

Prevalence & Serotype of Salmonella in Retail Foods in Southeast Asia: Review Article

Arafatulloh Andana Septiandi^{1*}, Manik Retno Wahyunitisari², Rebekah Juniati Setiabudi³

¹Microbiology Study Interest, Master Program of Basic Medical Science, Faculty of Medicine, Airlangga University, Surabaya, East Java, Indonesia

²Department of Medical Laboratory Technology, Health Polytechnic Ministry of Health Surabaya, East Java, Indonesia

^{1,3}Department of Clinical Microbiology, Faculty of Medicine, Airlangga University, Surabaya, East Java, Indonesia

^{2,3}Postgraduate School of Airlangga University, Surabaya, East Java, Indonesia

Corresponding Author:

Manik Retno Wahyunitisari, Department of Medical Microbiology and Parasitology, Faculty of Medicine, Airlangga University, Surabaya, Indonesia.

Email: manik-r-w@fk.unair.ac.id

ABSTRACT

Foodborne diseases, particularly those caused by non-typhoidal *Salmonella enterica*, remain a major public health problem in Southeast Asia. The high prevalence of *Salmonella* in retail foods reflects weaknesses in the food supply chain, hygiene practices, and weak surveillance systems. Understanding the distribution of prevalence, dominant serotypes, and antimicrobial resistance patterns is essential to support food safety interventions in this region. This review article synthesizes various studies reporting the prevalence, serotype distribution, and antimicrobial resistance patterns of *Salmonella* in retail foods in Southeast Asia. Data sources include animal products (pork, chicken, beef, seafood) and plant products (fresh vegetables) sold in traditional markets, supermarkets, and other distribution chains. Research results were compiled to identify regional patterns, main risk factors, and their implications for food safety. The review results show that the highest prevalence of *Salmonella* is found in animal products, particularly pork (up to 92.6%) and chicken (>60%), while fresh vegetables have a lower prevalence (20–40%). Dominant serotypes include *S. Enteritidis* and *S. Typhimurium*, with local variations such as *S. Rissen*, *S. Weltevreden*, and *S. Kentucky*. Main risk factors include poor sanitation in traditional markets, weak cold chain distribution, use of contaminated irrigation water, and raw food consumption habits. Antimicrobial resistance patterns show high resistance to older antibiotics (ampicillin, tetracycline, streptomycin, sulfamethoxazole/trimethoprim), with a trend of emerging resistance to fluoroquinolones and third-generation cephalosporins. These findings confirm the need to strengthen food safety systems in traditional markets and the informal sector, enhance serotype and resistance surveillance, control antibiotic use in livestock, and foster cross-country cooperation to prevent the spread of *Salmonella* in the Southeast Asian region.

KEYWORDS: *Salmonella*, Prevalence, Serotype, Retail Food, Southeast Asia, Food Safety

How to Cite: Arafatulloh Andana Septiandi, Manik Retno Wahyunitisari, Rebekah Juniati Setiabudi. (2025) Prevalence & Serotype of *Salmonella* in Retail Foods in Southeast Asia: Review Article, *Vascular and Endovascular Review*, Vol.8, No.2, 255-262.

INTRODUCTION

Foodborne diseases remain a global public health problem, especially in developing countries with food supply chain systems that are not fully standardized. It is estimated that foodborne diarrheal diseases cause more than 230,000 deaths annually, with non-typhoidal *Salmonella enterica* among the top four pathogens causing diarrhea, accounting for approximately 59,000 deaths globally [1].

Salmonella is a Gram-negative bacterium of the Enterobacteriaceae family consisting of more than 2,600 serovars based on O, H, and K antigens. These serovars are divided into typhoidal strains that only infect humans, and non-typhoidal (NTS) strains that can infect both humans and animals [2,3]. Contamination can occur through various routes, including consumption of contaminated fresh meat, vegetables, and seafood, use of polluted water, and poor hygiene practices in markets and farms [4–6].

