found to be quite rare: Westhampton, Shubra, Panama, Lomita, Irumu, Haifa, Hindmarsh, Hamburg, Potsdam, Dublin, Indiana, Livingstone, Agona, etc.

Eggs and poultry meat production is at risk if effective management and physical measures aimed at reducing the introduction and spread of infections on farms are not implemented. Addressing these issues was the responsibility of the *Salmonella* Program in Ukraine, and currently falls under the provisions of the Instruction, which, as shown in this analysis, were implemented almost in full. Therefore, the salmonellosis Program examines a wide range of materials, including: day-old chicks (carcasses; litter from transport crates), 4-week-old chicks (carcasses), chicken manure collected 2 weeks prior to egg laying, manure collected every 2 weeks after the start of egg laying, swabs from egg storage room equipment, swabs from poultry house equipment, feed, poultry by-products (neck skin), commercial flock (laying hens), breeding poultry (hens), broilers, turkeys, day-old chicks (meconium), swabs from walls, equipment, and incubation trays in the incubator, eggshells from suffocated chicks in the incubator, market eggs, poultry carcasses, egg powder, egg melange, egg mass for processing, swabs from refrigerators and freezers, poultry prior to slaughter (2 weeks before shipment to the slaughterhouse), slaughterhouses, semi-finished products, poultry meat, poultry slaughter by-products (category 1 and 2 by-products), etc, which can significantly reduce the prevalence of microbial pathogens associated with poultry production.

To understand the compliance of the Salmonella Programme with European requirements and the effectiveness of surveillance, we conducted an analysis of the results for the five-year period of the National Programmes of Italy, the Czech Republic and Ukraine. The choice of countries was influenced by the latest results of the EFSA summary report on the NCP. Thus, Italy has the highest percentage of positive samples in broiler flocks in the EU, which is 28.8%, and the lowest rates of registered salmonellosis cases in humans, 4.5 per 100,000 population. In the Czech Republic, on the contrary, the positivity in broilers was 1.6% and 64.2 cases of salmonellosis were registered per 100,000 population (EFSA and ECDC, 2025). The results of the analysis are presented in Table 2.

Table 2: Comparison of the number of isolated serovars for the period from 2020 to 2024 by NCP in Ukraine, Italy and Czech Republic.

Countries	2020	2021	2022	2023	2024	Total
Ukraine	44 (0.02%)	15 (0.008%)	27 (0.02%)	10 (0.006%)	20 (0.01%)	116 (0.013%)
Italy	5424 (13.89%)	8548 (21.1%)	7948 (21.4%)	9691 (25.47%)	8749 (25.1%)	40360 (21.3%)
Czech Republic	116 (1.87%)	121 (1.9%)	101 (1.63%)	72 (1.17%)	100 (1.6%)	510 (1.64%)

Summarized according to EFSA and ECDC reports (2020–2024).

A comparison of the numbers of reported serovars between these countries during 2020–2024 revealed significant differences in the distribution of identified serovars ($\chi^2 = 122.52$, df = 8, $P < 0.0001$). Italy consistently reported substantially higher numbers of serovars than both Ukraine and the Czech Republic throughout the study period. In contrast, Ukraine demonstrated the lowest number of identified serovars in all years analyzed.

These differences may reflect variations in the scale and effectiveness of National surveillance Programs, laboratory diagnostic capacity, implementation of serotyping methods, and the intensity of poultry production. Conversely, the relatively low number of serovars identified in Ukraine may indicate underrepresentation of circulating serovars due to limitations in surveillance coverage, reduced sampling intensity, or restricted access to advanced serotyping techniques.

During this five-year period, 12 serovars were isolated in Ukraine for NCP. Comparison with the 20 most frequently reported serovars in the European Union showed that seven serovars (*Salmonella* Enteritidis, *Salmonella* Infantis, *Salmonella* Give, *Salmonella* Anatum, *Salmonella* Typhimurium, *Salmonella* Agona and *Salmonella* Livingstone) were common to both datasets, representing 35% of the EU top-20 serovars. However, five serovars detected in Ukraine (*Salmonella* Isangi, *Salmonella* Kambole, *Salmonella* Djugu, *Salmonella* Kisii and *Salmonella* Portland) were not included among the most prevalent serovars reported in the European Union.

Despite this overlap, the serovar distribution differed considerably between Ukraine and the EU. *Salmonella* Enteritidis remained the predominant serovar in Ukraine (30.2%), whereas *Salmonella* Infantis was the leading serovar reported by EU National Control Programmes. Furthermore, several serovars that are frequently detected in the European Union, including *Salmonella* Kentucky, *Salmonella* Mbandaka, *Salmonella* Newport and *Salmonella* Senftenberg, were not identified within the Ukrainian Program. These findings suggest that although the Ukrainian National Control Program captures the major epidemiologically important *Salmonella* serovars circulating in Europe, it also reflects country-specific features of serovar circulation and indicates differences in the epidemiological structure of *Salmonella* populations between Ukraine and EU Member States.

