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RESEARCH ARTICLE

Integrating One Health strategy to mitigate antibiotic resistance in *Salmonella*: insights from poultry isolates in Southeast Asia

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ABSTRACT

Salmonellosis is a major bacterial foodborne infection worldwide. Inappropriate usage of drugs, especially antimicrobial usage in animal production, is one of the leading issues of antimicrobial resistance (AMR) in Southeast Asia (SEA) countries, especially in treating *Salmonella* cases. The AMR issue is critical as antimicrobials have been used indiscriminately for the prevention of diseases and it is threatening food safety, especially in poultry production, which carries the largest group of *Salmonella* as a natural host. In SEA, the range of resistance for penicillin is 13.3% to 89.5% and for tetracycline, it is 25% to 95.7%. Therefore, to develop prompt interventions, the public health authorities must first be aware and have a complete understanding of *Salmonella* AMR in poultry settings. This review focuses on insight into the epidemiology of *Salmonella* and information on the current AMR in poultry chickens, as well as the impact on society. It emphasises the need for collaborative efforts to implement the One Health approach to mitigate the AMR of *Salmonella* in SEA.

Keywords: *Salmonella*; poultry; Southeast Asia; prevalence; AMR.

INTRODUCTION

Salmonella is the main pathogen of foodborne infection that causes diseases in humans (Angulo & Mølbak, 2005). It is commonly found in poultry samples, particularly in Southeast Asia (SEA), where poultry farming is common (Nguyen *et al*., 2016). Salmonellosis is prevalent in SEA poultry samples and has been a major concern as it is correlated with *Salmonella*-contaminated food products made from poultry sources (Popa & Papa, 2021). The poultry industry is a significant contributor to the economy of SEA, with poultry farming being a common practice in the region (Mottet & Tempio, 2017).

However, poultry samples with a high prevalence of *Salmonella* from SEA have become a concerning issue for public health officials and the food industry (Niyomdecha *et al*., 2016). Many small-scale poultry farmers lack proper sanitation and hygiene practices, which allow for the spread of *Salmonella* in their flocks (Abdi *et al*., 2017). Antibiotics are commonly used in poultry farming in SEA to prevent and treat bacterial infections (Malik *et al*., 2023). However, the overuse of antibiotics can lead to the development of antimicrobial resistance (AMR) in *Salmonella*, which makes it difficult to treat the infections in humans (Dugassa & Shukuri, 2017).

It is projected that by 2050, approximately 10 million lives annually and a total of USD100 trillion in economic output are in jeopardy due to the increasing prevalence of drug-resistant infections (O'Neill, 2016). In 2019, it was estimated that bacterial antimicrobial resistance was associated with 4.95 million deaths at the global level and 1.02 million deaths in SEA, East Asia, and Oceania based on a systematic analysis of the global burden of bacterial AMR in 2019 (Murray *et al*., 2022). *Salmonella* is one of the 33 bacterial pathogens that were associated with 13.6% of all global deaths in 2019 and 56.2% of all infection-related deaths in 2019 (Ikuta *et al*., 2022).

The AMR profile of *Salmonella* in poultry isolates from SEA is a major concern for public health. Several studies have reported the presence of multi-drug resistant *Salmonella* spp. in poultry isolates from SEA (Akbar & Anal, 2013; Ghurnee *et al*., 2021; Patra *et al*., 2021). The One Health methods and successful intervention can result in a reduction of *Salmonella* cases (Silva *et al*., 2014). This review assesses the antibiotic resistance of non-typhoidal *Salmonella* in poultry isolates from SEA, investigates its effects on human health, and discusses how a One Health approach can mitigate these challenges.

Characteristics of non-typhoidal *Salmonella*

Salmonella is a Gram-negative bacteria genus in the family of *Enterobacteriaceae* (Ohl & Miller, 2001). Two species that comprise the genus *Salmonella* are *Salmonella bongori* and *Salmonella enterica. S. enterica subsp. enterica*, *S. enterica subsp. salamae*, *S. enterica subsp. houtenae, S. enterica subsp. arizonae,* and *S. enterica subsp. indica* are the six subspecies that belong to *S. enterica* (Grimont & Weill, 2007).