In the Southeast Asian region, salmonellosis cases are reported to be quite high. For example, research in Cambodia showed the prevalence of *Salmonella* spp. in food samples reached 48.4%, with the highest contamination rates in meat (71%) and seafood (64%), while leafy vegetables reached 33% [7]. The dominant serogroups found were B and C, which are also reported as the main causes of salmonellosis in various countries [7,8].

This high prevalence is closely related to the food market system in Southeast Asia, which is still largely informal. Poor sanitation practices, such as storing food directly on the floor, washing vegetables with surface water, and using unhygienic storage containers, increase the risk of cross-contamination [9,10]. Therefore, a review-based study is crucial to analyze the distribution of *Salmonella* prevalence and serotypes in various retail foods in Southeast Asia, while providing recommendations for improving food safety.

PREVALENCE OF SALMONELLA IN RETAIL FOODS IN SOUTHEAST ASIA

Various studies show that Salmonella is the most dominant bacterial contaminant in retail foods in Southeast Asia, especially fresh meat. Studies in Laos and Thailand show that animal-based foods, particularly pork, beef, and chicken, are susceptible to Salmonella contamination, indicating weaknesses in the supply chain and hygiene practices in traditional markets [11,12]. Besides the high prevalence, molecular studies found similarities in Salmonella enterica serotypes between isolates from humans, livestock, and slaughterhouse workers, indicating cross-host transmission and reinforcing the zoonotic nature of this pathogen [13]. Further findings from genomic analysis indicate the presence of identical strains found in Laos, Thailand, and China, suggesting that Salmonella spread occurs not only locally but also across borders [14]. This situation is reinforced by evidence that Salmonella is a leading cause of diarrhea cases in Laos, especially among vulnerable groups like children [16]. High prevalence especially in countries with traditional markets and lack of adequate sanitation/storage regulations:

Table 1. Comparison of Salmonella Prevalence in Food, Animals, and Environment in Southeast Asia

Country / Region	Product / Sample	Salmonella Prevalence	Reference
Cambodia (Phnom Penh)	Meat & Green Leafy Vegetables	~ 71% Meat; ~ 33% Meat & Green Leafy Vegetables	Huoy et al. (2024)[15]
Thailand (Bangkok & Sentral)	Pork & Chicken Meat	~ 82% Pork; ~ 62% Chicken Meat	Niyomdech et al. (2016)[16]
Vietnam (Ho Chi Minh City)	Shrimp & Vegetable	~ 75% Shrimp; ~ 17,5% Vegetable	Yen et al. (2020)[17]
Malaysia	Retail fish seafood	~ 59,9% Retail fish seafood	Odeyemi et al. (2023)[18]
Laos (Pakse, Champasak)	Pork, beef, buffalo meat	80–93% depending on meat type	Boonmar et al. (2013)[19]
Vietnam (Delta Mekong)	Fresh Vegetables	~30–40%	Nguyen et al. (2021)[20]
Singapore	Humans, Food, Livestock, Environment	Food & Animals ~20–25%, Humans ~15%	Aung et al. (2020) [21]
Laos	Vegetables	~25–35%	Meunsene et al. (2022)[22]
Cambodia (52 traditional markets + 6 supermarkets, 25 provinces)	Chicken meat, pork, chicken & pork cutting boards	42,1% (224/532) total; chicken meat 42,6%; pork 45,1%; chicken cutting board 41,9%; pork cutting board 30,6%	Rortana et al. (2021)[23]
Thailand-Cambodia border provinces (Sa Kaeo, Banteay Meanchey)	Broiler chicken & pork (slaughterhouse, market)	in Thailand-Cambodia: pork carcass market 56.3% in Sa Kaeo; 71.1% in Banteay Meanchey; chicken carcass market; ~65.7%-82.8% depending on region	Trongjit et al. (2017)[24]
Cambodia (5 provinces, small-medium scale farms)	Feces / cloacal & rectal swabs from pigs and poultry	6,58% overall, 6,96% in pigs, 6,30% in poultry	Chea et al. (2025)[25]
Laos (Vientiane & NongThai), Champasack Province	Meat (chicken, pork, beef, buffalo)	Prevalence in Laos: very high; pork ≈ 92.6%, beef ± 80-82% depending on type, chicken & other meats >50-70% depending on market	Thompson et al. (2024)[26]
Laos (Champasack Province)	Meat (pork, beef, buffalo)	Pork 92.6%; Beef 82.4%; Buffalo meat 80.0%	Boonmar et al. (2007)[12]
Laos (Vientiane, retail markets)	Meat (pork, beef, chicken)	Pork 72.7%; Beef 60.3%; Chicken 55.6%	Meunsene et al. (2021)[11]