With the growing global demand for poultry meat and egg products, ensuring safe and hygienic poultry management is critically important. In the current era of *Salmonella* resistance to many antimicrobial agents, greater emphasis should be placed on a multi-vector strategy that reduces the bacterial load of *Salmonella* in poultry and ultimately prevents contamination of carcasses at processing plants. Currently, there are numerous options that promise to reduce this pathogen levels in poultry farming. Ongoing monitoring studies should also be conducted to ensure the safety of all available new control strategies (Shaji *et al*., 2023). Although the number of biological samples tested for salmonellosis in Ukraine has decreased somewhat due to military operations, the system remains quite effective. In recent years, we have observed a decrease in the number of isolated cultures at all stages of production.

The Salmonella Control Program in Ukraine is a government veterinary and public health Program designed to control salmonellosis (primarily in poultry and poultry products). Its main goal is to reduce the spread of bacteria in the poultry industry and make food safer. The Program has improved food safety in Ukraine, as it provided for continuous monitoring of *Salmonella* spp. at all stages of production (poultry breeding, rearing, housing, production, and distribution). The implementation of its provisions has helped reduce the risk of human infection through poultry meat and eggs. The reduction in the incidence of salmonellosis in poultry in Ukraine was achieved through veterinary measures that reduced the number of affected farms and the level of infection in poultry. These measures included laboratory testing of flocks, vaccination, feed control, and the implementation of sanitary rules on farms. This Program was developed in accordance with EU requirements and international veterinary standards, thereby enabling the export of eggs and poultry meat and expanding international trade in poultry products. The alignment of Ukraine's veterinary legislation with the EU was achieved by incorporating EU regulations on the control of zoonoses. Thus, this Program has enabled the control and reduction of salmonellosis in poultry in Ukraine and brought veterinary standards closer to those of the EU.

Our analysis shows that the number of tested poultry under the Program was significantly higher, as a large number of samples were collected depending on the size of the flock. For example, for flocks of 200–300 birds, approximately 200 samples had to be collected for testing. In the provisions of the 2016 Instructions, the sampling system became more rational and risk-based, so the number of samples was reduced and some individual tests were replaced with pooled samples (swabs, droppings, group samples). The number of tested poultry was reduced in the Instructions, but control remained effective thanks to group samples and modern monitoring methods. Thus, the number of investigated samples was reduced to 20–30, and group samples began to be used on a large scale. Thanks to these standards, the number of tests decreased by nearly 10 times, but the effectiveness of control was maintained (Korniienko *et al.*, 2025). Our studies also showed a significant decrease in the isolation of *Salmonella* cultures from various biological materials (no more than 44 after 2019). However, in the years prior to the implementation of the Instruction provisions, 2.5–3 times more strains of the pathogen were isolated. The peak years for the isolation of various cultures were 2010 (118), 2013 (142), 2014 (102), and 2018 (120 cultures).

The results indicate that, in fact, the salmonellosis Program in Ukraine has evolved from a centralized Soviet system to a modern European-style model with an emphasis on epidemiological monitoring, control in poultry farming, and laboratory diagnostics. Despite the challenging conditions of recent years, the system remains functional and aligned with EU standards (Podavalenko *et al.*, 2021; Shchur *et al.*, 2025).

CONCLUSION

Studies conducted in various regions of Ukraine under the National Program for the Control of Salmonellosis in Poultry for the period 2010–2025 were analyzed. An analysis of the results of these studies within the framework of the Program provided insight into the true extent of the persistence of *Salmonella* spp. in Ukrainian poultry farms. It was found that broilers and broiler meat products are one of the main sources of these pathogens and pose significant risks to public health. Therefore, the National Program for the Control of Salmonellosis in Poultry should be regularly reviewed to ensure meat quality, which will strengthen consumer protection. Systematic results of statistical analysis indicate that over the 16-year period, the rate of detection of positive samples did not show a uniform linear trend. Consequently, the measures taken within the National Program allowed to maintain the incidence at a stable level with sporadic occurrence. This study has certain limitations related to the serotyping of *Salmonella* spp. isolates, which affects the prevalence assessment, and the determination of antimicrobial susceptibility, which would improve knowledge and strategies for preventing the emergence of antibiotic-resistant serovars of *Salmonella* spp.

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NOVELTY STATEMENT

For the first time in Ukraine, a comprehensive national-level analysis of the implementation results of the National Poultry Salmonellosis Control Program was conducted over a 16-year period (2010–2025). During this period, 2 773 989 samples were tested (94.6% of the planned number), with 941 *Salmonella* isolates detected across different stages of the poultry production chain, corresponding to a detection rate of 0.03% among the tested samples. A total of 44 different serovars were identified, of which *Salmonella* Enteritidis accounted for 30.8%, *Salmonella* Eimsbuettel for 11.1%, *Salmonella* Infantis for 8.3%, and *Salmonella* Typhimurium for 3.4%, indicating the predominance of specific serovars against a background of considerable serovar diversity. For the first time, the temporal and geographical heterogeneity of *Salmonella* spp. circulation within the national control system was characterized, revealing pronounced regional differences in the detection rates of positive samples. The results also enabled the identification of similarities and differences in the *Salmonella* serovar spectrum in Ukraine compared with national control programs in EU countries, providing a scientific basis for further improvement of the poultry salmonellosis surveillance system in Ukraine.

AUTHOR'S CONTRIBUTION

All authors contributed equally to thework.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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