According to the Kauffmann-White scheme, more than 2,160 serovars of *Salmonella* strains are serologically categorised based on their specific antigenic reaction (Guibourdenche *et al*., 2010). Non-typhoidal *Salmonella* (NTS) refers to a group of bacterial pathogens belonging to the *Salmonella* genus that primarily cause

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gastroenteritis in humans. Unlike typhoidal *Salmonella*, including the notorious *Salmonella* Typhi, which causes typhoid fever, NTS strains encompass a diverse range of serotypes, such as *Salmonella* Typhimurium and *Salmonella* Enteritidis, which cause approximately 60% of all *Salmonella* outbreaks globally (Hendriksen *et al*., 2011). NTS infections are usually self-limiting diarrheal illnesses with low-case fatality. The condition usually becomes severe in immunocompromised persons, the elderly, and children (Kirk *et al*., 2015).

Epidemiology of non-typhoidal *Salmonella* of poultry isolates in Southeast Asia

Southeast Asia, a region containing eleven developing countries with 656 million population, is home to about 9% of the global population (Qin *et al*., 2023) and is expected to have 25% of the global population in 2100 (Maja & Ayano, 2021). Meat and eggs are known as vital protein sources across different countries in SEA. Based on the Food and Agriculture Organization (FAO, 2023a), as depicted in Figure 1, the production of chicken meat increased from 3 million tonnes in 1994 to 10.74 million tonnes in 2022. The production of chicken meat and years show a direct linear relationship (Figure 1).

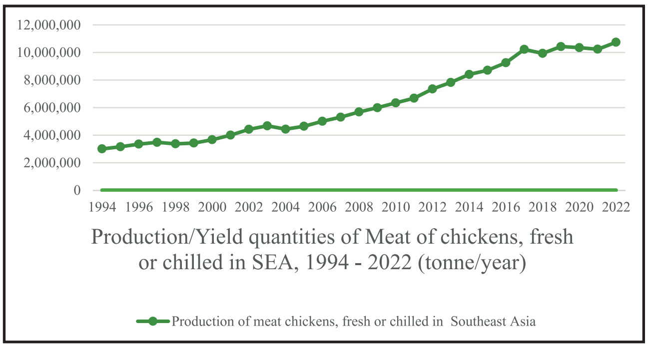

Figure 1. Production trend of meat chickens, fresh or chilled in SEA. Source: FAO (2023a).

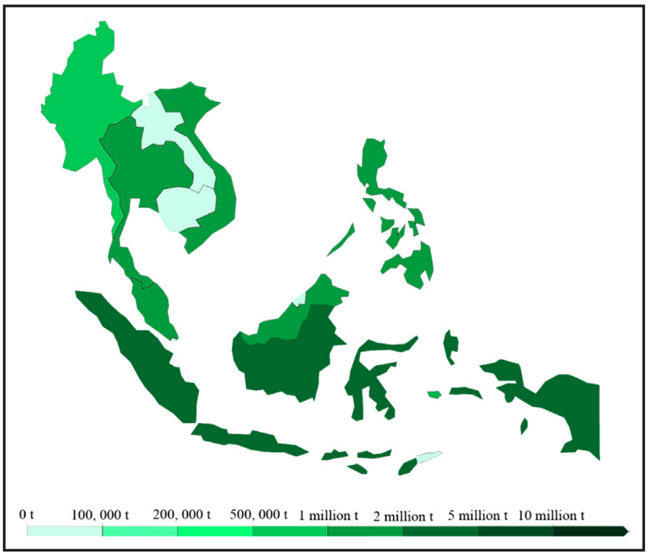

Figure 2. Chicken meat production in 2022 in SEA measured in tonnes per year. Source: FAO (2023b).