The prevalence of Salmonella in retail foods in Southeast Asia shows significant differences between countries and product types. In general, animal products, especially pork, chicken, and seafood, show much higher contamination levels compared to fresh vegetables, which have relatively low prevalence. In some countries, like Laos and Thailand, pork has the highest risk, followed by chicken, while in Vietnam and Malaysia, seafood products like shrimp and fish show high prevalence. Traditional market conditions and distribution practices play an important role in contamination levels; for example, the use of unhygienic cutting boards and post-slaughter handling increase the risk of cross-contamination. Conversely, live animals on farms have low prevalence, confirming that most contamination occurs during processing and food distribution. This pattern emphasizes that interventions targeting market sanitation, supply chains, and meat and seafood handling practices are crucial steps to reduce the risk of Salmonella infection for consumers in this region.

RISK FACTORS FOR CONTAMINATION IN SOUTHEAST ASIA

Risk factors for food contamination in Southeast Asia can be analyzed through two main aspects: differences in distribution channels (traditional markets, supermarkets, and online stores) and the influence of tropical climate and food distribution chains. In terms of market type, research shows that traditional markets have a higher risk of contamination compared to supermarkets and online stores. This is associated with poor cleanliness, unmaintained sanitation, and a high likelihood of cross-contamination due to limited cooling facilities [27]. A study in Huzhou, China, found that the majority of *Salmonella* isolates came from samples collected in traditional markets (70 cases), far higher than supermarkets (10 cases) and online stores (9 cases) [28].

Research in Phnom Penh, Cambodia, found that the prevalence of *Salmonella* spp. in meat (71%), seafood (64%), and vegetables (33%) from traditional markets was much higher compared to supermarkets and organic stores (46%)⁷. This is mainly related to poor sanitation conditions, use of storage containers without cleaning, mixing of animal and plant products, and exposure to unhygienic environments¹¹. Conversely, supermarkets and online stores generally have more controlled supply chains with cold storage and better hygiene standards, resulting in lower contamination risk [29,30].

The tropical climate in Southeast Asia with average temperatures of 21–35°C, reaching 40°C in the dry season, supports the growth of bacterial pathogens including *Salmonella* [31]. Studies show that the prevalence of vegetable contamination is higher in the dry season (56.5%) compared to the rainy season (15.4%) in Cambodia [9]. This condition is exacerbated by long and informal food distribution chains, for example vegetables stored directly on the ground, transported by motorbike or trailer for 1–2 days without adequate cooling, thus increasing the opportunity for bacterial growth [32].

Data shows that the detection rate of *Salmonella* increases significantly in the second to fourth quarters, when environmental temperatures are higher (16–35°C), compared to the first quarter with lower temperatures [33]. This is relevant to the Southeast Asian context, where warm temperatures year-round can shorten the shelf life of fresh food and increase contamination risk if the cold chain is not consistently maintained. Additionally, ready-to-eat foods (such as cold processed meats or traditional cold dishes) are highly vulnerable, especially if stored long-term at room temperature [34].

