Prevalence of *Campylobacter* and Non-typhoidal *Salmonella* in Chicken and Chicken Products in South and Southeast Asia: A Systematic Review and Meta-analysis

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Roll No: 0120/01

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A thesis submitted in the partial fulfillment of the requirements for the degree of Master of Science in Epidemiology

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JUNE 2022

Authorization

I hereby declare that I am the sole author of the thesis submitted in fulfillment of the requirements for the Degree of Master of Science (MS) in Epidemiology in the Department of Medicine and Surgery, Faculty of Veterinary Medicine, Chattogram Veterinary and Animal Sciences University (CVASU). I authorize CVASU to lend this thesis or to reproduce the thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

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This is to certify that we have examined the above Master's thesis and have found that it is complete and satisfactory in all respects, and all revisions required by the thesis examination committee have been made

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Dedication

This Master’s thesis is dedicated to the poultry farmers

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Nurun Nahar Chisty

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List of Abbreviations and Elaborations

Abbreviation	Elaboration
Adj	Adjusted
AF	Afghanistan
Agarose	agarose gel diffusion
B	Biochemical tests
BD	Bangladesh
BE	Boiled egg
BH	Bhutan
Both	Dead and clinically healthy
Br	Breeder
C	Culture
CAM	Cambodia
Car	Carcass
CC	Caecal content
CDC	Centers for Disease Control and Prevention
CH	Clinically healthy
CI	Confidence interval
Cl	Cloacal swab
CM	Cooked meat
Co	Country
Coc	Cockerel
Con	Convenient sampling
Cr	Crop
CS	Cross sectional
D	District
DE	Dead embryo
E	Egg
EB	Exotic broiler
EC	Egg content
EFSA	European Food Safety Authority

Abbreviation	Elaboration
EL	Exotic layer
ES	Egg surface swab
Fa	Farm
FAO	Food and Agricultural Organization
Fea	Feather
FEM	Fixed-Effect Model
Gi	Gizzard
H	Hatchery
HB	Hybrid broiler
HH	Household
Hr	Heart
HS	Health status
I	Indigenous
I^2	Heterogeneity
In	Intestine
IND	India
INDO	Indonesia
K	Kidney
L	Study level
LA	Lao People's Democratic Republic
Laboratoty	Lab
LBM	Live bird market
Li	Liver
Lu	Lungs
M	Mixed
MALDI-TOF	Matrix-assisted laser desorption/ionization-time of flight
MC	Method of confirmation
Mec	Chick meconium
MM	Myanmar
Mo	Mouth

Abbreviation	Elaboration
MP	Multiple province
MV	Maldives
MY	Malaysia
n	Number of studies / number of positive samples
N	Total number of samples/ No
NM	Not mentioned
NP	Nepal
NTS	Non-typhoidal *Salmonella*
O	Ovary
OECD	Organization for Economic Co-operation and Development
Ovi	Oviduct
p	Probability
PAK	Pakistan
PCR or P	Polymerase chain reaction
PFGE	Pulse field gel electrophoresis
PH	Philippines
PM	Processed meat
Po	Pooling
Pr	Probabilistic sampling
prev	Prevalence
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PrP	Proportionate probabilistic
PT	Production type
Pur	Purposive
Q	Quality of study
Re	Restaurant
REM	Random-Effect Model
RIR	Rhode Island Red
RM	Raw meat

Abbreviation	Elaboration
RTE	Ready to eat meat
S	Study site
s.e.	Standard error
SA	Sampling approach
Sam	Sample
SD	Study design
Se	Serotyping
SH	Slaughter house
SIN	Singapore
Sk	Skin
SL	Sri Lanka
SLR	Systematic Literature Review
Son	Sonali
SP	Study period
SP	Single province
Spl	Spleen
SPr	Simple probabilistic
SysPr	Systematic probabilistic
TH	Thailand
TL	Timor-Leste
USA	United States of America
V	Vietnam
WHO	World Health Organization
Y	Yes
Yo	Yolk sac

Abstract

This systematic literature review and meta-analysis took the very first attempt to assess the prevalence of *Campylobacter* and non-typhoidal *Salmonella* in chicken samples and chicken eggs in south and south-east Asia along with the associated risk factors. A computerized literature search was performed targeting publications from 2000 to 2020 on PubMed, ProQuest, Embase, Web of Science and Google Scholar. A total of 60 *Campylobacter* articles and 121 non-typhoidal *Salmonella* articles were selected for this meta-analysis after title, abstract and full-text screening. The overall estimated random effect pool prevalence of *Campylobacter* in chicken in south and south-east Asia at sample unit was 42.4% (95% Confidence Interval: 36.1% to 48.7%) and farm unit was 58.4% (95% CI: 42.4% to 74.4%). On the other hand, overall random-effect non-typhoidal *Salmonella* prevalence in chicken samples was 26.1% (95% CI: 22.5% to 29.8%) and egg samples was 9% (95% CI: 4.7% to 13.3%) in this region. Meta-regression results suggested that both *Campylobacter* [Co-efficient: 23.5 (95% Confidence interval: 9.2 to 37.7); p=0.001] and non-typhoidal *Salmonella* [Co-efficient: 22.5 (95% CI: 13.3 to 31.7); p=<0.001] were most prevalent among samples from Thailand. Samples collected from live bird markets showed the highest prevalence [Co-efficient: 17.6 (95% CI: 3.5 to 31.7); p=0.01] for *Campylobacter* while non-typhoidal *Salmonella* was most prevalent in retail outlets [Co-efficient: 28.1 (95% CI: 11.0 to 45.1]. Non-typhoidal *Salmonella* was detected more in carcass [Co-efficient: 38.4 (95% CI: 22.4 to 54.3), p<0.001] and raw meat [Co-efficient: 17.6 (95% CI: 6.5 to 29.0); p=0.002] samples. Egg shells [Co-efficient: 15 (95% CI: 2.2 to 27.7); p=0.02] significantly contained more non-typhoidal *Salmonella* than egg content. *C. jejuni* [79.9%; 95% CI: 78.2% to 81.4%] and *C. coli* [17.1%; 95% CI: 15.6% to 18.6%] were the predominant *Campylobacter* species. *Salmonella enterica* serovar Enteritidis (30.3%; 95% CI: 27.7% to 33.1%) was the most commonly identified in chicken samples and *Salmonella enterica* serovar Typhimurium (62.5%; 95% CI: 48.5% to 75.1%) was most common in egg samples. Installment of surveillance system, proper training of the workers of live bird markets and retail outlets to maintain hygiene and avoiding raw and undercooked meat and egg is recommended to prevent and control these pathogens.

Keywords: *Campylobacter*, Chicken, Non-typhoidal *Salmonella*, Prevalence, Risk factor.

Chapter-1: Introduction

South and southeast Asia is a region have undergone major changes in poultry production in the last decade and have become global leaders in poultry production, consumption, and exports. This fact is related to an increase in the demand for animal protein, linked to the development of these countries, as well as the increase in population and per capita income, and the position of broiler meat and egg as affordable protein sources (Soriano, 2022). Despite this growth, the sustainability of this industry is challenged by potential public health risks such as poultry borne campylobacteriosis and non-typhoidal salmonellosis in human.

Campylobacter and non-typhoidal *Salmonella* (NTS) are bacterial enteric pathogens associated with food animal reservoirs. They are transmitted to humans predominantly by contaminated food and water. Foodborne zoonoses, including those caused by *Campylobacter* and NTS, are recognized by the World Health Organization (WHO) as important causes of human illness and death worldwide (Havelaar et al., 2015). It is estimated that *Campylobacter* are responsible for > 95 million foodborne illnesses and > 21,000 deaths and NTS for > 78 million foodborne illnesses and > 59,000 deaths globally (Havelaar et al., 2015).

Based on the latest report of Centers for Disease Control and Prevention (CDC, 2023) 30 to 70% of the international travelers get diarrhea and majority of them get it from Asia. Both Campylobacter and NTS are two important pathogens to cause traveler's diarrhea (CDC, 2023). In Southeast Asia, the overall prevalence of *Campylobacter* infections in human is 7.8%. However, such kind of data could not be found for NTS infection in human (Wada and Abdul-Rahman, 2022).

Besides the health aspect, food poisonings also affect the economy due to the costs of hospitalization, work absence, financial losses associated with consumers' concerns of food quality, and the costs of legal proceedings (Zeng et al., 2016). The 2019 World Bank report on the economic burden of the foodborne diseases indicated that the total productivity loss associated with foodborne disease in low- and middle-income countries was estimated at US$ 95.2 billion per year, and the annual cost of treating foodborne illnesses is estimated at US$ 15 billion (WHO, 2022). However, there have been not any evaluation of the status and economic burden of *Campylobacter* and NTS in human in south and southeast Asian countries (WHO, 2012).

These data indicate that *Campylobacter* and *NTS* infections in human are endemic in south and southeast Asian countries. Furthermore, the reported cases of *Campylobacter* and NTS infections are likely to represent only the tip of the iceberg owing to underreporting (Wagenaar et al., 2013).

It was determined that nearly 30% of all campylobacteriosis cases of infection were caused by the consumption of chicken meat, including 50–80% of isolated *Campylobacter spp.* strains of chicken origin (Josefsen et al., 2015; Hald et al., 2016;). The main source of pathogenic *Salmonella* causing food poisoning in humans is chicken meat and eggs (Saravanan et al., 2015; Hurtado et al., 2017). According to an old systematic review in Japan, 71% of retail chicken samples were positive for *Campylobacter* (Saito et al., 2005). The prevalence of NTS in raw chicken meat was 26.4% in China according to a recent systematic review and meta-analysis (Sun et al., 2021). But currently there is no systematic review and meta-analysis on the overall prevalence of *Campylobacter* and NTS in chicken from the countries of south and southeast Asia.

Chicken meat production is central to livelihoods in the south and southeast Asian countries, with meat from poultry being a key protein source in subsistence communities (OECD/FAO, 2016). In many low-resource settings, industrialization, urbanization, and the shift from planned to market economies are leading to rapid changes in the way that food is produced, distributed, sold, and consumed (Carron et al., 2018; Grace, 2017). Such market-driven changes within agricultural production towards wider distribution networks, centralized processing, larger-scale and more intensive systems, have been linked to the emergence of zoonotic diseases (Jones et al., 2013) and the potential impact on chicken originated food products within low- and middle-income countries is increasingly recognized (WHO, 2017).

Overall, campylobacteriosis and salmonellosis are still most important infectious diseases that are likely to challenge global health in the years to come. Data on the presence of *Campylobacter* and *NTS* in the chicken meat production pathway in South and South-east Asia are limited and are not currently available in aggregate form.

Therefore, this study aims to perform a systematic review on *Campylobacter* and NTS in chickens and chicken eggs to inform further studies, food safety policy and identify scientific data gaps through the following objectives:

i) Assess the prevalence of *Campylobacter* and NTS in chickens and chicken eggs in south and south-east Asia

ii) Describe factors associated with the presence of *Campylobacter* and NTS in chickens and chicken eggs in south and south-east Asia

1.1. Outcomes of the study:

i. This systematic literature review and meta-analysis provides quality evidence on the prevalence of *Campylobacter* species and NTS serovars in chicken meat and egg.

ii. The study identifies the associated factors with the presence of *Campylobacter* and NTS in chicken such as both the pathogens are significantly most prevalent in Thailand. Live bird market is a significant source of *Campylobacter* whereas retail meat outlet, carcass, raw meat and egg surface are significant sources of NTS.

Chapter-2: Review of Literature

The overall goal of this chapter was to review past relevant research findings related to the Master's project **"Prevalence of *Campylobacter* and Non-typhoidal *Salmonella* in Chicken and Chicken Products in South and Southeast Asia: A Systematic Review and Meta-analysis"** to identify the gaps and justify the present research. Published literatures were obtained by searching online sources like PubMed, Web of Science, Embase, ProQuest and Google Scholar. This chapter is arranged in a series of sections including a review of literatures on etiology, clinical signs of campylobacteriosis and salmonellosis in human and chicken, chicken as a reservoir of *Campylobacter* and *non-typhoidal Salmonella* (NTS), risk factors for the transmission of Campylobacter and NTS in human and global burden of these two pathogens in human and chicken.

2.1. Campylobacteriosis and Salmonellosis

Campylobacteriosis and Salmonellosis are bacterial foodborne zoonoses caused by *Campylobacter* species (family: Campylobacteriaceae) such as *Campylobacter jejuni* subspecies *jejuni* (95% of cases of zoonoses) and *Campylobacter coli* (five percent of the zoonoses) and non-typhoidal *Salmonella* (family: Enterobacteriaceae) such as *Salmonella enterica* serovars specially *S.* Enteritidis and *S.* Typhimurium (Krutkiewicz, 2008; Fàbrega and Vila, 2013; Li et al., 2013 and Modi et al., 2015).

People with *Campylobacter* infection usually have diarrhea (often bloody), fever, and stomach cramps. Nausea and vomiting may accompany the diarrhea. These symptoms usually start 2 to 5 days after the person ingests *Campylobacter* and last about one week. Sometimes *Campylobacter* infections cause complications, such as irritable bowel syndrome, temporary paralysis, and arthritis (CDC, 2023).

Typical signs of infection with non-typhoid serovars of *Salmonella spp.* are stomach ache and diarrhea, but other possible symptoms include: vomiting, nausea, fever, shivers, muscular or articular pain, cramps and loss of appetite (Hald, 2013; Antillón et al., 2017; Hung et al., 2017).

Though both the infections are self-limiting and less severe, sometimes they can be fatal. In people with weakened immune systems, such as those with a blood disorder, with acute immune deficiency syndrome, or receiving chemotherapy, *Campylobacter* occasionally spreads to the bloodstream and causes a life-threatening infection (CDC, 2023).

In case of NTS, fatalities are most often observed in children below the age of 4 years who are infected with serotypes Enteritidis or Typhimurium (De Jong et al., 2012; Evangelopoulou et al., 2015). Bacteremia develops in 5–10% of people infected with NTS and may lead to focal infections, such as meningitis, endocarditis, arthritis, and osteitis (Chen et al., 2013; Hald, 2013).