Based on data from the FAO (2023b) as depicted in Figure 2, the country with the highest chicken meat production in SEA in 2022 was Indonesia (4.04 million tonnes/year), followed by Thailand (1.83 million tonnes/year), Malaysia (1.6 million tonnes/year), Philippines (1.43 million tonnes/year), and Vietnam (1.07 million tonnes/year). Based on data from the Organization for Economic Co-operation and Development, Malaysia (29 kg/capita) has the highest poultry meat consumption per capita in 2023 in SEA countries (OECD & FAO, 2024). Thus, ensuring the microbial safety of poultry meat products is crucial, given the rising consumption and production in this sector. WHO (2015) estimated that in 2010, foodborne non-typhoidal *Salmonella enterica* was responsible for over 78 million illnesses and 59,153 deaths. Typhoid fever was estimated to cause around 148 thousand deaths, and 14.3 million cases of typhoid and paratyphoid fevers happened in 2017 (Wang *et al*., 2016; Stanaway *et al*., 2019). Thus, the reliance on antimicrobials to tackle *Salmonella* contamination also keeps escalating; however, antibiotic-resistant bacteria develop due to the misuse of antibiotics. Inheritance of antibiotic-resistant genes can occur through vertical transmission and the genes are disseminated among bacteria via horizontal gene transfer facilitated by mobile genetic elements (Von Wintersdorff *et al*., 2016). Due to the progressing antibiotic resistance patterns, poultry fields turn into significant reservoirs for antibiotic-resistant bacteria as the high prevalence of resistance genes, manure, farms' drainage system, and waste are of significant concern since they can transfer resistant genes to the surrounding environment and thus directly impacting poultry health (Xu *et al*., 2022).

Various studies have revealed a heterogeneous distribution of *Salmonella* serovars. Research by Trongjit *et al*. (2017) described the prevalence of *Salmonella* in meat products, broiler chickens, and pigs in Thailand-Cambodia border provinces. Although most of the research described *Salmonella* contamination on pig carcasses, about 90 broiler chicken and 84 broiler chicken carcasses retrieved from slaughterhouses and 105 broiler carcasses in the market were reported to be contaminated. This study also reported that about 345 isolates comprised of 47 serotypes were detected, where *S.* Typhimurium was determined the most predominant serovar (29%). Countries with wider borders showed illegal slaughtering and trafficking of animals to be the main cause of *Salmonella* contamination (Trongjit *et al*., 2017). As the article in this study pointed out, awareness of *Salmonella* contamination has just started to rise in large countries like Indonesia. It was the first to establish a report on NTS strains isolated with AMR in chickens from Indonesia (Takaichi *et al*., 2022). The research reported that *S.* Schwarzengrund was the main serovar detected among the samples, and it is known to be a widespread strain among humans and animals from Asia. Besides, the research also showed that this strain becomes less susceptible to several antibiotics, such as tetracycline and ampicillin, which are first-line antibiotics commonly used in the treatment of animals. In Laos, a surveillance study on *Salmonella* contamination was carried out from 2018 to 2021. Inthavong *et al*. (2022) reported that *Salmonella* isolation rates were substantially lower in local birds but higher in layer and broiler chickens. It was speculated that infection was caused by the cross-contamination of slaughtering process activities and poor backyard animal husbandry practices in most residential settings. The chicken samples showed resistance to azithromycin, ampicillin, cefotaxime, ceftazidime, chloramphenicol, nalidixic acid, and ciprofloxacin.

In Malaysia, it was revealed that *S.* Enteritidis is the predominant serovar (Thung *et al*., 2016; Jajere *et al*., 2020; Zakaria *et al*., 2022), which is causing the spread of foodborne illness. It can infect chickens by colonising their reproduction organs, affecting

Table 1. Antimicrobial resistance of different poultry *Salmonella* isolates in SEA countries

Author (Year)	Country	Antimicrobial resistance (%)													
		Amp	**Sxt**	**Kn**	**Te**	**NA**	**St**	**C**	**AMC**	**Ci**	**G**	**V**	**N**	**P**	**E**
Trongjit *et al*. (2017)	Thailand–Cambodia border provinces	72.4	71	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Takaichi *et al*. (2022)	Indonesia	47.8	NA	30.4	95.7	100	NA	NA	4.3	8.7	21.7	NA	NA	NA	NA
Moe *et al*. (2017)	Myanmar	47.1	70.3	NA	54.3	NA	49.3	29.7	17.4	9.4	8	NA	0.7	NA	NA
Inthavong *et al*. (2022)	Laos	NA	NA	NA	NA	19	NA	NA	NA	67	NA	NA	NA	NA	NA
Thung *et al*. (2016)	Malaysia	72.73	NA	NA	NA	9.09	9.09	NA	NA	27.27	NA	100	NA	100	100
Chuah *et al*. (2018)		89.5	58.8	NA	85.1	45.6	58.8	75.4	NA	3.5	6.1	NA	NA	NA	NA
Abatcha *et al*. (2018)		35.3	35.3	17.6	44.4	35.3	70.6	35.3	0	0	5.9	NA	NA	NA	NA
Jajere *et al*. (2020)		17.6	NA	NA	35.3	14.7	35.3	11.8	2	0	0	NA	NA	NA	NA
Zakaria *et al*. (2020)		14.8	NA	NA	46.8	NA	2.1	NA	NA	NA	2.1	NA	NA	NA	NA
Zakaria *et al*. (2022)		13.3	2.2	NA	44.4	NA	NA	2.2	NA	NA	2.2	NA	NA	NA	NA
Niyomdecha *et al*· (2016)	Thailand	60	NA	NA	NA	76	NA	48	NA	NA	NA	NA	NA	NA	NA
Meunsene *et al*· (2021)		20.93	16.28	NA	25.6	6.97	9.3	4.65	4.65	NA	NA	NA	0	NA	NA
Kongsanan *et al*. (2021)		41	14	NA	25	74	51	12	0	8	NA	NA	4	NA	NA
Ta *et al*. (2014)	Vietnam	41.6	34.6	3.1	59.1	NA	NA	37.4	0	3.5	5.7	NA	NA	NA	NA
Trung *et al*. (2017)		26.2	26.8	NA	39.6	NA	NA	28	12.8	1.8	1.8	NA	NA	NA	NA