At the production level, the use of unhygienic irrigation water is a major factor in the spread of *Salmonella* and other pathogens on leafy vegetables. A study in Cambodia found that farmers often use contaminated pond or canal water to wash harvests, triggering cross-contamination from the start [35]. Similar conditions are reported in Malaysia, where *Salmonella* prevalence is high on vegetables and poultry due to minimal agricultural sanitation practices [36]. The presence of animal waste around fields and the use of unprocessed organic fertilizer also add to the risk, as shown in research on retail poultry in Phnom Penh which showed high contamination rates [37].

At the transportation stage, weak implementation of the cold chain is a major issue. Fresh products are transported by motorbike or open trucks without refrigeration, allowing bacteria to multiply in tropical temperatures. This is consistent with findings⁴⁰ showing *Salmonella* can survive in fish and shrimp products under suboptimal storage conditions. Furthermore, distribution journeys taking days further increase the possibility of contamination, especially for vegetables.

Risk factors are also frequently found in traditional and retail markets. Animal products and vegetables are often placed close together or even use the same containers, triggering cross-contamination. A study [10] in informal Cambodian markets found high *Salmonella* prevalence on food contact surfaces, indicating poor market cleanliness. Inadequate market sanitation conditions, including drainage, floor cleanliness, and the presence of flies, are also important factors, as reported in Bangkok markets [38]. The absence of cooling facilities in Thai retail markets contributes to high levels of antimicrobial resistance in *Salmonella* isolates [29].

From the consumer side, inadequate washing practices of fresh products also increase the risk. Many vendors only rinse once or not at all, so bacterial contamination persists until consumption⁴. The habit of consuming fresh vegetables or raw seafood in Southeast Asia also increases direct exposure, as emphasized by Amagliani et al. (2012) [39] in a review on seafood safety. At the systemic level, weak regulations and the dominance of the informal sector make oversight of the food supply chain difficult. Rortana et al. (2021) [23] noted the presence of *Salmonella* and *Staphylococcus aureus* in chicken and pork from Cambodian traditional markets, indicating low effectiveness of regulations and oversight. Additionally, high antimicrobial resistance in *Salmonella* isolates from Malaysia [36] and Thailand [29] further exacerbates the public health threat.

Overall, risk factors for food contamination in Southeast Asia are multidimensional, encompassing aspects of the agricultural environment, unhygienic supply chains, traditional markets with low sanitation, raw food consumption habits, and weak regulations. Cross-country findings from Cambodia, Thailand, and Malaysia show similar risk patterns, so effective interventions must be comprehensive and strengthen the food safety system in the informal sector.

DOMINANT SALMONELLA SEROTYPES

The dominant *Salmonella* serotypes globally and regionally show a relatively consistent pattern, with *Salmonella enterica* serovar Enteritidis and Typhimurium being the main causes of salmonellosis in humans and isolates from animal food products. These two serovars are closely associated with poultry, eggs, and meat, thus often detected in clinical cases and food surveillance [40]. In Southeast Asia, although Enteritidis and Typhimurium remain dominant, several other serovars such as *S. Infantis*, *S. Kentucky*, and *S. Rissen* are also frequently reported, especially in samples of pork, poultry, and fresh vegetables sold in traditional markets [41]. This serotype variation shows a close link between animal reservoirs, food distribution chains, and local market hygiene

conditions.

The dominance of certain serovars is influenced by both biological and anthropogenic factors. For example, *S. Enteritidis* has an efficient colonization ability in laying hens, making eggs a primary transmission route. The clonal spread of this serovar is also reinforced by centralized poultry production systems and global trade of day-old chicks, contributing to the homogenization of serotype patterns in various countries [42]. On the other hand, *S. Typhimurium* often emerges as a multidrug-resistant serovar, driven by antibiotic use in intensive farming that provides selective pressure and promotes the expansion of resistant clones [43]. This shows that serovar dominance is not only a matter of natural ecology but also a result of food production and consumption practices.