Non-typhoidal *Salmonella* and *Campylobacter* are the most frequently isolated foodborne pathogens, and are predominantly found in chicken and eggs (CDC, 2023). Campylobacteriosis as a clinical disease is not common in chickens. Some strains of *C. jejuni* have been reported to cause enteritis and death in newly hatched chicks (MSD veterinary manual, 2022).

Salmonella causes pullorum disease and fowl typhoid in chickens. Pullorum disease is caused by *Salmonella enterica* Pullorum and is characterized by very high mortality in young chickens. Affected birds huddle near the heat source, are anorectic, weak, depressed, and have white fecal material pasted to the vent area. In addition, the birds may have respiratory disease, blindness, or swollen joints. Whereas, the causal agent of fowl typhoid is *Salmonella enterica* Gallinarum. Clinical signs are similar to pullorum disease but there is a much greater tendency to spread among growing or mature flocks. Mortality in young birds is similar to that seen in *S. enterica* Pullorum infection but may be higher in older birds (MSD Veterinary Manual, 2022).

2.2. Chicken as a reservoir of *Campylobacter* and non-typhoidal *Salmonella*

Campylobacter spp. colonize in the mucosa of the caecum and cloaca crypts of infected chickens, but may also be present in the spleen, blood, and liver (Lin, 2009). In newborn chickens before 3rd week of life, no presence of *Campylobacter* is found, which may be associated with the presence of antibodies from the maternal organism, the addition of antibiotics in feed, and development of the intestine and its microbiota (Lin, 2009; Saint-Cyr et al., 2016). After that time, if a single bird in the flock contracts the infection, it will be transmitted to the rest within days (approximately 3 days) through pathogen-containing faces, or by rodents, water, insects, or farm workers (Lin, 2009; Whiley et al., 2013; Saint-Cyr et al., 2016).

The intestines of chickens are asymptomatically colonized by *Salmonella spp.* as a result of a horizontal or vertical transmission of bacteria at the stage of primary production (Dunkley et al., 2009; Antunes et al., 2016). The horizontal route of infection includes contaminated feed and water, as well as bedding, soil, air, and farm personnel (Singh et al., 2013; Nidaullah et al., 2017). The vertical route includes direct infection of offspring by its flock (Sivaramalingam et al., 2013; Nidaullah et al., 2017). *Salmonella spp.* may be present in as much as 65% of individuals in a flock. Besides, the unrestricted dissemination and colonization of intestines, *Salmonella spp.* may also be transferred to the liver, spleen, and ovaries (Dunkley et al., 2009) of bacterial colonization of the hen's genital system. Moreover, eggs may also be also infected through the environment, and pathogenic bacteria may be present not only on the surface of an egg shell, but also penetrate the inside (Whiley et al., 2015).

2.3: Risk factors for the transmission of *Campylobacter* and non-typhoidal *Salmonella* in human

Campylobacter and non-typhoidal *Salmonella* are primarily transmitted through the consumption of contaminated chicken meat, including raw or undercooked chicken (WHO, 2018; WHO, 2020). The organisms can also be transmitted through cross-contamination in the kitchen, from cutting boards and utensils that have come into contact with contaminated chicken meat (WHO, 2018; WHO, 2020). Additionally, there are reports of asymptomatic shedding of *Salmonella* in the gut of healthy chicken, which could be a source of human infection (Monack, 2012). Asymptomatic shedding of *Salmonella* in the gut of hens can also be a source of egg contamination (Monack, 2012). This could be a potential source of human infection if eggs are not properly cooked. The zoonotic transmission of *Campylobacter a*nd *Salmonella enterica* can occur through direct contact with chickens and environmental exposure (WHO, 2018; WHO, 2020).

2.4. Global burden of *Campylobacter* and Non-typhoidal *Salmonella* in human

The incidence of infections caused by *Campylobacter* and NTS in human has been constantly growing. These two pathogens are one of the four global key causes of diarrhoea (WHO, 2018) and the most common foodborne bacterial zoonosis in the world (Galate and Bangde, 2015; Kashoma et al., 2015).

It is estimated that *Campylobacter* causes 500 million infections in the world every year (Kashoma et al., 2015). On the other hand, annual number of cases of non-typhoidal salmonellosis in the world, ranging between 200 million to over 1 billion (Whiley et al., 2015; Bierschenk et al., 2017).

In the European Union, the number of cases of Campylobacteriosis rose to 246,307 million in 2017 (EFSA, 2018). The number of confirmed NTS cases was 94,530 in 2016 (EFSA, 2017). It is estimated that in the United States of America (USA), Campylobacteriosis affects a million people a year, and in Canada, there are over 200 thousand cases registered each year (Ravel et al., 2016; Rosenberg Goldstein et al., 2016). Over a million cases of non-typhoidal salmonellosis in a year are estimated in the USA. Nearly 20,000 require hospitalization and there are approximately 400 cases of death resulting from infection with NTS (Jiang et al., 2015; Anderson et al., 2016). However, death rates are not available for human campylobacteriosis.

In southeast Asia, the overall prevalence of *Campylobacter* infections in human is 7.8%. (Wada and Abdul-Rahman, 2022). In addition, based on the 2007-2011 reports of the International Society of Travel Medicine and the Centers for Disease Control and Prevention (CDC), the majority of diseases (32.6%) were reported from international travelers returning from Asia, with diarrhea being the most common infection (34%) where *Campylobacter* and NTS were the frequent causes (Leder et al., 2013).

2.5. Global burden of *Campylobacter* and Non-typhoidal *Salmonella* in chickens

The prevalence of *Campylobacter* in chicken was found 40.2% in gut samples and 21.3% in meat and organs in a systematic review conducted in Africa where *C. jejuni* and *C. coli* were more detected among the species (Thomas et al., 2020). Non-typhoidal *salmonella* was present at 13.4% gut samples and 13.2% meat and organ samples where *S.* Typhimurium and *S.* Enteritidis were most dominant (Thomas et al., 2020).

Another systematic review conducted in middle east reported that 39% of the chicken and chicken products were contaminated with *Campylobacter* (*C. jejuni*: 25% and *C. coli*:13%) and 31% with NTS (*S.* Typhimurium: 7% and *S.* Enteritidis: 9%) (Abukhattab et al., 2022).

Presence of campylobacter in chickens is also common in south and south-east Asian countries. Though no systematic reviews were found, several studies reported 9% to 80% prevalence in raw meat in this region where *C. jejuni* and *C. coli* were the most isolated species (Premarathne et al., 2017). The situation is similar for NTS, with moderate to high rates of prevalence (15% to 28%) reported in raw chicken meat from south and south-east Asian countries (Nguyen et al., 2012; Ta et al., 2014; Khan et al., 2019).

Therefore, *Campylobacter* and NTS are recognized as the main hazards that lead to foodborne infections around the globe and chicken is the main source of these pathogens. So, lots of surveillance, research findings and systematic reviews are available for developed countries in human and chicken (Silva et al., 2011; Al-Sakkaf, 2012). Though there is one meta-analysis on human burden of Campylobacteriosis in southeast Asia (Wada and Abdul-Rahman, 2022) and some surveillances available for developing countries in the south and south-east Asia, no systematic review and meta-analysis is available till to date for the prevalence of *Campylobacter* and NTS along with the associated factors in chicken.

Aggregation of data regarding these two important pathogens from chicken origin in this area through a systematic literature review and meta-analysis is necessary to plan prevention and control measures as well as identify future research priorities.

Chapter-3: Methodology

We conducted a Systematic Literature Review (SLR) and meta-analysis to assess the prevalence of *Campylobacter* and non-typhoidal *Salmonella* (NTS) in chickens and chicken eggs in south and southeast Asia along with the associated risk factors. This SLR was adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009).

3.1. Search strategy

A computerized literature search was performed from 30 June to 7 July 2020 targeting publications from 2000-2020 listed on PubMed, ProQuest, Embase, Web of Science and Google Scholar. The search used the Boolean search criteria “A AND C AND D” and “B AND C AND D”, as follows:

A. Campylobacter*
B. Salmonel*
C. (Chicken) OR (chickens) OR (broiler) OR (layer) OR (poultry) OR (hen) OR (cock) OR (cocks) OR (cockerel) OR (laying hen*) OR (chick) OR (chicks) OR (Egg*)
D. (South Asia*) OR (Southeast Asia*) OR (Afghanistan*) OR (India*) OR (Pakistan*) OR (Bangladesh*) OR (Sri Lanka*) OR (Nepal*) OR (Bhutan*) OR (Maldives*) OR (Indonesia*) OR (Malaysia*) OR (Singapore*) OR (Philippines*) OR (East Timor*) OR (Brunei*) OR (Cambodia*) OR (Laos*) OR (Lao) OR (Myanmar) OR (Burma*) OR (Thailand*) OR (Vietnam*) OR (Viet Nam)

The “Title”, “Keywords,” and “Abstract” fields were selected for EMBASE, “Title” and “Abstract” for PubMed, “Abstract” for ProQuest, and “Topic” for Web of Science. Mendeley was used to manage citations and remove duplicates. Articles only published in English were allowed in the literature search and the timeline was restricted to January 2000 to May 2020.

For grey literature, reports and unpublished data, hand searching was performed from Google organization websites. A series of some simple search strings (e.g., *Campylobacter* in poultry; Salmonella in poultry) was used to search the first 100 hits of each result in Google Scholar.

3.2. Screening of references

A number of inclusion and exclusion criteria were set to screen the relevant papers.

The inclusion criteria were, a) Articles published between January 2000- May 2020; b) Published research articles (full length or short communication), grey literature, reports and unpublished data; c) Observational studies that should include at least the total number of chickens/chicken meat/eggs/ processed products being tested and the number of positive samples; e) Articles had to describe the identification, or prevalence of *Campylobacter* spp, in chickens organs and/or eggs and/or processed products in south and south-east Asia; f) The diagnostic method for *Campylobacter* spp and *Salmonella spp* had to be at least standard bacteriological culture (ISO 10272-1:2017, ISO 6579-1:2017(en)) and g) Articles had to be published in English .

The exclusion criteria were, a) Articles published before January 2000 and after May 2020; b) Review articles and book chapters; c) Articles that did not describe the prevalence of *Campylobacter* and Non-typhoidal *Salmonella* in chickens/chicken meat/eggs/ processed products d) Articles that had some differences between the results written in the text and the tables or graphs e) Studies that were conducted outside south and south-east Asia; f) Diagnostic method based on only post-mortem or serological test; and g) Articles published in other than English language.

Screening of titles and abstracts and full texts was conducted independently by two reviewers and checked by a third reviewer to remove studies unlikely to contain relevant information. Where exclusion could not be justified by one reviewer based solely on screening of a record's title and abstract, the full text was retrieved to allow both reviewers to reach a consensus.

A structured word form was used to extract data from each selected article. Data were extracted by a first reviewer and then checked for missing data and inaccuracies by a second reviewer. Finally, the extracted data were transferred to a structured Microsoft office Excel-2010 spreadsheet for analysis.

3.3. Statistical analysis

We used two sets of data (*Campylobacter* and non-typhoidal *Salmonella*) for the analysis. Data cleaning, sorting and coding and recoding were done in Microsoft office excel-2010 before exporting to STATA-18 ((Stata Corp, 4905, Lakeway Drive, College Station, Texas 77845, USA) for statistical analysis. At first, we calculated the prevalence for each study by dividing the positive samples with the total number of samples. Then 95% confidence interval (95% CI) was calculated using the following formula: prev +/- 1.96*(√prev(1-prev)/N) (Here, prev= Prevalence; N= Total number of sample). We performed Random-Effect Model (REM) to estimate the overall prevalence with 95% CI and we examined heterogeneity between studies using the I^2 statistic. We used a REM for meta-analysis as this includes consideration of heterogeneity in the effect estimate (Ryan, 2016). A Fixed-Effect Model (FEM) assumes that there is no statistical heterogeneity between studies (i.e., that the estimated effects from each study would all be the same if the studies were large enough); while the REM assumes that the effects estimated within each study are not identical but do follow a specific distribution (Ryan, 2016). We conducted further subgroup analysis and meta-regression to examine the more influential group in the prevalence based on country, sample type and source in the studies. Pooled estimates were not computed for single study subgroups. Meta-regression was only considered for the subgroups having at least ten studies. Funnel-plot analysis was performed in the study to identify the qualitative bias in the publications. If the funnel plots were visually not symmetrical and some of the points fall outside of the funnel, indicated publication bias. To evaluate the small-study effects, we performed a regression-based Egger's test. If the p value was less than 0.05 indicated presence of small study effect.

3.4. Study quality

Studies were given an overall grade one or two (Table 3.1). Quality 1 studies had well described study design and methods. Their sampling approaches and study level were highly ranked, e.g., probabilistic sampling approaches at the multiple provincial or at single provincial level. The diagnostic methods were also highly ranked; culture, followed by biochemical tests and PCR (Polymerase chain reaction) or only PCR. Quality 2 studies contained some weaknesses in their sampling approach (non-probabilistic sampling) and/or diagnostic methods (only culture and biochemical methods).

Table 3.1. Grading of study quality based on study methodology criteria (Dean et al., 2012)

Methodological criteria	Quality 1	Quality 2
Sampling approach		
Probabilistic	√	
Non-probabilistic		√
Not mentioned		√
Study level		
Multiple province	√	
Single province	√	
District		√
Not mentioned		√
Diagnostic methods		
Culture followed by biochemical test and PCR	√	
Culture followed by biochemical tests		√
PCR	√	

Chapter-4: Results

4.1. Selection of *Campylobacter* studies

A flow diagram of the review is shown in Figure 4.1. A total of 394 unique articles were screened for relevance of which 58 relevant articles were selected. Additional 15 references were retrieved from the full-text screening among which, two references were relevant. So, 60 articles were finally selected for this review (Figure 4.1).