Amp: ampicillin, Sxt: sulfamethoxazole, Kn: kanamycin, Te: tetracycline, NA: nalidixic acid, St: streptomycin, C: chloramphenicol, AMC: amoxicillin/clavulanic acid, Ci: ciprofloxacin, G: Gentamycin, V: Vancomycin, N: Norfloxacin, P: penicillin, E: erythromycin

Table 2. Data of *Salmonella* serovars, number of samples and methods for antibiotic sensitivity test

Author (Year)	Country	*Salmonella* serovar	Number of samples	Methods for antimicrobial Sensitivity Test (AST)
Trongjit *et al*. (2017)	Thailand–Cambodia border provinces	*S.* Typhimurium (29%)	345	Agar dilution
Takaichi *et al*. (2022)	Indonesia	*S.* Schwarzengrund (46%)	50	Broth Microdilution
Moe *et al*. (2017)	Myanmar	*S.* Albany (38%), *S.* Kentucky (11%), *S.* Braenderup (10%), *S.* Indiana (8%)	141	Disc diffusion
Inthavong *et al*. (2022)	Laos	*Salmonella enterica*	4,797	Sensititre™ Minimum Inhibitory Concentration EUVSEC plates
Thung *et al*. (2016)	Malaysia	*S.* Enteritidis (20.8%), *S.* Typhimurium (6.7%)	120	Disc diffusion
Chuah *et al*. (2018)		*S.* Albany (29.1%), *S.* Brancaster (19.2%), *S.* Corvallis (14.3%)	182	Disc diffusion
Abatcha *et al*. (2018)		*S.* Corvallis (20%), *S.* Brancaster (17.86%), *S.* Corvallis (14.3%), *S.* Albany (20%)	35	Disc diffusion
Jajere *et al*. (2020)		*S.* Weltevreden (20.6%), *S.* Agona (17.6%), *S.* Typhimurium (17.6%), *S.* Albany (8.8%), *S.* Enteritidis (8.8%)	1,042	Disc diffusion
Zakaria *et al*. (2020)		*S.* Enteritidis	47	Disc diffusion
Zakaria *et al*. (2022)		*S.* Enteritidis	45	Disc diffusion
Niyomdecha *et al*. (2016)	Thailand	*S.* Panama (15%), *S.* Schwarzengrund (12%), *S.* Rissen, *S.* Anatum, *S.* Stanley (11% each), *S.* Albany (9%), *S.* Indiana (8%)	40	Disc diffusion
Meunsene *et al*. (2021)		*S.* London (26.99%), *S.* Corvallis (13.79%), *S.* Rissen (6.47%), *S.* Weltevreden (6.03%)	133	Disc diffusion
Kongsanan *et al*. (2021)		*S.* Enteritidis (21.57%), *S.* Typhimurium (23.53%), *S.* Schwarzengrund (17.65%),	51	Disc diffusion
Ta *et al*. (2014)	Vietnam	*S.* Albany (34.1%), *S.* Agona(15.5%), *S.* Dabou (8.8%)	457	Disc diffusion
Trung *et al*. (2017)		*S.* Weltevreden (10.3%), *S.* Enteritidis (4.4%)	204	Disc diffusion