Control efforts for salmonellosis in various countries heavily depend on understanding the dynamics of dominant serotypes. Serotype data obtained from animal, food, and clinical case surveillance can be used to design poultry vaccination programs, strengthen sanitation standards in the food distribution chain, and suppress antibiotic use that potentially accelerates the emergence of resistance.

Table 2: Distribution of Salmonella Serotypes in Poultry, Pigs, Cattle, and Fishery Products in Southeast Asia

Food Type	Dominant Serovar	Serogroup	Reference
Chicken & Eggs	Enteritidis, Stanley, Typhimurium	Enteritidis (D), Typhimurium (B)	Aung et al. (2020)[21]
Pork & Pork Products	Typhimurium, Derby, Rissen	Typhimurium (B), Rissen (C1)	Aung et al. (2020); Trongjit et al. (2017)[21,24]
Beef/buffalo meat	NTS variation, no specific dominant	Typhimurium (B)– Enteritidis (D)	Thompson et al. (2024)[26]
Seafood (shrimp, fish)	Weltevreden, Enteritidis, NTS B–D	Rissen (C1), Enteritidis (D)	Aung et al. (2020); Yen et al. (2020)[17,21]
Humans (ASEAN)	Enteritidis, Typhimurium, Stanley, Weltevreden	Enteritidis (D), Typhimurium (B), Rissen (C1)	Aung et al. (2020); Thompson et al. (2024)[21,26]
Pork	Rissen, Monophasic Typhimurium 4,5,12:i:-, Derby	Rissen (B), Typhimurium monophasic (B), Derby (B)	Nadimpalli et al. (2019)[44]
Fish	Saintpaul, Newport, Bovismorbificans, Virchow	Saintpaul (C1), Newport (C2–C3), Bovismorbificans (C2), Virchow (C1)	
Chicken	Rissen	Rissen (B)	

The distribution of Salmonella serotypes in Southeast Asia shows that serogroups B, C, and D are the most frequently found in various food sources. In Vietnam, non-typhoidal Salmonella (NTS) isolates from retail shrimp were mostly in serogroups B, C, and D [17]. Similar results are reported in Thailand and Cambodia, where *S. Typhimurium* (serogroup B) and *S. Rissen* (serogroup C1) dominate in pigs, broiler chickens, and meat products [24]. In the Laos-Thailand border, *S. Typhimurium* was again identified as the dominant serotype in both animal and human samples, showing the consistent importance of serogroup B in the transmission chain [21].

From the perspective of human health, serovar *S. Enteritidis* (serogroup D) is the leading cause of human salmonellosis in Singapore, contributing over 20% of isolates, followed by *S. Stanley*, *S. Weltevreden*, *S. Typhimurium* [21]. In Laos, research found genetic similarity between isolates from pigs and humans, confirming the potential for zoonotic transmission through contaminated food [26]. Thus, serovars Enteritidis and Typhimurium can be said to be most closely associated with human salmonellosis cases in this region.

Serotype distribution patterns also differ by food type. In poultry and eggs, *S. Enteritidis* is the dominant serovar with prevalence reaching 28.5% in chickens and 61.5% in eggs[21]. In pork and its products, *S. Typhimurium* (35.2%) and *S. Derby* (18.8%) dominate, while in Thailand-Cambodia, *S. Rissen* is also reported with high prevalence [21,24]. In beef and buffalo meat, Salmonella contamination is found, but no specific serovar is highly dominant[28]. In contrast, in seafood (fish, shrimp, shellfish) [21], *S. Weltevreden* is the most frequently isolated serovar, for example 19.2% of isolates from seafood in Singapore, while in Vietnam, NTS from retail shrimp are also dominated by serogroups B–D [17].