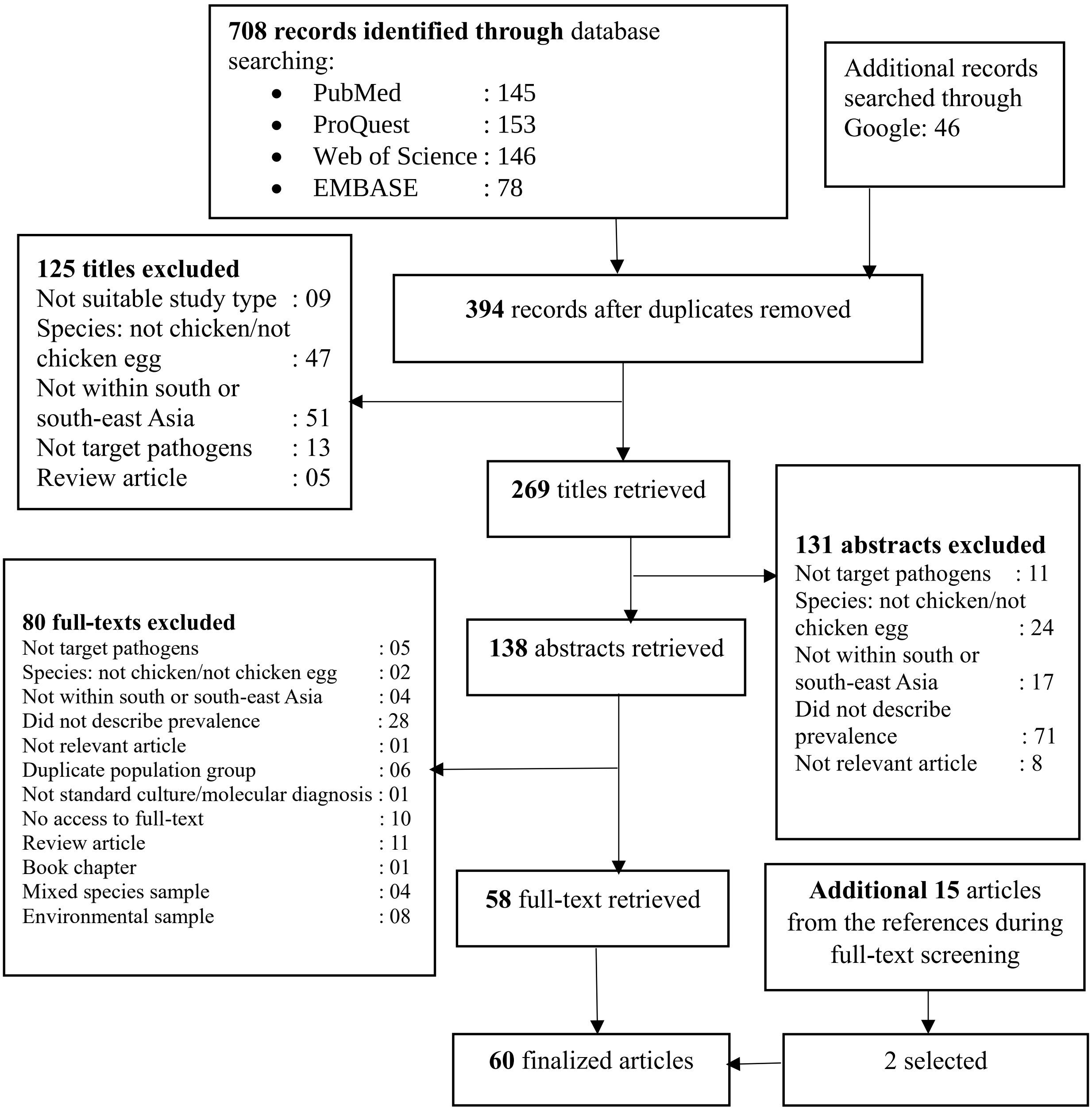

Figure 4.1. Flowchart of selected *Campylobacter* studies

4.2. Selection of non-typhoidal *Salmonella* studies

A total of 1765 unique references were screened for relevance of which 115 relevant references were identified. Additional nine articles were retrieved from the full-text screening among which, six articles were relevant. A total of 121 articles were finalized for the review (Figure 4.2).

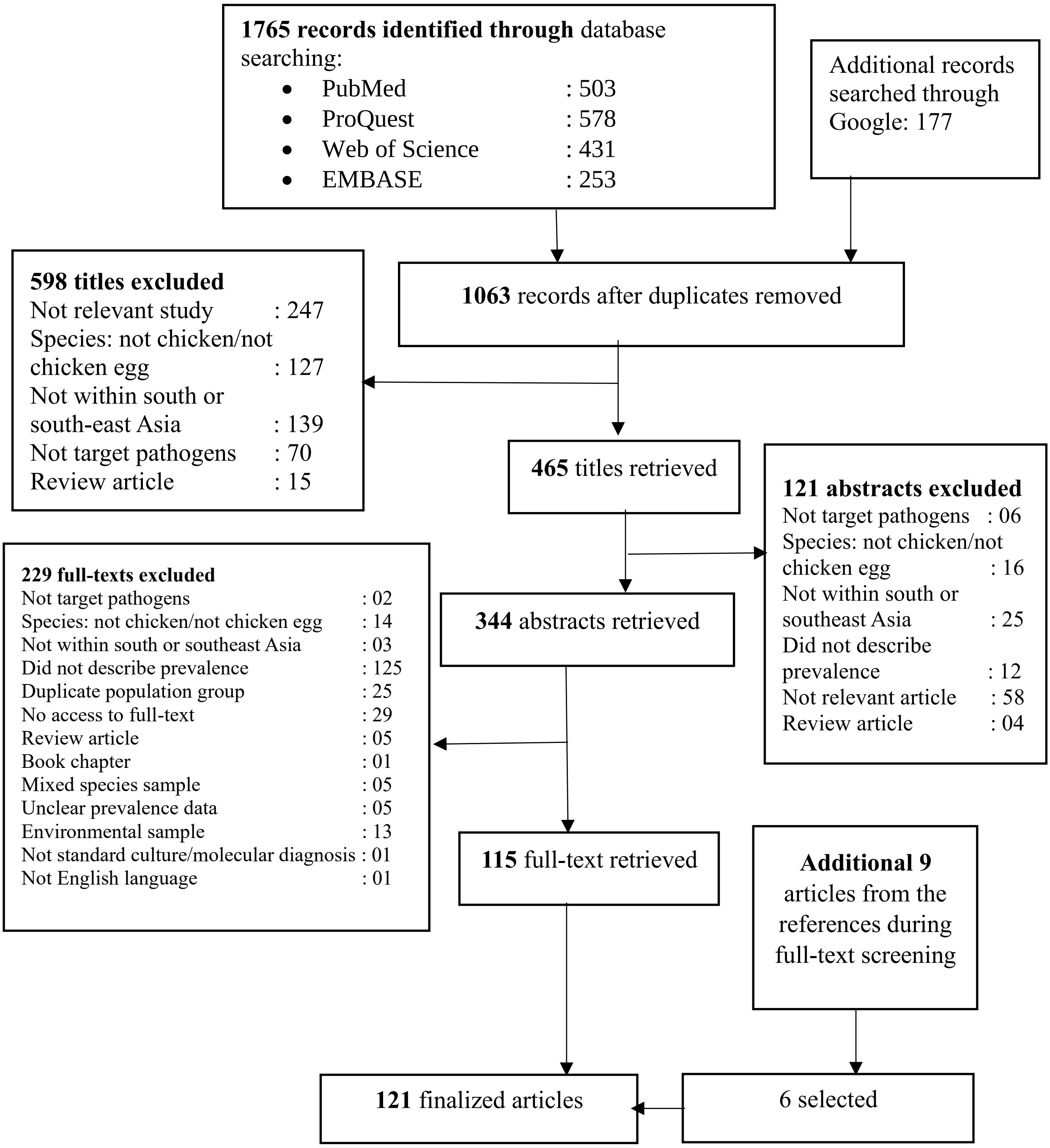

Figure 4.2. Flowchart of selected non-typhoidal *Salmonella* studies

4.3. Characteristics of the selected *Campylobacter* studies

Articles that reported multiple studies conducted in different sample types or populations (e.g., Farm, live bird market, slaughterhouse etc. and cloacal swab, raw meat) were considered as separate studies. A summary table for all the selected *Campylobacter* studies has been added in the Appendix A.

All the studies (100%) were cross-sectional studies. The studies were conducted between 2002 and 2019 (Appendix A). A total of 60 articles incorporated 95 studies which included 84 sample units, 12 farm units, two live bird market units, one retail outlet unit, two restaurant units, and one super shop unit prevalence studies. Most of the studies were from India (n=28) followed by Thailand (n=20), Bangladesh (n=9), Malaysia (n=9) and Pakistan (n=9). Eight studies were conducted in Philippines, five in Sri Lanka, four in Vietnam, two in Cambodia and one in Singapore (Figure 4.1).

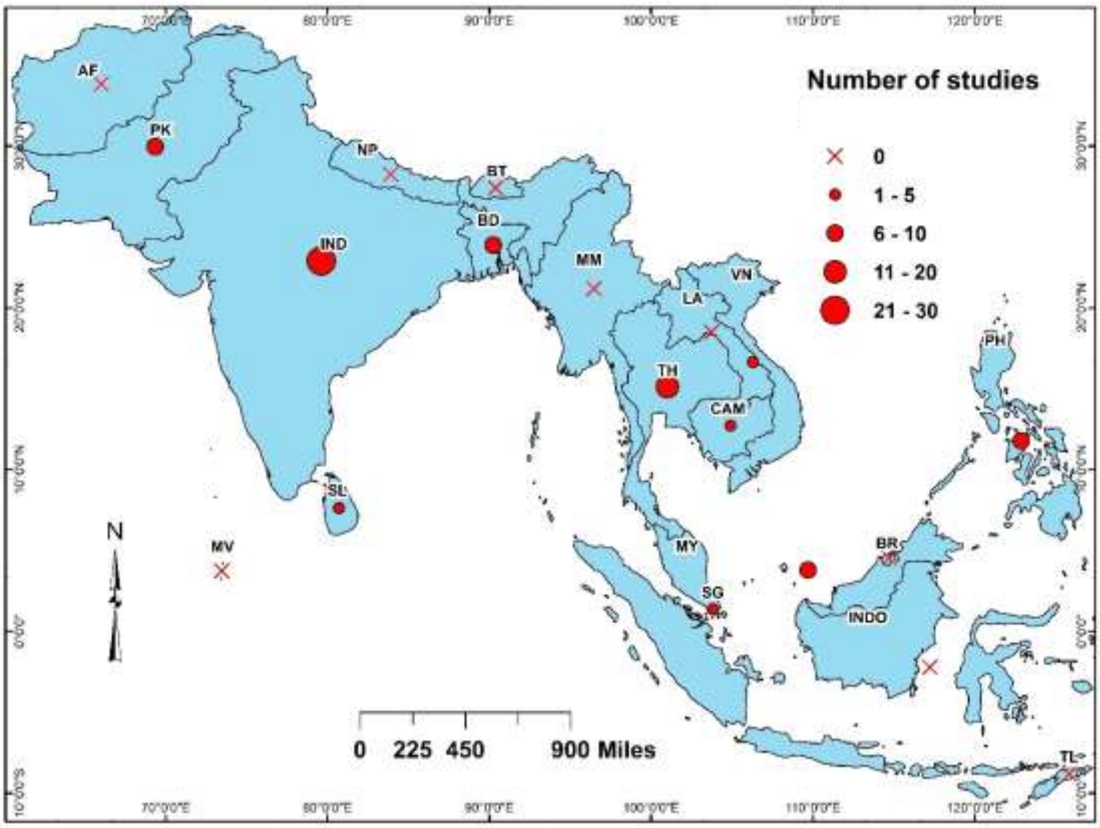

Figure 4.3. Map showing number of *Campylobacter* studies in chicken and chicken egg across south and south-east Asian countries between 2002 and 2019

(AF= Afghanistan, BD= Bangladesh, BH= Bhutan, CAM= Cambodia, IND= India, INDO= Indonesia, LA= Lao, MM= Myanmar, MV= Maldives, MY=Malaysia, NP=Nepal, PH= Philippines, PAK= Pakistan, SIN= Singapore, SL= Sri Lanka, TH= Thailand, TL= Timor-Leste, V= Vietnam)

Among the sample type, raw meat (n=31), cloacal swab (n=16), caecal content (n=14) and skin (n=11) were the most common. Other samples were intestine (n=4), cooked meat (n=4), carcass (n=4), liver (n=2), chick meconium (n=1), egg shell swab (n=1), feather (n=1), gizzard content (n=1) and processed meat (n=1). Four studies collected different type of samples but reported the number of tested and positive samples collectively. The sample types for these 4 studies were considered as mixed type (Appendix A).

Study sites also varied highly. Twenty-two studies collected sample from live bird markets (LBM), 18 from slaughterhouses, 14 from farms, 9 from retail outlets, 4 from restaurants, 4 from super shops, 2 from hatcheries and 2 from households. There were 13 studies which collected samples from different sites but reported the number of tested and positive samples collectively. These study sites were considered as mixed sites. Seven studies did not mention the study sites (Appendix A).

Exotic broiler was the most common (n=68, 71.6%) production type where many studies did not report any production type (n=21, 22.1%). Three studies were conducted in indigenous chicken, one in breeder house, one in hatchery and one in cockerels (Appendix A).

A total of 25 studies followed a probabilistic sampling approach, whereas 10 studies followed convenient sampling. Rest of the 60 studies did not mention their sampling approaches (Appendix A).

Where most of the studies were conducted at a single province (n= 41, 43.2%), 26.3% (n=25) were conducted at district level and 25.3% (n=24) were at multiple provinces. The study location or level was not mentioned in 5.6% (n=5) of the studies (Appendix A).

For confirmation of the positive samples, 49 studies conducted standard culture and biochemical method. Forty-five studies conducted PCR along with standard culture and biochemical method. One study conducted only PCR for confirmation of *Campylobacter* positive samples (Appendix A).

Ten studies were graded as Quality1 and 85 studies as Quality2 (Appendix A).

4.4. Characteristics of the selected non-Typhoidal *Salmonella* studies

A summary table for all the selected Non-Typhoidal Salmonella (NTS*)* studies has been added in the Appendix B.

The studies were all cross-sectional and conducted between 1997 and 2018 (Appendix B). A total of 220 articles incorporated 216 sample units, three farm units, two live bird market units and super shop unit prevalence studies. Among the sample unit studies, 179 were chicken samples (e.g., cloacal sample, raw meat) and 37 studies were egg sample studies (e.g., egg shell, egg content, boiled egg) (Appendix B).