both layers and eggs, leading to its frequent occurrence in poultry products as bacteria can infiltrate the egg prior to the formation of the eggshell within the oviduct (De Reu *et al*., 2006). According to El-Aziz (2013), an inappropriate de-feathering process causes a significant frequency of *Salmonella* in chicken flesh in comparison to samples from the liver, heart, and gizzards. This ultimately leads to the spread of *Salmonella* in chicken meat. A study of poultry farms on the East Coast of Peninsular Malaysia implied that variables related to farm contact, such as sample source, location, sewage system, and water source, are significantly associated with the presence of *Salmonella* isolates (Osman *et al*., 2021). Thus, *Salmonella*-contaminated farms significantly elevate the risk of human exposure, underscoring the need for enhanced monitoring and surveillance systems that focus on environmental sanitation and behavioural interventions (Osman *et al*., 2021). *Salmonella* contamination can also be found in poultry processing in Malaysia. A study conducted at wet markets and small-scale processing plants in Penang and Perlis found positive *Salmonella* in 91.67% (11/12) of de-feathering machines, 83.33% (5/6) of drain swabs, and 66.67% (4/6) of apron swabs (Nidaullah *et al*., 2017). In Myanmar, a study found that 97.9% of the Yangon retailed chicken meat was *Salmonella* positive (Moe *et al*., 2017). This high contamination rate can be due to a lack of hygiene practices and conditions at the market stalls. Factors such as the slow turnover rate of chicken meat, improper storage temperatures, and unsterilised utensils can also cause the growth of *Salmonella*-contaminated chicken meat (Yang *et al*., 2011).

From the AMR perspective, *Salmonella* showed high resistance to ampicillin based on Table 1. Past literature from other parts of the world also showed that *Salmonella* isolates from chicken are mostly highly resistant to ampicillin, sulphonamides, nalidixic acid, tetracycline, and streptomycin (Shang *et al*., 2019; EFSA & ECDC, 2021; Wei *et al*., 2021). These findings exhibit multi-drug resistance NTS as it is resistant to at least one class of antimicrobials (Magiorakos *et al*., 2012).

Effects of Non-typhoidal *Salmonella* in Humans

Public health

Salmonella is the second most frequent zoonoses in humans. In 2021, there were 60,050 confirmed cases of human salmonellosis, resulting in a European Union notification rate of 15.7 per 100,000 people, representing a 14.3% increase compared to the rate in 2020 (EFSA & ECDC, 2022). European Food Safety Authority and European Centre for Disease Prevention and Control (2022) report also stated that the predominant serovar was *S.* Enteritidis. In the SEA context, Sia *et al*. (2023) reported that the frequent non-typhoidal serovars in human clinical cases in the Philippines were *S.* Typhimurium and *S.* Enteritidis from 2014 to 2018. The carriers for these serovars were mainly from poultry. The increasing prevalence of antimicrobial-resistant *Salmonella* isolates can limit treatment options and lead to prolonged illness, increased healthcare costs, and potentially higher mortality rates. The recommended medications for Multiple Drug Resistance (MDR) *Salmonella* infections have been quinolones and third-generation cephalosporins (Karon *et al*., 2007). MDR refers to an organism that has acquired resistance to three or more antimicrobial classes (Magiorakos *et al*., 2012). However, a recent retrospective cross-sectional study of human patients in Chiang Mai, Thailand, by Buddhasiri *et al*. (2023) discovered 21 *S.* Typhimurium isolates out of 120 (17.5%) resistant towards third and second-generation cephalosporins, and 5% (18/120) of *S.* Typhimurium isolates were resistant to cefepime which is a fourth-generation cephalosporin.

Food security

The effects of *Salmonella* can also have a detrimental impact on global food security, especially in SEA countries. In 2021, the Singapore Food Agency reported a recall for Malaysian farm eggs due to the presence of *S.* Enteritidis (SFA, 2021). A recall was also reported in October 2022 for a similar reason but on a different farm in Malaysia (SFA, 2022a). Some of the importers have been instructed to refrain from distributing the affected eggs. This has impacted the food security in Singapore as over 90% of the food supply is imported since only about 1% of its land is dedicated to agriculture, based on Singapore Food Statistics 2021 (SFA, 2022b). This report also stated that 72% of eggs were imported from Malaysia in 2019.