Overall, this data shows that *S. Enteritidis* and *S. Typhimurium* play important roles in human salmonellosis cases, while *S. Weltevreden* is more characteristically associated with fishery products. Serogroups B, C, and D can be considered dominant groups that need attention in food surveillance and public health efforts in Southeast Asia.

GENERAL PATTERNS OF ANTIMICROBIAL RESISTANCE IN SALMONELLA ISOLATES

Patterns of antimicrobial resistance in Salmonella isolates consistently show a dominant trend of high resistance to "older" antibiotic groups such as ampicillin, tetracycline, streptomycin, and sulfamethoxazole/trimethoprim. This pattern has long been documented and persists to this day, reflecting the impact of historical use of these antibiotics in both clinical practice and the livestock and food sectors. Several studies show that multidrug-resistant variants with the classic ACSSuT pattern (ampicillin, chloramphenicol,

streptomycin, sulfonamides, tetracycline) are still frequently found in clinically important serovars, such as *Salmonella* Typhimurium and *Salmonella* Enteritidis. This condition indicates that the use of older antibiotics as empirical therapy is increasingly unreliable in various regions [45,46].

In contrast to this pattern, susceptibility to more modern antibiotics, such as fluoroquinolones and third-generation cephalosporins, shows more complex dynamics. For fluoroquinolones, full resistance to ciprofloxacin is still relatively low in some reports, but a trend of decreasing susceptibility is increasingly reported, usually preceded by resistance to nalidixic acid, which is an early indicator of mutations in the DNA gyrase and topoisomerase target genes. This phenomenon of reduced susceptibility has serious clinical implications as it can reduce the effectiveness of first-line therapy for invasive salmonellosis [47]. Meanwhile, for third-generation cephalosporins such as ceftriaxone and cefotaxime, resistance prevalence is still lower than for older antibiotics, but isolates carrying genes encoding extended-spectrum β -lactamases (ESBL), especially the bla_{CTX-M} group, have emerged. Surveillance reports from various countries show an increasing trend of isolates resistant to third-generation cephalosporins, so the effectiveness of standard β -lactam-based therapy is also potentially threatened [48].

This phenomenon is generally triggered by a combination of chromosomal mutations, efflux pump mechanisms, changes in membrane permeability, and horizontal gene transfer through plasmids and integrons that facilitate the spread of resistance determinants between strains and even species. Thus, although resistance to older antibiotics reflects the trace of historical selection, the trend of resistance to modern antibiotics shows a new threat that must be closely monitored. Continuous surveillance, control of antibiotic use in clinical and non-clinical sectors, and evidence-based control strategies become very important to prevent the widening spread of resistance that could reduce therapeutic options in the future [49].

Table 3. Results of Antimicrobial Susceptibility Testing of *Salmonella* Isolates from Various Food Commodities in Thailand, Vietnam, and Cambodia