The highest number of studies were conducted in India (n=85), Thailand (n=42), Pakistan (n=28) and Vietnam (n=15). Thirteen studies were conducted in Malaysia and 12 in Bangladesh. Countries that conducted a smaller number of studies were Sri Lanka (n=8), Cambodia (n=5), Nepal (n=4), Singapore (n=3), Indonesia (n=2), Bhutan (n=1), Myanmar (n=1) and Philippines (n=1) (Figure 4.2).

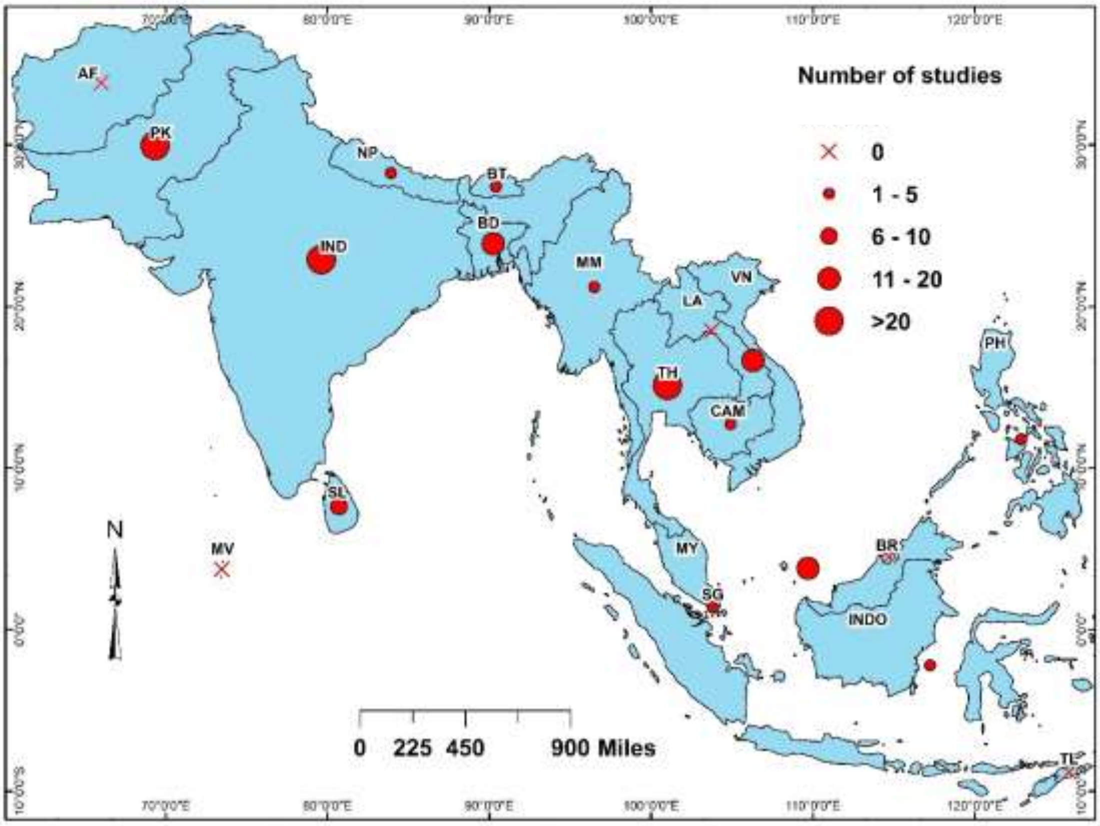

Figure 4.4. Map showing number of non-typhoidal *Salmonella* studies in chicken and chicken egg across south and southeast Asian countries between 1997 and 2018

(AF= Afghanistan, BD= Bangladesh, BH= Bhutan, CAM= Cambodia, IND= India, INDO= Indonesia, LA= Lao, MM= Myanmar, MV= Maldives, MY=Malaysia, NP=Nepal, PH= Philippines, PAK= Pakistan, SIN= Singapore, SL= Sri Lanka, TH= Thailand, TL= Timor-Leste, V= Vietnam)

Raw meat (n=76), cloacal swab (n=23) and carcass (n=14) were more frequently sampled among the studies. Among the 37 studies sampled egg, 12 sampled egg shell swab and 14 egg content and one boiled egg. The rest of the 10 studies reported the sample type as egg and did not specify egg shell or content. Intestine, liver and cooked meat were sampled in eight studies each; caecal content and processed meat were sampled in five studies each. The number of studies for other samples were- ovary (n=4), skin (n=3), spleen (n=3), kidney (n=3), heart (n=2), ready to eat meat (n=2), mouth (n=1), dead embryo (n=1), oviduct (n=1), crop (n=1), lung (n=1) and yolk sac (n=1). Twelve studies collected different type of samples but reported the number of tested and positive samples collectively. The sample types for these 12 studies were considered as mixed type. One study did not mention the sample type (Appendix B).

Among the study sites, retail outlet (n=76), farm (n=47), live bird market (n=25), slaughterhouse (n=21), restaurants (n=14) and super shop (n=11) had the highest number of studies. Household (n=3), laboratory (n=2) and hatchery (n=1) were the sites with a smaller number of studies. Fourteen studies collected samples from different sites but reported the number of tested and positive samples collectively. These study sites were considered as mixed sites. The study sites were not mentioned in six studies (Appendix B).

The production type of the study chickens was not mentioned in most of the studies (n=128). The studies that mentioned production type were- exotic broiler (n=30), exotic layer (n=20), breeder (n=2), hybrid broiler (n=1), Rhode Island Red (n=1) and Sonali (Cross between Rhode Island Red male and Fayoumi female) (n=1). Production type was not applicable for the egg sample (n=37) studies (Appendix B).

The health status of the sampled chickens was not mentioned in 150 studies. In 17 studies, the chickens were dead, clinically healthy in 11 studies and sick in 4 studies. One study sampled from both sick and dead chickens. Health status was not applicable for the egg samples (Appendix B).

Majority of the studies were conducted in district level (n=83). Sixty-seven studies were conducted in multiple provinces and 58 were conducted in a single province. Twelve studies did not mention the study area (Appendix B).

Sampling approach was not specified in 137 studies. Forty-three studies mentioned to follow probabilistic sampling without specifying the category. Simple probabilistic sampling approach was applied in 15 studies, proportionate probabilistic in two studies and systematic probabilistic in two studies as well. Convenient sampling method was followed in 18 studies and purposive sampling in three studies (Appendix B).

For detection of NTS positive samples, 123 studies conducted standard culture and biochemical method. Ninety-six studies conducted PCR along with standard culture and biochemical method. However, 70 studies did serotyping and/or pulse field gel electrophoresis and/or matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) and/or Agarose gel diffusion to identify the serovars (Appendix B).

Seven studies were graded as Quality1 and 213 studies as Quality2 (Appendix B).

4.5. Prevalence of *Campylobacter* in chicken samples and farm in South and Southeast Asia

The extracted dataset from the selected *Campylobacter* studies contained a good number of sample unit (n=85) and farm unit (n=12) studies while only one or two studies for the other units. So, the pooled estimates were computed for sample and farm unit studies.

The overall estimated random effect pool prevalence of *Campylobacter* in chicken in south and south-east Asia at sample unit was 42.4% (95% Confidence Interval (CI): 36.1% to 48.7%) and farm unit was 58.4% (95% CI: 42.4% to 74.4%).

The forest plots for different subgroups across the studies have been added in the appendices.

Philippines (75.5%; 95% CI: 61.8% to 89.2%), Cambodia (68.4%; 95% CI: 44.1% to 92.8%) and Thailand (52.1%; 95% CI: 42.0% to 62.1%) had the higher pooled prevalence in the sample unit data. Bangladesh had 39.5%; (95% CI: 19.0% to 59.9%) prevalence, India 28.6% (95% CI: 19.6% to 37.7%) and Vietnam 27.3% (95% CI: 18.1% to 36.5%) (Appendix C).

The farm unit pooled prevalence of *Campylobacter* was higher in Thailand (54.9%; 95% CI: 19.2% to 90.5%). Sri Lanka and Bangladesh had 52.8% (95% CI: 32.1% to 72.4%)) and 40.5% (95% CI: 30% to 51%) prevalence respectively (Appendix D).

The pooled estimates of *Campylobacter* in sample unit studies were higher in mixed type samples (79.1%; 95% CI: 57.8 to 100.5%), liver (63.9%; 95% CI: -2.1% to 129.9%) and skin (53.7%; 95% CI: 31.1% to 76.4%). Whereas, lower pooled prevalence was observed in cooked meat (20%; 95% CI: -25% to 42.4%) (Appendix E). Farm unit prevalence was 68.5% (95% CI: 38.0% to 99.0%) in cloacal swab which was higher compared to caecal content (58.1%; 95% CI: 22.4% to 93.7%) and skin (41.4%; 95% CI: 25.5% to 57.2%) (Appendix F).

The higher level of sample unit prevalence was observed in supershop (57.7%; 95% CI: 37.1% to 78.3%), LBM (56.9%; 95% CI: 46.3% to 63.5%) and farm (45.6%; 35.1% to 56.2%) (Appendix G). The prevalence in farm unit data was higher in samples collected from farm (72.3%; 95% CI: 50.0% to 94.6%) compared to slaughterhouse (38.4%; 95% CI: 15.1% to 61.7%) (Appendix H).

Sample unit prevalence in clinically healthy chickens was 40.9% (95% CI: 33.8% to 48.0%) and 47.4% in chickens where health status was not mentioned (95% CI: 38.5% to 56.3%) (Appendix I). Farm unit prevalence was higher in healthy chickens 72.3%; 95% CI: 49.9% to 94.6%) compared to the chickens with unreported health status (45.3%; CI: 26.8% to 63.8%) (Appendix J).

46.5% (95% CI: 40.1% to 52.9%) prevalence was estimated in exotic broiler samples (Appendix K). On the other hand, 59.4% exotic broiler farms were *Campylobacter* positive (95% CI: 42.4% to 76.5%) (Appendix L).

Significant heterogeneity was present across the studies of each subgroup (I^2>80%, p≤0.001).

Campylobacter jejuni (79.9%; 95% CI: 78.2% to 81.4%) and *Campylobacter coli* (17.1%; 95% CI: 15.6% to 18.6%) were the more prevalent species among the tested positive samples (Figure 4.3).

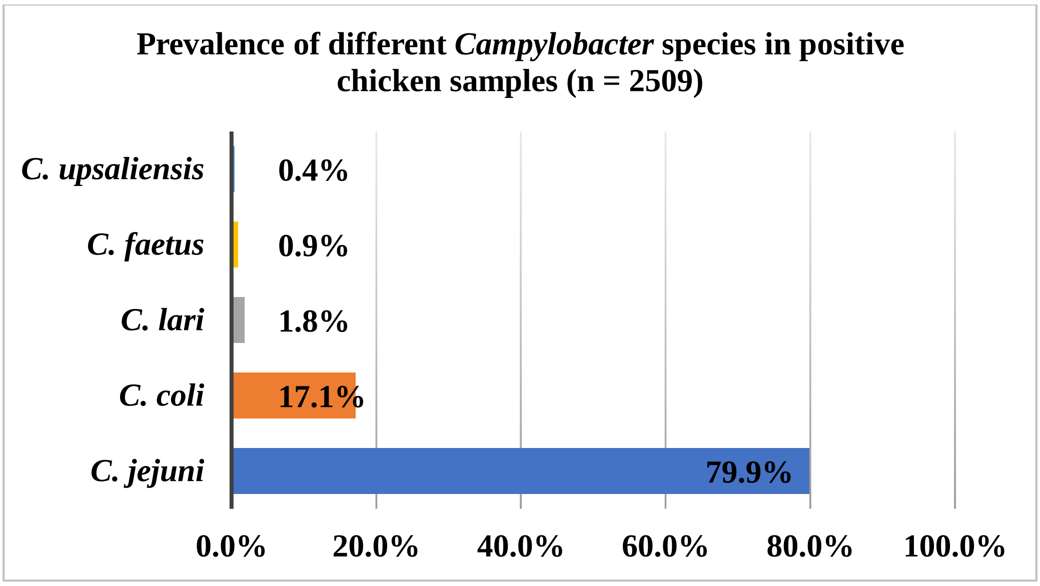

Figure 4.5. Breakdown of *Campylobacter* species in the tested positive samples

4.6. Prevalence of non-typhoidal *Salmonella* in chicken samples and egg samples in South and Southeast Asia

The extracted dataset from the selected NTS studies contained a good number of sample unit (n=216) studies among which, 179 studies contained chicken samples and 37 studies contained egg samples. Other units had only two or three studies. So, pooled estimates were computed separately for chicken sample and egg sample studies.

The overall estimated random effect pool prevalence of *NTS* in chicken in south and south-east Asia in chicken samples was 26.1% (95% Confidence Interval (CI): 22.5% to 29.8%) and egg samples was 9% (95% CI: 4.7% to 13.3%).

Bangladesh (40.4%; 95% CI: 19% to 61.9%) followed by Nepal (35.4%; 95% CI: 28.9% to 46.8%) and Sri Lanka (33.6%; 95% CI: 12.2% to 55%) had higher prevalence of NTS in chicken samples. Singapore (13%; 95% CI: 4.1% to 21.9%) and Pakistan (11.1%; 95% CI: 5.3% to 16.9%) had lower prevalence. India had 16.2% (95% CI: 11.7% to 20.7%) prevalence while Vietnam had 32.7% (95% CI: 22.5% to 29.8%) prevalence (Appendix M).

For the egg samples, Bangladesh (28.9%; 95% CI: -7.6% to 65.4%) and Sri Lanka (27.8%; 95% CI: -5.6% to 6.3%) showed higher pooled prevalence. On the contrary, Malaysia (0.8%; 95% CI: -1.7% to 3.3%) and India (2%; 95% CI: 1% to 3.1%) showed the lowest prevalence (Appendix N).

Among the chicken samples, the higher estimated pooled prevalence of NTS was in carcass (54.6%; 95% CI: 39.5% to 69.7%) and raw meat (34%; 95% CI: 28.3% to 39.8% and lower in cooked meat (10%; 95% CI: 1.1% to 18.6%) (Appendix O). The sample unit prevalence of NTS in egg shell was 22.3% (7.1 o 37.7%) and 1.4% (0.41% to 2.41%) in egg content (Appendix P).