One Health approach for mitigating antimicrobial resistance of *Salmonella* in SEA

Eradicating the AMR of *Salmonella* involves not only a single workforce but also multiple sectors. The ASEAN One Health Joint Plan of Action advocates for enhanced cross-sectoral collaboration among the sectors responsible for animal, human, plant, and environmental health, including food safety, between the ASEAN Fellow States, and its purposes are to progress regional and national capacity and capabilities by setting tangible, quantifiable, and time-bound targets (ASEAN, 2023). Based on the rapid assessment of regulatory measures to combat AMR in the ASEAN region; Singapore, Malaysia, Indonesia, and Thailand are the only SEA countries initiating human and animal AMR surveillance (ASEAN, 2022).

In Singapore, the National Strategic Action Plan (NSAP) on Antimicrobial Resistance was developed by the Ministry of Health (MOH), National Environment Agency (NEA), Agri-Food and Veterinary Authority (AVA), and PUB, Singapore's National Water Agency in November 2017 (Ministry of Health Singapore, 2017). Based on this plan, they listed five fundamental strategies for NSAP surveillance and risk assessment, optimisation of antimicrobial use, research, education, and prevention and control of infection. Before NSAP in Singapore, AMR surveillance was restricted to monitoring drug-resistant *S.* Enteritidis in chicken layer farms. After the implementation, the AVA broadened the scope of AMR surveillance to encompass every single *Salmonella* species as well as indicator *Escherichia coli*, encompassing all terrestrial livestock farms in Singapore. This expanded surveillance involves two quail layer farms, three chicken layer farms, two quail layer farms, three dairy cattle farms, and one dairy goat (Ministry of Health Singapore, 2021). Based on the core strategies of surveillance and risk assessment, Singapore took part in the WHO Global Antimicrobial Resistance Surveillance System (GLASS) in 2019 (Ministry of Health Singapore, 2021). GLASS was initiated by the WHO in 2015 to address existing knowledge gaps and inform strategies across various levels (WHO, 2020). GLASS was designed to gradually integrate data from AMR surveillance in humans, including the monitoring of resistance patterns, the usage of antimicrobial medications, and the presence of AMR in the food chain and environment that have presence of these eight priorities microbes: *Klebsiella pneumoniae, Acinetobacter baumannii, Escherichia coli, Staphylococcus aureus, Streptococcus pneumoniae, Shigella* species, *Neisseria gonorrhoeae* and *Salmonella* species.

Table 3. ASEAN countries' national action plans and participation in GLASS-AMR

Countries	National Action Plans	Reference Document	Participation of GLASS-AMR Source: WHO (2022)
Brunei	Brunei Darussalam: Antimicrobial Resistance National Action Plan 2019-2023	Ministry of Health Brunei (2019)	2019
Cambodia	Multi Sectoral Action Plan on Antimicrobial Resistance in Cambodia 2019–2023	Royal Government of Cambodia (2019)	2016
Thailand	Thailand's National Strategic Plan on AMR 2017–2021	Ministry of Public Health & Ministry of Agriculture and Cooperatives (2017)	2017
Laos	Strategic plan on the fight against antibiotic-resistant microorganisms of the Lao PDR 2019–2023	Ministry of Health & Ministry of Agriculture and Forestry of Lao PDR (2019)	2018
Malaysia	Malaysian second action plan on antimicrobial resistance (MyAP-AMR) 2022-2026	Ministry of Health Malaysia (2024)	2018
Indonesia	Second national action plan on antimicrobial resistance Indonesia 2020-2024	Coordinating Minister for Human Development and Cultural Affairs of The Republic of Indonesia (2022)	2019
Singapore	National Strategic Action Plan	Ministry of Health Singapore (2017)	2019
Vietnam	National Action Plan on Combatting Drug Resistance 2013–2020	Ministry of Health Vietnam (2013)	2021
Myanmar	National Action Plan for Containment of Antimicrobial Resistance: Myanmar 2017–2022	Ministry of Health and Sports Myanmar (2017)	2018
Timor-Leste	National Action Plan for Antimicrobial Resistance Containment (NAP-AMR) 2022-2026	Ministry of Health & Ministry of Agriculture and Fishery of Timor-Leste (2022)	2019
Philippines	The Philippine National Action Plan on Antimicrobial Resistance 2019-2023	Inter-Agency Committee on Antimicrobial Resistance (2019)	2016

GLASS-AMR participation in ASEAN countries increased throughout the year, which is consistent with the information obtained from the Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report 2022, as many nations across the world joined the initiatives (WHO, 2022).