Country / Sample	n	Antibiotic	Sensitive (%)	Intermediate (%)	Resistant (%)
Thailand – Pork[24]	25	Ampicillin	17.9	5.4	76.7
		Tetracycline	31.3	3.0	65.7
		Nalidixic acid	59.8	13.2	27.0
		Ciprofloxacin	82.6	10.2	7.2
		Chloramphenicol	68.7	8.9	22.4
		Gentamicin	86.4	6.0	7.6
Vietnam – Shrimp[18]	19	Ampicillin	15.0	12.1	72.9
		Tetracycline	29.5	9.0	61.5
		Nalidixic acid	54.2	9.6	36.2
		Ciprofloxacin	76.8	10.4	12.8
		Cefotaxime	82.3	8.2	9.5
		Gentamicin	86.4	6.0	7.6
Cambodia–Thailand border[50]	42	Ampicillin	22.5	8.0	69.5
		Sulfamethoxazole	31.4	7.2	61.4
		Tetracycline	34.2	6.1	59.7
		Ciprofloxacin	85.7	7.0	7.3
		Cefotaxime	78.1	9.0	12.9
		Gentamicin	86.4	6.0	7.6
Laos – Pork & Patients[50]	253	Ampicillin	9.0	-	91.0
		Tetracycline	7.5	-	92.5
		Nalidixic acid	89.1	-	10.9
		Ciprofloxacin	99.5	-	0.5
		Gentamicin	77.6	-	22.4
		Chloramphenicol	70.0*	-	30.0*
Cambodia – Fish	10/60 (17%)	Ampicillin, cephalosporins (CTX, FEP), tetracycline, TMP-SMX, chloramphenicol, fluoroquinolones	–	–	100
		Azithromycin	20	–	80
		Colistin	80	–	20
		Carbapenems (IPM, MEM, ETP)	100	–	–
Cambodia – Pork[44]	15/60 (25%)	Ampicillin, cephalosporins (CTX, FEP), tetracycline, TMP-SMX, chloramphenicol, fluoroquinolones	–	–	100
		Azithromycin	73	–	27
		Colistin	93	–	7
		Carbapenems (IPM, MEM, ETP)	100	–	–
Cambodia – Chicken[44]	1/30 (3%)	Ampicillin, cephalosporins (CTX, FEP), tetracycline, TMP-SMX, chloramphenicol,	–	–	100

	fluoroquinolones			
	Azithromycin	100	–	–
	Colistin	100	–	–
	Carbapenems (IPM, MEM, ETP)	100	–	–

The results of antimicrobial susceptibility testing of *Salmonella* isolates from various food commodities in Thailand, Vietnam, Cambodia, and Laos show a consistent resistance pattern to antibiotics that have long been used in the livestock sector, such as ampicillin and tetracycline. These findings align with reports [51] identifying high prevalence of resistance to both antibiotics in the pig production chain in southern Thailand. Ogasawara et al. (2008) [52] also confirmed that *Salmonella* isolates from animals and food products show similar patterns, with a tendency for broad resistance to "traditional" antibiotics.

Conversely, antibiotics from the fluoroquinolone and aminoglycoside groups generally maintain their effectiveness, although sporadic resistance indicators emerge. Supadej et al. (2024) [53] showed that ciprofloxacin remains effective against most *Salmonella* isolates, although resistance cases were found in specific samples, indicating potential future threats. Similarly, research in the Mekong Delta, Vietnam [54] showed gentamicin is still quite potent against animal and food isolates, so it can be considered as an alternative therapy.

Differing resistance patterns between countries also reflect variations in antibiotic use policies, oversight levels, and biosecurity practices within the food chain. This fact confirms that antimicrobial resistance in Southeast Asia is not only influenced by biological factors but is also closely related to socio-economic dynamics and animal health policies. The existence of multidrug-resistant *Salmonella* isolates adds to the challenge, as it potentially reduces the effectiveness of standard salmonellosis therapy in humans.

CONCLUSION

The prevalence of *Salmonella* in retail foods in Southeast Asia remains high, especially in animal products such as pork, chicken, and seafood, while in fresh vegetables the prevalence is relatively lower. This condition is influenced by the dominance of traditional markets with poor sanitation practices, weak implementation of cold chains, and the use of unhygienic water and storage containers that trigger cross-contamination along the food distribution chain. Serotype distribution shows that *Salmonella* Enteritidis and *Salmonella* Typhimurium remain the dominant serovars closely associated with human salmonellosis cases, while *Salmonella* Weltevreden is frequently found in fishery products. Antimicrobial resistance patterns show high resistance to long-used antibiotics, such as ampicillin and tetracycline, and a trend of decreasing susceptibility to fluoroquinolones and third-generation cephalosporins that potentially reduces therapy effectiveness. These findings confirm that salmonellosis in Southeast Asia is a multidimensional issues requiring strengthened market sanitation, implementation of supply chain-based food safety standards, control of antibiotic use in the livestock sector, and integrated surveillance to monitor the dynamics of serotypes and antimicrobial resistance.

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