Prevalence among different study sites also varied highly. Live bird market (40.3%; 95% CI: 30.2% to 50.5%), slaughterhouse (29.3%; 95% CI: 19.1% to 39.5%) and retail outlet (26.6%; 95% CI: 19.9% to 33.4%) had higher pooled prevalence. The lower prevalence sites were super shop (20.3%; 95% CI: 8.1% to 32.5%), farm (18.3%; 95% CI: 11.7% to 24.8%) and restaurant (11.3%; 95% CI: 4% to 18.6%) (Appendix Q). Egg samples had higher pooled prevalence in retail outlet (12.2%; 95% CI: 3.8 to 20.6) and 0% at farm (Appendix R).

Chicken samples from sick birds (30.5%; 95% CI: -8.7% to 69.7%) had higher prevalence than dead (21.4%; 95% CI: 10.5% to 32.3%) and clinically healthy birds (18.6%; 95% CI: 8.6% to 28.6%) (Appendix S).

Chicken samples from exotic broiler (25.5%; 95% CI: 17.8% to 33.2%) had higher NTS pooled prevalence than exotic layer (15.8%; 95% CI: 6.5% to 25.1%) (Appendix T).

All the subgroups had significant heterogeneity across the studies (I^2>80%, p=<0.001).

A total of 54 NTS serovars were reported in chicken samples. *Salmonella* Enteritidis (30.3%; 95% CI: 27.7% to 33.1%), *S*. Typhimurium (28.2%; 95% CI: 25.6% to 30.9%) and *S*. Gallinarum (4.4%; 95% CI: 3.3% to 5.7%) were the most frequent serovars isolated from the chicken samples (Figure 4.3.2.1). On the other hand, 9 serovars were identified in the egg samples among which, *S.* Typhimurium (62.5%; 95% CI: 48.5% to 75.1%), *S*. Enteritidis (8.9%; 95% CI: 3% to 19.6%), *S*. Emek (7.1%; 95% CI: 2% to 17.3%) and *S.* Heidelberg (7.1%; 95% CI: 2% to 17.3%) were the most prevalent (Figure 4.4).

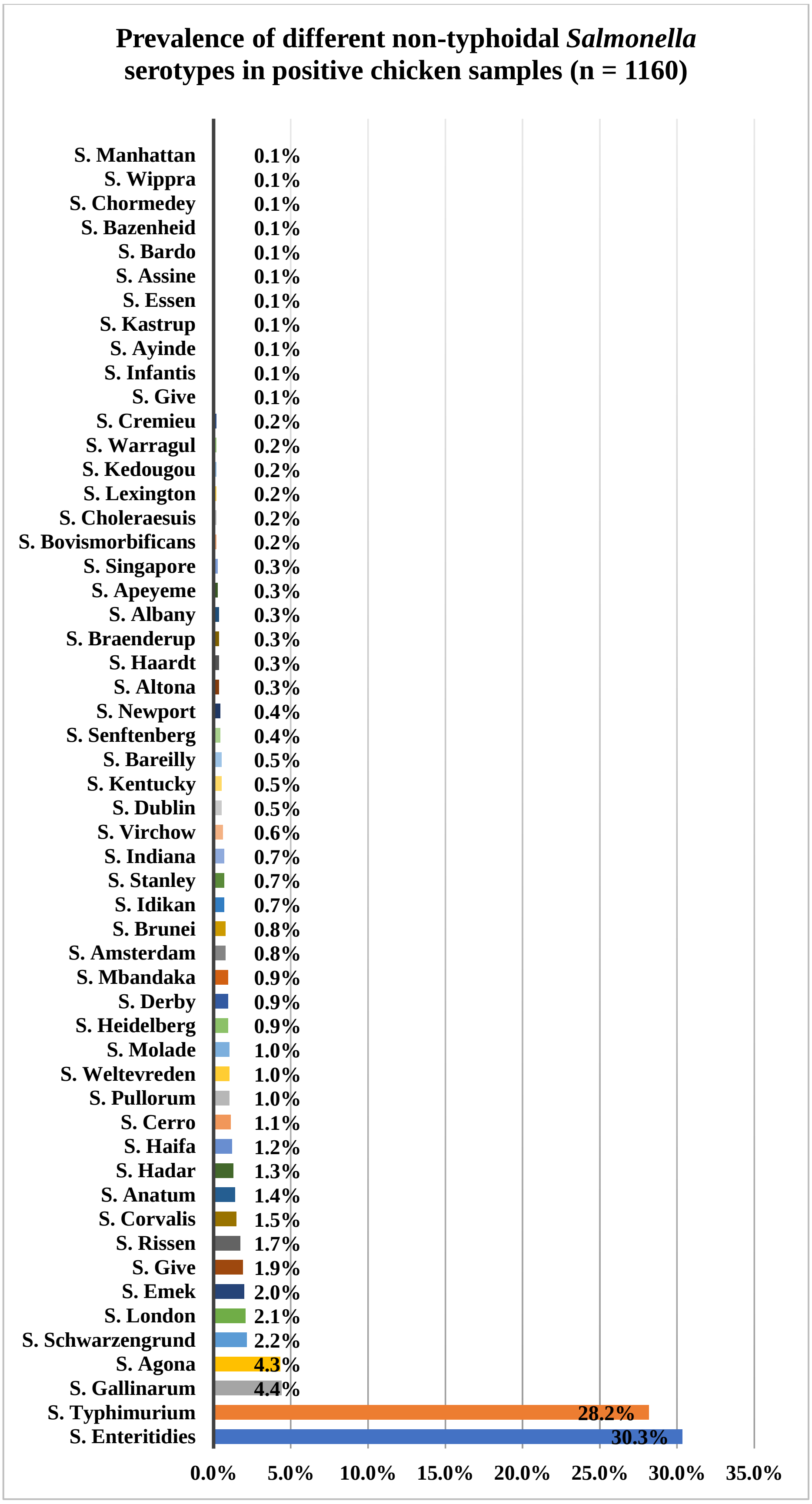

Figure 4.6. Breakdown of non-typhoidal *Salmonella* serovars in the tested positive chicken samples

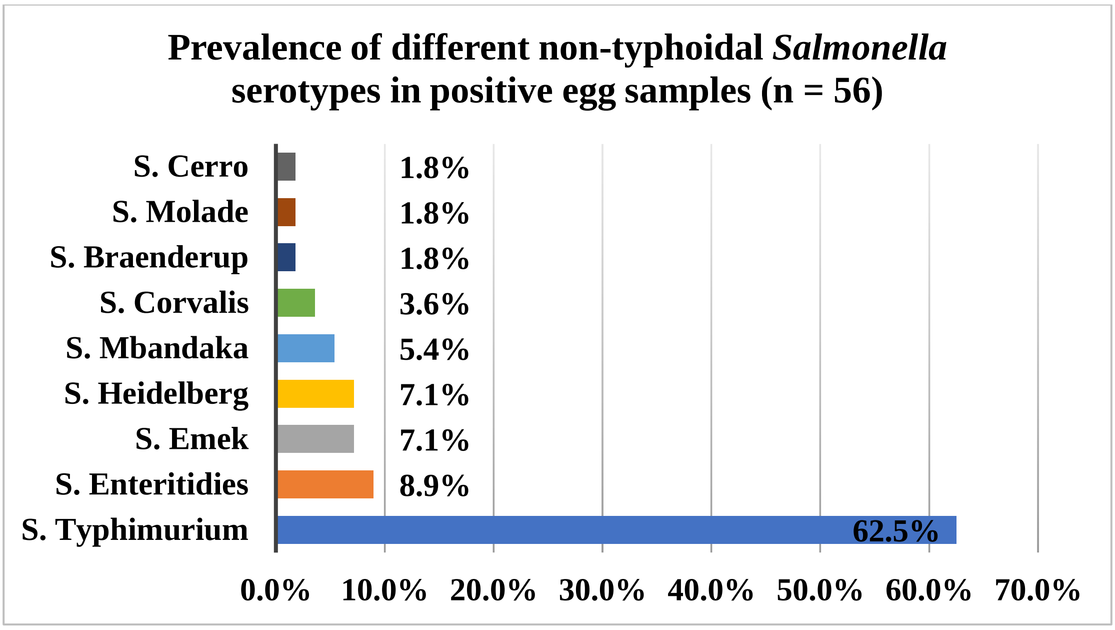

Figure 4.7. Breakdown of non-typhoidal *Salmonella* serovars in the tested positive egg samples

4.7. Meta-regression results

A meta-regression analysis was conducted to evaluate the effect of different predictors on the subgroup outcomes, as the large heterogeneity observed in the subgroup analysis supports the possibility of study factors impacting this variance. Mixed type sample, mixed type study site and not mentioned subgroups were not included in the meta-regression to avoid misinterpretation of results.

4.7.1. Meta-regression results for *Campylobacter* studies

Total three subgroups of outcomes (each containing at least ten studies) were amenable to meta-regression analysis from sample unit data: country, study site and sample type. The heterogeneity in the sample unit prevalence of *Campylobacter* was significantly associated with country and study site. The prevalence was significantly higher in Thailand (Co-efficient: 23.5 (95% CI: 9.2 to 37.7); p=0.001) compared to India (reference group) and LBM (Co-efficient: 17.6 (95% CI: 3.5 to 31.7); p=0.01) compared to slaughterhouse (reference group) (Table 4.1).

Table 4.1. Univariable meta-regression analyses of selected outcome subgroups for *Campylobacter* studies

Subgroup / predictors	Co-efficient (95% CI)	p	I^2	Adj. R^2
Country (n=44)				
India	Baseline	-		
Thailand	23.5 (9.2 to 37.7)	0.001	98.9%	18.6%
Study site (n=45)				
Slaughterhouse	Baseline	-		
Farm	6.3 (-9.9 to 22.5)	0.45		
Live bird market	17.6 (3.5 to 31.7)	0.01	97.2%	9.3%
Sample type (n=56)				
Raw meat	Baseline	-		
Cloacal swab	5.9 (-10.2 to 22.0)	0.47	98.6%	0.0%
Caecal content	7.2 (-8.0 to 22.5)	0.35		

p: Probability, CI: Confidence interval, I^2 = Heterogeneity, Adj= Adjusted,
n= Number of studies

4.7.2. Meta-regression results for non-typhoidal *Salmonella* studies

For the sample unit NTS studies, six subgroups of outcomes (each containing at least ten studies) were included in meta-regression analysis: country, study site, sample type, health status, production type and egg samples. The prevalence of NTS was significantly higher in Vietnam (Co-efficient: 16.3 (95% CI: 3.0 to 29.6), p=0.02) and Thailand (Co-efficient: 22.5 (95% CI: 13.3 to 31.7); p=<0.001) over India (Baseline). Among the study sites, retail outlet (Co-efficient: 28.1 (95% CI: 11.0 to 45.1); p=0.001) had significantly higher prevalence over restaurant (Baseline). Raw meat (Co-efficient: 17.6 (95% CI: 6.5 to 29.0); p=0.002) and carcass (Co-efficient: 38.4 (95% CI: 22.4 to 54.3), P<0.001) sample types had higher prevalence than cloacal swabs (Baseline). Egg shell (Co-efficient: 15 (95% CI: 2.2 to 27.7); p=0.02) samples had significantly higher prevalence than egg content (Baseline) (Table 4.2).

Table 4.2. Univariable meta-regression analyses of selected outcome subgroups for non-typhoidal *Salmonella* studies

Subgroup / predictors	Co-efficient (95% CI)	p	I^2	Adj. R^2
Country (n=165)				
India	Baseline			
Pakistan	5.5 (-4.8 to15.8)	0.29	100%	12.2%
Malaysia	14.5 (-0.4 to 29.3)	0.06		
Bangladesh	12.8 (-2.1 to 27.7)	0.09		
Vietnam	16.3 (3.0 to 29.6)	0.02		
Thailand	22.5 (13.3 to 31.7)	<0.001		
Study site (n=158)				
Restaurant	Baseline			
Farm	6.3 (-9.6 to 22.1)	0.44	100%	16.7%
Supershop	8.8 (-11.5 to 29.2)	0.39		
Live bird market	14.3 (-0.9 to 29.5)	0.07		
Slaughterhouse	17.1 (-0.1 to 34.2)	0.05		
Retail outlet	28.1 (11.0 to 45.1)	0.001		
Sample type (n=111)				
Cloacal swab	Baseline			
Raw meat	17.6 (6.5 to 29.0)	0.002	100%	16.6%
Carcass	38.4 (22.4 to 54.3)	<0.001		
Production type (n=49)				
Exotic broiler	Baseline			
Exotic layer	-10.5 (-22.4 to 1.4)	0.08	100%	5.3%
Health status (n=31)				
Healthy	Baseline			
Sick and dead	3.6 (-12.8 to 19.9)	0.67	100%	0.0%
Egg samples (n=26)				
Egg content	Baseline			
Egg shell	15 (2.2 to 27.7)	0.02	100%	14.1%

p: Probability, CI: Confidence interval, I^2 = Heterogeneity, Adj= Adjusted,
n= Number of studies

4.8. Publication bias

Publication bias was assessed separately for the study units included in the meta-analysis through funnel plots and bias egger test.

4.8.1. Publication bias in *Campylobacter* studies

We found a qualitatively asymmetrical association for prevalence of *Campylobacter* in the funnel-plot analysis (Figure 4.6 and Figure 4.7). A further regression -based egger's test showed that there was small study effect on the sample unit prevalence of *Campylobacter* (p=0.0003). But there was no small study effect on the prevalence of *Campylobacter* in farm unit studies (p=0.6).