Based on the latest National Action Plan from Indonesia and Malaysia, both countries have reported surveillance on poultry products and domestic chickens, which are vital in assessing the status of AMR in respected countries. From the first National Action Plan of Malaysia, which is the Malaysian Action Plan on Antimicrobial Resistance (MyAP-AMR) 2017-2021, the authority has discovered high *Salmonella* contamination in raw chicken meat retrieved from processing plants and these isolates exhibited a diverse spectrum of antibiotic resistance, including MDR phenotypes. This has highlighted the importance of public health in providing education for consumers on appropriate food hygiene and emphasising the need for continuous surveillance of foodborne pathogens throughout the food production chain, especially in regard to AMR variants (Ministry of Health Malaysia, 2017). Educating communities on AMR involves effective communication, learning, and training, one of which was outlined as the strategy for the action plan to mitigate antimicrobial resistance in the 11 ASEAN member countries.

Local communities also play a major role in mitigating AMR at the national level. In Thailand, the AMR Dialogues Public Engagement Project was organised, which brought together AMR stakeholders and the public through engagement events. These events aid researchers, policymakers, and community members to collaborate in finding locally relevant, context-specific, and realistic solutions to combat AMR (Poomchaichote *et al*., 2022). Data generated by community-based projects can be effectively utilised to influence and reform policy and practice at both local and national levels, thereby facilitating significant long-term change (Mitchell *et al*., 2019; Tsekleves *et al*., 2019). Private sectors and poultry associations contribute towards proper antimicrobial stewardship to reduce AMR. Twenty-six organisations have endorsed or adopted antimicrobial stewardship principles designed to reduce the necessity of antimicrobial use at the farm level, which includes organisations such as Thai Broiler Processing Exporters Association (TBA), Vietnam Poultry Association (VIPA), Hoa Phat, Animal Husbandry Association of Vietnam (AHAV) and many others (Cargill, 2024). This project was supported by the United States Agency for International Development (USAID), which was conducted by Cargill and includes Ausvet, Heifer International, and the International Poultry Council (USAID, 2021).

Implementations of the One Health strategy present significant challenges, especially in low- and middle-income countries (LMICs) in SEA. The nature of AMR itself is very complex, and it is deemed as a 'super-wicked' problem, further exacerbated by the numerous interdependent biological and social drivers of AMR, making it a global-scale issue (Littmann *et al*., 2020). The drivers of AMR, particularly in LMICs, are frequently linked to behaviours at both individual and community levels, which include health-seeking behaviours, water, sanitation, and hygiene (WASH) practices within households and communities, and the agricultural methods employed in food animal production (Ghiga *et al*., 2023). Prophylactic use of antibiotics in poultry farms is common in SEA countries and is often indistinguishable from treatment, as seen in Vietnam and Indonesia (Carrique-Mas *et al*., 2015; Van Cuong *et al*., 2021; Hibbard *et al*., 2023). In many instances, this appeared to result from both limited access to resources like diagnostic testing and a lack of shared understanding of the appropriate use of antibiotics (Hibbard *et al*., 2023).

CONCLUSION

Ensuring food safety in the poultry industry is paramount to protect public health and prevent the spread of *Salmonella*. The usage of antimicrobials plays a critical role in controlling *Salmonella* infections and reducing the risk of contamination in poultry products. However, their misuse or overuse can lead to negative implications such as antimicrobial resistance and deterioration of human health. This study can provide baseline data for improving hygiene practices in poultry food handling to reduce *Salmonella* contamination risk. Understanding the One Health approach that interrelates human, animal, and environmental health is crucial for comprehensive *Salmonella* control. Collaborative efforts between human health, veterinary, and environmental sectors can lead to more effective prevention and control strategies. Therefore, it is essential to implement comprehensive strategies, such as promoting responsible antimicrobial use, adopting proper practices in farm management and hygiene, and monitoring antimicrobial residues in poultry products. Additionally, governments, industry stakeholders, and consumers must work together to establish robust regulations, enforce compliance, and promote awareness regarding the responsible use of antimicrobials in the poultry industry. By prioritising food safety and employing appropriate measures, we can ensure the production and consumption of safe poultry products while mitigating the risks of antimicrobial resistance using the One Health approach.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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