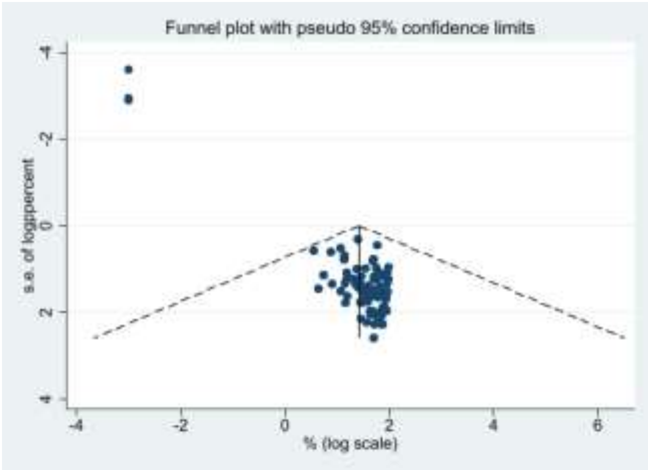

Figure 4.8. Funnel plot for examination of publication bias in sample unit data for *Campylobacter* (%= prevalence percent, s.e.= standard error)

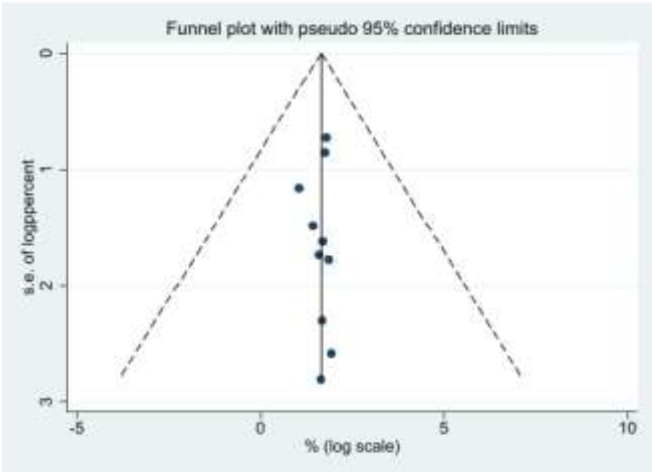

Figure 4.9. Funnel plot for examination of publication bias in farm unit data for *Campylobacter* (%= prevalence percent, s.e.= standard error)

4.8.2. Publication bias in non-typhoidal *Salmonella* studies

Both the funnel plots for NTS studies (chicken samples and egg samples) showed qualitatively asymmetrical association (Figure 4.8 and Figure 4.9). The regression - based egger's test indicated that there was small study effect on both chicken sample and egg sample studies ($p \leq 0.001$).

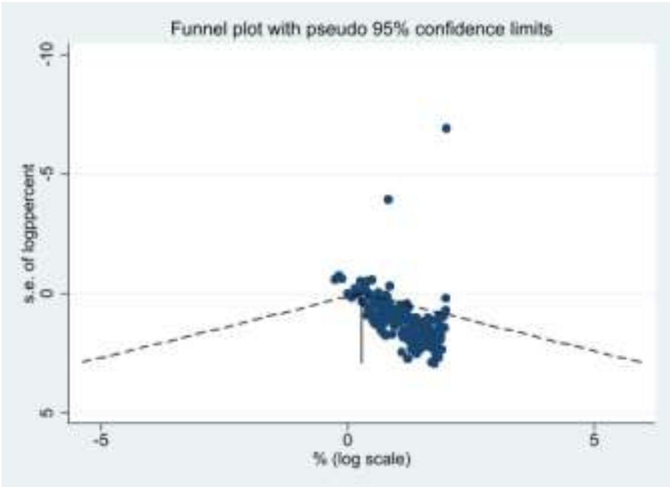

Figure 4.10: Funnel plot for examination of publication bias in sample unit data for non-typhoidal Salmonella (studies with chicken samples*)*

%= prevalence percent, s.e.= standard error

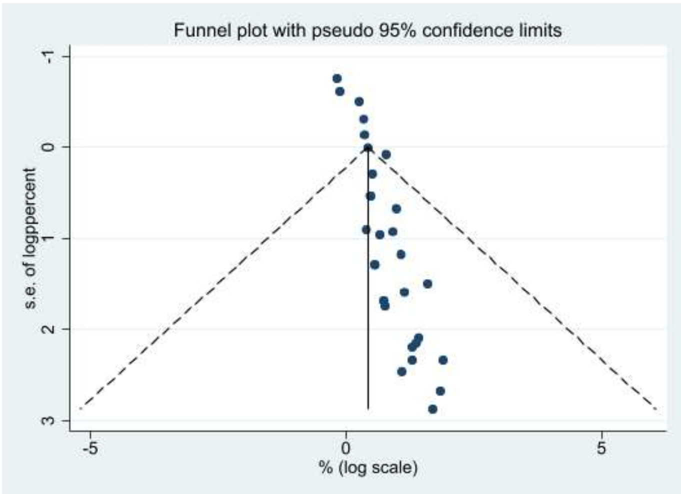

Figure 4.11: Funnel plot for examination of publication bias in sample unit data for non-typhoidal *Salmonella* (studies with egg samples)

%= prevalence percent, s.e.= standard error

Chapter-5: Discussion

To the best of our knowledge, this is the first meta-analysis on prevalence of *Campylobacter* and non-typhoidal *Salmonella* (NTS) in chicken in south and south-east Asian countries based on the literature published between 2000 to 2020.

Our systematic review has demonstrated widespread prevalence of *Campylobacter* species and non-typhoidal *Salmonella* (NTS) serovars in chicken species across the study area. Both *Campylobacter* and NTS were significantly most prevalent in Thailand and least prevalent in India in various chicken samples. Vietnam also had significantly higher NTS prevalence in chicken samples compared to India but less than Thailand. Though any direct evidence could not be found, structural and operational variation in the poultry value chain between these countries could have contributed to this difference. However, presence of both the pathogens in chicken even at a lower percentage is a serious public health concern as they are sporadic in nature, low infective dose required for human illness and multiple ways of cross-contamination (Widdowson et al., 2005; Felde et al., 2014; Myintzawet al., 2023).

Among the study sites, *Campylobacter* had significantly higher prevalence in live bird market than slaughterhouse. Transportation from farms to live bird market has been identified as a critical harbor for the transmission and colonization of *Campylobacter* in live birds. This is due to the reuse of contaminated crates for shipping, animal hoarding, and induced-stress during the transportation of live birds from different flocks and/or farms to live bird markets as well as the unhygienic environment of the live bird market (Rabbi et al., 2021; Slader et al., 2002). Similar trend was reported for avian influenza (AI) in poultry where AI prevalence is higher than farm in Bangladesh (Kim et al., 2018). Non-typhoidal *Salmonella* were significantly more prevalent in retail outlets than restaurants. Evisceration process and cross contamination between carcasses prior shipping to retail outlets as well as unhygienic condition at retail outlets could attribute to this higher prevalence (Carrasco et al., 2012; Nair and Johny, 2019).

No significant difference was observed in *Campylobacter* prevalence among different type of samples. While NTS was significantly more likely to be isolated or detected from carcass rinse and raw meat than cloacal swab. Environmental contamination of carcass and meat could increase the detection rate of *Salmonella* compared to the cloacal samples (Carrasco et al., 2012; Nair and Johny, 2019, Rabbi et al., 2021).

Egg content contained significantly less NTS compared to egg shell. For instance, *Salmonella* being a mesophilic aerobic bacteria can survive on eggshells regardless of storage conditions up to 21 days. Further, the survival rate of *S. enterica* on egg shells can be increased with the presence of chicken faeces (Park et al., 2015).

C. jejuni and *C. coli* were the most predominant *Campylobacter* species identified and Salmonella serovar in south and southeast Asian chickens. These results are similar to a systematic review and meta-analysis conducted in Africa region (Thomas et al., 2020). Thermophilic *Campylobacter* species*, C. jejuni, C. coli, C. lari,* and *C. upsaliensis* accounted for the majority of *Campylobacter* isolated so far and cause the majority of human *Campylobacter* infection (Lastovica and le Roux, 2000).

Salmonella enterica serovar Enteritidis was the most commonly identified serovars in chicken samples while *Salmonella enterica* serovar Typhimurium was most identified in egg samples. According to a meta-analysis (Ferrari et al., 2019) *S.* Enteritidis is the most prevalent serovar from poultry origin in Asia. No evidence was found specifying prevalent NTS serovars in chicken eggs. However, according to World Health Organization (2022), these two serovars of NTS are transmitted from poultry to human in most parts of the world (WHO, 2022).

The extent of publication bias in the selected studies (sample unit, chicken unit and farm unit prevalences) was measured and demonstrated by the funnel plot. Except the farm unit studies, the funnel plots were clearly not symmetrical and some of the points fall outside of the funnel, indicating publication bias. The sources of the funnel plot asymmetry were tested by Egger test, the result of which confirmed small study effects in sample unit prevalences for both the pathogens. However, there are many different possible factors for funnel plot asymmetry, namely selection bias, true heterogeneity, data irregularities, artifact as well as by chance (Egger et al. 1997).

Where prevalence data show that end product samples in south and south-east Asia are highly contaminated with *Campylobacter* or NTS, as was the case for chicken meat, organs and eggs; local and national policy makers and enforcers may be able to more effectively develop control measures to reduce these potential pathogens in the food chain.

While source attribution studies to show link with human have been performed in some parts of the world, few are available for *Campylobacter* and NTS in south and south-east Asia (Myintzawet al., 2023). It is important to ascertain whether or not increasing scales and intensification of meat production are contributing to human disease in South and south-east Asia. The presence of *Campylobacter* and NTS in food animals and meat products may or may not indicate human disease risk. We have shown, *Campylobacter* species and NTS serovars identified, vary according to geographical location, study site and sample. Without a more in depth look at the link between chicken and human isolates, such as whole genome sequencing and patterns of human exposure, including raw meat and egg handling and cooking practices, we have less information about whether or not *Campylobacter* and NTS from South and southeast Asian food animals are contributing to human disease.

There were many studies where the authors did not report some important information such as- study period, sampling approach, study level, study site, production type and health status. Therefore, the authors should carefully report all these information to make their studies more impactful.

There were some limitations while conducting this systematic literature review and meta-analysis. Our formal bias assessment determined the overall risk of bias from sampling approach (probabilistic or non-probabilistic), study level (district, single province or multiple province) and detection method (culture, biochemical and polymerase chain reaction (PCR). Most of the studies belonged to quality-2 studies (11.8% *Campylobacter* studies and 98.8% NTS studies) which could introduce potential bias in the results.

No *Campylobacter* studies were conducted in chicken in Brunei Darussalam, Indonesia, Lao People's Democratic Republic, Myanmar, Timor-Leste, Afghanistan, Bhutan, Maldives and Nepal. And no NTS studies were conducted in Afghanistan, Lao People's Democratic Republic, Timor-leste and Maldives. The pooled estimates could not be conducted for these countries for the respective pathogens.

We did not include the subgroups having fewer than 10 studies in meta-regression out of concern about a reduction in the association detection power of the test. Moreover, several variables had categories labeled "not mentioned" and mixed type sample or study site due to missing information in the literatures. These variables were not evaluated for potential causes of heterogeneity between studies, thereby lacking adequate details. Asymmetric funnel plots, as well as outcomes of the Egger test, showed that publication bias was prevalent throughout the studies in most subgroups. However, true heterogeneity, selection bias, study level differences, data irregularities, and artifacts could be accountable for this (Egger et al. 1997). Therefore, the results should be interpreted with caution.

There are also some other limitations, and are worth noting when interpreting our results. First, the review did not include any non-English literature, which would have led to the exclusion of a few relevant studies. However, we lessened the likelihood of this happening by multiple databases searching and employing a search verification approach where the English translated literature should have been present. Second, several studies presented prevalence data merged with environmental samples or other livestock species and couldn't be sorted, thereby being excluded. Thirdly, the studies had to be excluded that reported number of isolates for different and *Campylobacter* species and *Salmonella* serovars instead of the number of positive samples for those species and serovar. Fourthly, we could not perform multivariable meta-regression as there were different number of studies in different subgroups. Finally, the relatively small number of studies in a few subgroups, which may overestimate or underestimate the calculated pooled prevalence, limits the power of the meta-analysis.

Chapter-6: Conclusion, Recommendation and Future Direction

Both *Campylobacter* and non-typhoidal *Salmonella* (NTS) were most prevalent among samples from Thailand, and were less common among samples from India. Live bird markets (LBM) showed the highest prevalence for *Campylobacter* while NTS was most prevalent in retail outlets. Non-typhoidal *Salmonella* was detected more in carcass and raw meat samples. Egg shells contained more NTS than egg content. *C. jejuni* and *C. coli* were the predominant *Campylobacter* species and *Salmonella enterica* serovar Enteritidis and Typhimurium were the most commonly identified *Salmonella* serovar in south and southeast Asian chicken and chicken eggs. However, due to substantial level of heterogeneity among the studies, existence of publication bias and significant small study effect, the interpretation of the findings should be done with caution.

6.1. Recommendations

I. Maintaining good sanitary measures in live bird markets (LBM) and retail outlets will reduce the contamination to a great extent.

II. Training in hygienic food handling for transportation staffs, LBM workers and retail outlet workers is essential to keep contamination to a minimum.

III. Regular monitoring of the LBMs and retail outlets to maintain hygienic environment in both the settings is crucial.

IV. Chicken meat or egg should be properly cooked before eating and raw or undercooked meat and should always be avoided.

6.2. Future directions

I. A comprehensive study along the different nodes of chicken meat/egg value chains should be thought of estimating the true status of *Campylobacter* and NTS; and identifying riskiest nodes for specific intervention.

II. Testing different intervention strategies (for example, training versus penalty) to maintain good hygienic practices at live bird markets (LBM) and retail outlets should be carried out to identify and implement more effective intervention measures.

III. Knowledge, attitude and practices of the LBM and retail outlet workers about maintaining hygiene should be studied in detail to identify the gaps and develop proper training strategy for them.

IV. The high prevalence of these organisms in chicken and chicken eggs, their important role as human pathogens, and lack of evidence on direct contribution to human illness in South and southeast Asia, indicate source attribution studies would be a useful tool to more definitively identify priorities for food safety interventions.

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Appendices

Appendix A. Summary table for the selected *Campylobacter* studies conducted in south and southeast Asia from 2000 to 2020 in chickens and chicken eggs

SN	Reference	SD	Co	SP	Po	Sampling unit n/N, % (95% CI)						ST	S	HS	PT	L	SA	DM	Q
						Sam	Fa	RO	Re	LBM	SS								
1	Anonymous, 2009	CS	TH	NM	N	91/140, 65% (57.1% to 72.9%)	7/7, 100% (100% to 100%)					CC	Fa	CH	EB	NM	NM	C+B	2
2	Arshad et al., 2019	CS	PAK	NM	N	24/48, 50% (35.9% to 64.1%)			11/16, 68.7% (46% to 91.5%)			CM	Re	NM	NM	D	Pr	C+B	2
3	Aung et al., 2018	CS	SIN	2010 to 2013	N	0/136, 0% (-0.1% to 0.1%)			0/61, 0% (-0.1% to 0.1%)			CM	Re	NM	NM	MP	Con	C+B	2

SD= Study design, CS= Cross-sectional,
C= Country, TH= Thailand, BD= Bangladesh, PAK= Pakistan, IND= India, MY=Malaysia, CAM= Cambodia, SL= Sri Lanka, PH= Philippines, V= Vietnam, SIN= Singapore, MM= Myanmar, NP=Nepal, INDO= Indonesia, BH= Bhutan
SP= Study period,
Po= Pooling, Y=Yes, N=No
n= Number of positive samples, N= Number of total samples, CI= Confidence interval
Sam= Sample unit, ST=Type of sample, RM= Raw meat, Cl= Cloacal swab, CC= Caecal content, Sk= Skin, Car= Carcass, CM=Cooked meat, RTE= Ready to eat meat, In= Intestine, Fea= Feather, PM= Processed meat, Li= Liver, Mec= Chick meconium, Gi= Gizzard, M= Mixed, ES= Egg surface swab, EC= Egg content, E= Egg (shell or content not specified), BE= Boiled egg, Hr= Heart, K= Kidney, Yo= Yolk sac, O= Ovary, Spl= Spleen, Lu= Lungs, DE= Dead embryo, Ovi= Oviduct, Cr= Crop, Mo= Mouth
S= Study site, LBM= Live bird market, SH= Slaughter house, Fa=Farm, RO= Retail outlet, SS= Supershop, Re= Restaurant, HH= Household, H= Hatchery
PT= Production type, EB= Exotic broiler, EL= Exotic layer, I= Indigenous, Br= Breeder, Coc= Cockerel, HB= Hybrid broiler, Son= Sonai, Lab=Laboratory
HS= Health status, CH= Clinically healthy, Both= Dead and clinically healthy, NA= Not applicable
L= Study level, D= District, SP= Single province, MP= Multiple provinces, NM= Not mentioned
SA= Sampling approach, Pr= Probabilistic sampling, SPr= Simple probabilistic, SysPr= Systematic probabilistic, PrP= Proportionate probabilistic, Con= Convenient sampling, Pur= Purposive
MC= Method of confirmation, C= Culture, B= Biochemical tests, P= Polymerase chain reaction S= Serotyping, MALDI-TOF= Matrix-assisted laser desorption/ionization-time of flight, PFGE= Pulse field gel electrophoresis Agarose = Agarose gel diffusion
Q= Quality of study, 1= Quality 1, 2= Quality 2

4	Bandekar et al., 2005	CS	IND	NM	N	38/40, 95% (88.2% to 101.8%)						RM	RO	NM	NM	MP	NM	C+B	2
5	Bao et al., 2006	CS	V	2004 to 2005	N	112/319, 35.1% (29.9% to 40.3%)						Car	SH	NM	NM	MP	Con	C+B	2
6	Begum et al., 2015	CS	IND	NM	N	27/38, 71.1% (56.6% to 85.5%)						CS	NK	NM	NM	SP	NM	C+B +P	2
7	Bodhidatta et al., 2013	CS	TH	2002 to 2003	N	32/40, 80% (67.6% to 92.4%)						RM	LBM	NM	NM	D	NM	C+B	2
8	Chattopadhyay et al., 2003	CS	IND	NM	N	48/100, 48% (38.2% to 57.8%)						CC	LBM	NM	NM	SP	NM	C+B	2
9	Chokboonmong kol et al., 2013	CS	TH	2010 to 2011	Y		11/98, 11.2% (5% to 17.5%)					CC	SH	NM	EB	SP	Pr	C+B +P	1

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10	Chokboonmongkol et al., 2013	CS	TH	2011 to 2011	Y		50/98, 51% (41.1% to 60.9%)					Sk	SH	NM	EB	SP	Pr	C+B +P	1
11	Ejaz et al., 2004	CS	PAK	NM	N	581/1000, 58.1% (55% to 61.2%)	20/20, 100% (100% to 100%)					CS	Fa	CH	EB	D	Pr	C+B	2
12	Garin et al., 2012	CS	V	2005 to 2006	N	23/150, 15.3% (9.6% to 21.1%)						Sk	SH	NM	EB	SP	Pr	C+B	2
13	Geetha, 2013	CS	IND	2010	N	28/110, 25.5% (17.3% to 33.6%)						RM	SH	CH	EB	D	NM	C+B +P	2
14	Dao et al., 2006	CS	V	NM	N	17/60, 28.3% (16.9% to 39.7%)						CM	Re	NM	NM	SP	Con	C+B	2
15	Hasan et al., 2020	CS	BD	2019	Y		30/75, 40% (28.9%					CS	Fa	CH	EB	MP	Pr	C+B +P	1

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							to 51.1%)												
16	Hasan et al., 2020	CS	BD	2019	Y		4/9, 44.4% (12% to 76.9%)					CS	Fa	CH	Coc	MP	Pr	C+B +P	1
17	Huong et al., 2006	CS	V	2005	N	31/100, 31% (21.9% to 40.1%)						RM	RO	NM	EB	D	Pr	C+B	2
18	Hussain et al., 2007	CS	PAK	2002 to 2004	N	236/492, 48% (43.6% to 52.4%)						RM	Re	NM	EB	MP	Pr	C+B	2
19	Ibrahim et al., 2018	CS	MY	NM	N	28/140, 20% (13.4% to 26.6%)						RM	LBM	NM	EB	SP	Pr	C+B +P	1
20	Kabir et al., 2019	CS	BD	2013	N	25/36, 69.4% (54.4% to 84.5%)						RM	LBM	NM	NM	D	NM	C+B	2
21	Kabir et al., 2019	CS	BD	2013	N	7/14, 50% (23.8% to 76.2%)						Sk	LBM	NM	NM	D	NM	C+B	2
22	Kalupahana et al., 2018	CS	SL	2009 to 2011	Y		346/542, 63.8% (59.8%					CC	SH	NM	EB	MP	Pr	C+B	2

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							to 67.9%)												
23	Kalupahana et al., 2009	CS	SL	NM	Y		42/59, 71.2% (59.6% to 82.7%)					M	M	NM	EB	SP	NM	C+B	2
24	Khan et al., 2018	CS	IND	2014 to 2015	N	36/150, 24% (17.2% to 30.8%)						CC	RO	NM	NM	D	NM	C+B +P	2
25	Khan et al., 2019	CS	IND	2014 to 2015	N	58/150, 38.7% (30.9% to 46.5%)						RM	RO	NM	NM	D	NM	C+B +P	2
26	Khan et al., 2020	CS	IND	2014 to 2015	Y	4/50, 8% (0.5% to 15.5%)						Fea	RO	NM	NM	D	NM	C+B +P	2
27	Kottawatta et al., 2017	CS	SL	2006 to 2007	Y		28/102, 27.5% (18.8% to 36.1%)					Sk	SH	NM	EB	NM	NM	C+B +P	2
28	Kottawatta et al., 2018	CS	SL	2006 to 2007	Y		12/25, 48% (28.4%					Sk	LBM	NM	EB	NM	NM	C+B +P	2

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							to 67.6%)												
29	Kottawatta et al., 2019	CS	SL	2006 to 2007	N	22/37, 59.5% (43.6% to 75.3%)		22/37, 59.46% (43.6% to 75.3%)				RM	RO	NM	EB	NM	NM	C+B +P	2
30	Kumar et al., 2015	CS	IND	NM	N	46/100, 46% (36.2% to 55.8%)						RM	NM	NM	EB	D	NM	C+P	2
31	Lay et al., 2011	CS	CAM	2006 to 2007	N	123/152, 80.9% (74.7% to 87.2%)						Sk	LBM	NM	NM	D	Con	C+B	2
32	Malik et al., 2014	CS	IND	NM	N	32/100, 32% (22.9% to 41.1%)						CC	M	NM	EB	D	NM	C+B +P	2
33	Mani et al., 2018	CS	IND	NM	N	16/210, 7.6% (4% to 11.2%)						CC	NK	NM	NM	SP	NM	C+B +P	2
34	Mani et al., 2019	CS	IND	NM	N	4/111, 3.6% (0.1% to 7.1%)						RM	NK	NM	NM	SP	NM	C+B +P	2
35	Mansourinajand et al., 2012	CS	MY	NM	N	34/87, 39.1%						CS	LBM	CH	EB	SP	NM	C+B	2

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						(28.8% to 49.3%)													
36	Mansourinajand et al., 2012	CS	MY	NM	N	53/87, 60.9% (50.7% to 71.2%)						CC	LBM	CH	EB	SP	NM	C+B	2
37	Islam et al., 2018	CS	BD	NM	N	15/20, 75% (56% to 94%)				15/20, 75% (56% to 94%)		RM	LBM	CH	EB	MP	Pr	C+B +P	1
38	Mohamed-Yousif et al., 2019	CS	MY	NM	N	61/101, 60.4% (50.9% to 69.9%)						CS	Fa	NM	EB	SP	NM	C+B +P	2
39	Monika et al., 2016	CS	IND	NM	N	34/251, 13.5% (9.3% to 17.8%)						RM	NK	NM	NM	SP	NM	C+B +P	2
40	Neogi et al., 2020	CS	BD	2015 to 2016	N	21/49, 42.9% (29% to 56.7%)						CS	Fa	CH	EB	MP	NM	C+B +P	2
41	Neogi et al., 2020	CS	BD	2015 to 2016	N	8/28, 28.6% (11.8% to 45.3%)						RM	Fa	CH	EB	MP	NM	C+B +P	2

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42	Neogi et al., 2020	CS	BD	2015 to 2016	N	14/27, 51.9% (33% to 70.7%)						RM	LBM	CH	EB	MP	NM	C+B +P	2
43	Neogi et al., 2020	CS	BD	2015 to 2016	N	0/33, 0% (-0.1% to 0.1%)						Mec	H	CH	EB	MP	NM	C+B +P	2
44	Nisar et al., 2017	CS	PAK	2014 to 2015	N	58/200, 29% (22.7% to 35.3%)						RM	SS	CH	EB	D	NM	C+B +P	2
45	Osbjer et al., 2016	CS	CAM	2011 to 2013	N	198/353, 56.1% (50.9% to 61.3%)						CS	HH	CH	I	MP	Con	C+B +P	2
46	Osiriphun et al., 2011	CS	TH	NM	N	123/240, 51.3% (44.9% to 57.6%)						Car	SH	CH	EB	SP	Pr	C+B	2
47	Lim et al., 2017	CS	PH	NM	N	18/41, 43.9% (28.7% to 59.1%)						RM	M	NM	EB	SP	NM	C+B	2
48	Lim et al., 2017	CS	PH	NM	N	31/41, 75.6% (62.5% to 88.8%)						CC	M	NM	EB	SP	NM	C+B	2

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49	Lim et al., 2017	CS	PH	NM	N	36/42, 85.7% (75.1% to 96.3%)						In	M	NM	EB	SP	NM	C+B	2
50	Lim et al., 2017	CS	PH	NM	N	17/19, 89.5% (75.7% to 103.3%)						Gi	M	NM	EB	SP	NM	C+B	2
51	Lim et al., 2017	CS	PH	NM	N	37/38, 97.4% (92.3% to 102.5%)						Li	M	NM	EB	SP	NM	C+B	2
52	Lim et al., 2017	CS	PH	NM	N	37/42, 88.1% (78.3% to 97.9%)						Sk	M	NM	EB	SP	NM	C+B	2
53	Lim et al., 2017	CS	PH	NM	N	31/42, 73.8% (60.5% to 87.1%)						RM	M	NM	EB	SP	NM	C+B	2
54	Padungtod et al., 2005	CS	TH	2002 to 2003	N	265/534, 49.6% (45.4% to 53.9%)						CS	Fa	CH	EB	MP	Con	C+B +P	2

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55	Padungtod et al., 2005	CS	TH	2002 to 2003	N	26/73, 35.6% (24.6% to 46.6%)						CS	SH	CH	EB	MP	Con	C+B +P	2
56	Padungtod et al., 2005	CS	TH	2002 to 2003	N	28/72, 38.9% (27.6% to 50.1%)						RM	LBM	CH	EB	MP	Con	C+B +P	2
57	Prachantasena et al., 2017	CS	TH	2012 to 2014	Y		252/442, 57% (52.4% to 61.6%)					CC	Fa	CH	EB	MP	NM	C+B +P	2
58	Prachantasena et al., 2017	CS	TH	2012 to 2014	N	89/138, 64.5% (56.5% to 72.5%)						CS	Fa	CH	BB	MP	NM	C+B +P	2
59	Prachantasena et al., 2017	CS	TH	2013 to 2014	N	0/36, 0% (0.0% to 0.0%)						ES	H	CH	H	MP	NM	C+B +P	3
60	Prachantasena et al., 2017	CS	TH	2012 to 2014	N	250/1010, 24.8% (22.1% to 27.4%)						CS	Fa	CH	EB	MP	NM	C+B +P	2

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61	Prachantasena et al., 2017	CS	TH	2012 to 2014	N	172/268, 64.2% (58.4% to 69.9%)						CS	SH	CH	EB	MP	NM	C+B +P	2
62	Raja et al., 2018	CS	IND	NM	N	0/36, 0% (-0.1% to 0.1%)						RM	RO	CH	EB	D	NM	P	2
63	Rajkumar, 2010	CS	IND	NM	N	42/300, 14% (10.1% to 17.9%)						Sk	SH	CH	NM	D	NM	C+B	2
64	Rawat et al., 2018	CS	IND	NM	N	18/116, 15.5% (8.9% to 22.1%)						CC	NK	CH	EB	D	Pr	C+B +P	2
65	Reddy et al., 2019	CS	TH	NM	N	38/135, 28.1% (20.6% to 35.7%)						Sk	SH	CH	EB	D	NM	C+B	2
66	Reddy et al., 2019	CS	TH	NM	N	61/135, 45.2% (36.8% to 53.6%)						In	SH	CH	EB	D	NM	C+B	2
67	Reddy et al., 2019	CS	TH	NM	N	27/120, 22.5% (15% to 30%)						RM	RO	CH	EB	D	NM	C+B	2

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68	Rejab et al., 2012	CS	MY	2008 to 2009	N	28/30, 93.3% (84.4% to 102.3%)						Sk	LBM	CH	EB	MP	NM	C+B	2
69	Rejab et al., 2012	CS	MY	2008 to 2009	N	131/216, 60.6% (54.1% to 67.2%)						Sk	SH	CH	EB	MP	NM	C+B	2
70	Rizal et al., 2016	CS	IND	NM	N	60/250, 24% (18.7% to 29.3%)						In	SH	CH	EB	MP	NM	C+B	2
71	Parkar et al., 2013	CS	IND	2008 to 2009	N	143/240, 59.6% (53.4% to 65.8%)						CC	SH	NM	EB	SP	Pr	C+B	2
72	Parkar et al., 2013	CS	IND	2008 to 2009	N	137/240, 57.1% (50.8% to 63.3%)						Car	SH	NM	EB	SP	Pr	C+B	2
73	Saiyudthong et al., 2015	CS	TH	2013 to 2014	N	83/122, 68% (59.8% to 76.3%)						M	SS	NM	EB	SP	NM	C+B +P	2
74	Saiyudthong et al., 2015	CS	TH	2013 to 2014	N	97/108, 89.8%						M	LBM	NM	EB	SP	NM	C+B +P	2

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						(84.1% to 95.5%)													
75	Samad et al., 2018	CS	PAK	2016	N	32/100, 32% (22.9% to 41.1%)						PM	LBM	CH	EB	SP	NM	C+B +P	2
76	Samad et al., 2018	CS	PAK	2016	N	48/100, 48% (38.2% to 57.8%)						RM	LBM	CH	EB	SP	NM	C+B +P	2
77	Rahul et al., 2016	CS	IND	2014 to 2016	N	43/370, 11.6% (8.4% to 14.9%)						CS	Fa	CH	EB	SP	NM	C+B	2
78	Sharma et al., 2016	CS	IND	NM	N	72/100, 72% (63.2% to 80.8%)						RM	LBM	CH	EB	SP	NM	C+B	2
79	Siddiqui et al., 2015	CS	PAK	2011 to 2012	N	31/88, 35.2% (25.2% to 45.2%)						CS	SH	CH	EB	NM	NM	C+P	2
80	Singh et al., 2009	CS	IND	NM	N	5/35, 14.3% (2.7% to 25.9%)						RM	M	CH	EB	SP	NM	C+B	2
81	Singh et al., 2009	CS	IND	NM	N	6/51, 11.8% (2.9% to 20.6%)						Car	M	CH	EB	SP	NM	C+B	2

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82	Sinulingga et al., 2019	CS	MY	NM	N	107/210, 51% (44.2% to 57.7%)	6/7, 85.7% (59.8% to 111.6%)					CS	Fa	CH	EB	SP	Pr	C+B +P	1
83	Sinulingga et al., 2019	CS	MY	NM	N	12/85, 14.1% (6.7% to 21.5%)				11/11, 100% (100% to 100%)		RM	LBM	CH	EB	SP	Pr	C+B +P	1
84	Sinulingga et al., 2019	CS	MY	NM	N	17/25, 68% (49.7% to 86.3%)					5/5, 100%(100% to 100%)	RM	SS	CH	EB	SP	Pr	C+B +P	1
85	Sison et al., 2014	CS	PH	2013	N	57/120, 47.5% (38.6% to 56.4%)						RM	LBM	CH	EB	SP	Pr	C+B	1
86	Upadhyay et al., 2016	CS	IND	NM	N	34/251, 13.5% (9.3% to 17.8%)						RM	NK	NM	EB	SP	NM	C+B	2
87	Vaishnavi et al., 2014	CS	IND	NM	N	57/127, 44.9%						In	Fa	NM	EB	SP	NM	C+B	2

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						(36.2% to 53.5%)													
88	Vindigni et al., 2007	CS	TH	2003	N	10/27, 37% (18.8% to 55.3%)						RM	LBM	CH	EB	SP	Con	C+B	2
89	Vindigni et al., 2007	CS	TH	2003	N	16/23, 69.6% (50.8% to 88.4%)						RM	SS	CH	EB	SP	Con	C+B	2
90	Vivekanandhan et al., 2020	CS	IND	NM	N	3/54, 5.6% (-0.6% to 11.7%)						CC	HH	CH	I	D	Pr	C+P	2
91	Wai et al., 2012	CS	PAK	2010	N	52/57, 91.2% (83.9% to 98.6%)						CC	LBM	CH	EB	D	Pr	C+B	2
92	Wai et al., 2012	CS	PAK	2010	N	23/32, 71.9% (56.3% to 87.5%)						CC	LBM	CH	I	D	Pr	C+B	2
93	Kulasooriya et al., 2019	CS	IND	2014	N	8/51, 15.7% (5.7% to 25.7%)						RM	M	NM	NM	D	Pr	C+B	2

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Sam= Sample unit, ST=Type of sample, RM= Raw meat, Cl= Cloacal swab, CC= Caecal content, Sk= Skin, Car= Carcass, CM=Cooked meat, RTE= Ready to eat meat, In= Intestine, Fea= Feather, PM= Processed meat, Li= Liver, Mec= Chick meconium, Gi= Gizzard, M= Mixed, ES= Egg surface swab, EC= Egg content, E= Egg (shell or content not specified), BE= Boiled egg, Hr= Heart, K= Kidney, Yo= Yolk sac, O= Ovary, Spl= Spleen, Lu= Lungs, DE= Dead embryo, Ovi= Oviduct, Cr= Crop, Mo= Mouth
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Q= Quality of study, 1= Quality 1, 2= Quality 2

94	Kulasooriya et al., 2019	CS	IND	2014	N	1/23, 4.3% (-4% to 12.7%)						CM	M	NM	NM	D	Pr	C+B	2
95	Nayak et al., 2005	CS	IND	NM	N	18/60, 30% (18.4% to 41.6%)						Li	RO	NM	NM	SP	NM	C+B +P	2

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Appendix B. Summary table for the selected non-typhoidal *Salmonella* (NTS) conducted in south and southeast Asia from 2000 to 2020 in chicken and chicken eggs

SN	Reference	SD	Co	SP	Po	Sampling unit n/N, % (95% CI)				ST	S	PT	HS	L	SA	MC	Q
						Sam	Fa	LBM	SS								
1	Akbar and Anal, 2015	CS	PAK	NM	N	1/181, 0.6% (-0.5% to 1.6%)				RTE	SS	NM	NM	NM	NM	C+B+P	2
2	Sinwat et al., 2015	CS	TH	2010 to 2013	N	80/221, 36.2% (29.9% to 42.5%)				RM	SH	EB	NM	MP	NM	C+B+P	2
3	Thung et al., 2016	CS	MY	2014	N	16/60, 26.7% (15.5% to 37.9%)				RM	LBM	NM	NM	D	Pr	C+B+P+Se	2
4	Thung et al., 2016	CS	MY	2014	N	9/60, 15% (6% to 24%)				RM	SS	NM	NM	D	Pr	C+B+P+Se	2
5	Niyomdecha et al., 2016	CS	TH	2015	N	25/40, 62.5% (47.5% to 77.5%)				RM	RO	NM	NM	MP	Pr	C+B	2
6	Trongjit et al., 2017	CS	TH	2014 to 2015	N	10/90, 11.1% (4.6% to 17.6%)				RM	SH	NM	NM	SP	NM	C+B+P	2
7	Trongjit et al., 2017	CS	TH	2014 to 2015	N	1/84, 1.2% (-1.1% to 3.5%)				Car	SH	NM	NM	SP	NM	C+B+P	2
8	Trongjit et al., 2017	CS	TH	2014 to 2015	N	69/105, 65.7% (56.6% to 74.8%)				Car	LBM	NM	NM	SP	NM	C+B+P	2

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9	Trongjit et al., 2017	CS	CAM	2014 to 2015	N	6/100, 6% (1.4% to 10.7%)				RM	SH	NM	NM	SP	NM	C+B+P	2
10	Trongjit et al., 2017	CS	CAM	2014 to 2015	N	72/87, 82.8% (74.8% to 90.7%)				Car	LBM	NM	NM	SP	NM	C+B+P	2
11	Kaluaphana et al., 2016	CS	SL	NM	Y	12/100, 12% (5.6% to 18.4%)				ES	RO	NA	NA	D	Pr	C+B	2
12	Kaluaphana et al., 2016	CS	SL	NM	Y	3/100, 3% (-0.3% to 6.3%)				EC	RO	NA	NA	D	Pr	C+B	2
13	Moe et al., 2017	CS	MM	2014 to 2015	N	138/141, 97.9% (95.5% to 100.3%)		138/141, 97.9% (93.9% to 99.6%)		RM	RO	NM	NM	D	SPr	C+B+Se	2
14	Abatcha et al., 2018	CS	MY	2015 to 2016	N	17/35, 48.6% (32% to 65.1%)				Car	LBM	NM	NM	MP	NM	C+B	2
15	Aditya, 2015	CS	BD	2014	N	16/50, 32% (19.1% to 44.9%)				RM	LBM	EB	CH	SP	NM	C+B+P	2
16	Akbar et al., 2013	CS	TH	NM	N	11/210, 5.2% (2.2% to 8.3%)				RM	LBM	NM	NM	SP	Pr	C+B	2
17	Akhtar et al., 2009	CS	PAK	NM	N	48/120, 40% (31.2% to 48.8%)				ES	NM	NA	NA	D	NM	C+B	2
18	Akhtar et al., 2009	CS	PAK	NM	N	10/120, 8.3% (3.4% to 13.3%)				EC	NM	NA	NA	D	NM	C+B	2
19	Akhtar et al., 2009	CS	PAK	NM	N	55/85, 64.7% (54.6% to 74.9%)				RM	NM	NM	NM	D	NM	C+B	2

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20	Alam et al., 2020	CS	BD	2017	N	24/50, 48% (34.2% to 61.9%)				Cl	Fa	NM	NM	SP	Pr	C+B+P	1
21	Ananchaipattana et al., 2016	CS	TH	2013 to 2015	N	1/30, 3.3% (-3.1% to 9.8%)				CM	Re	NM	NM	MP	Pr	C+B	2
22	Ananchaipattana et al., 2016	CS	TH	2013 to 2015	N	0/15, 0% (0% to 0%)				RTE	SS	NM	NM	MP	Pr	C+B	2
23	Angkititrakul et al., 2005	CS	TH	2003	N	30/40, 75% (61.6% to 88.4%)				RM	RO	NM	NM	SP	NM	C+B+Se	2
24	Anukampa et al., 2017	CS	IND	2014 to 2016	N	12/47, 25.5% (13.1% to 38%)				RM	Re	NM	NM	MP	Con	C+B+P	2
25	Anukampa et al., 2018	CS	IND	2014 to 2016	N	1/6, 16.7% (-13.2% to 46.5%)				CM	Re	NM	NM	MP	Con	C+B+P	2
26	Anukampa et al., 2019	CS	IND	2014 to 2016	N	1/6, 16.7% (-13.2% to 46.5%)				PM	Re	NM	NM	MP	Con	C+B+P	2
27	Anukampa et al., 2020	CS	IND	2014 to 2016	N	1/18, 5.6% (-5% to 16.1%)				BE	Re	NA	NA	MP	Con	C+B+P	2
28	Anukampa et al., 2021	CS	IND	2014 to 2016	N	1/18, 5.6% (-5% to 16.1%)				E	Re	NA	NA	MP	Con	C+B+P	2
29	Arora et al., 2015	CS	IND	2011 to 2013	Y		253/309, 81.9% (77.1% to 86%)			M	Lab	EB	Sick	SP	Pur	C+B+Se	2
30	Asif et al., 2017	CS	PAK	2014 to 2015	N	4/30, 13.3% (1.2% to 25.5%)				Hr	RO	EB	NM	D	SPr	C+B+P	2

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31	Asif et al., 2017	CS	PAK	2014 to 2015	N	6/30, 20% (5.7% to 34.3%)				K	RO	EB	NM	D	SPr	C+B+P	2
32	Asif et al., 2017	CS	PAK	2014 to 2015	N	8/30, 26.7% (10.8% to 42.5%)				Li	RO	EB	NM	D	SPr	C+B+P	2
33	Asif et al., 2017	CS	PAK	2014 to 2015	N	17/60, 28.3% (16.9% to 39.7%)				RM	RO	EB	NM	D	SPr	C+B+P	2
34	Aung et al., 2018	CS	SIN	2010 to 2013	N	2/136, 1.5% (-0.6% to 3.5%)				CM	Re	NM	NM	MP	Con	C+B+Se	2
35	Mat Zin et al., 2017	CS	MY	2014	N	5/55, 9.1% (1.5% to 16.7%)				CM	Re	NM	NM	SP	NM	C+B	2
36	Badhe et al., 2013	CS	IND	NM	N	141/210, 67.1% (60.8% to 73.5%)				RM	RO	NM	NM	SP	NM	C+B	2
37	Badhe et al., 2013	CS	IND	NM	N	23/70, 32.9% (21.9% to 43.9%)				RM	SH	NM	NM	SP	NM	C+B	2
38	Bangtrakulnonth et al., 2006	CS	TH	2004 to 2005	N	39/50, 78% (66.5% to 89.5%)				RM	M	NM	NM	SP	NM	C+B	2
39	Bantawa et al., 2018	CS	NP	2017	N	9/15, 60% (35.2% to 84.8%)				RM	RO	NM	NM	D	NM	C+B	2
40	Biswas et al, 2005	CS	BD	2002 to 2003	N	87/1227, 7.1% (5.7% to 8.5%)				M	HH	HB	Dead	MP	PPr	C+B	2
41	Biswas et al., 2006	CS	BD	2003 to 2004	N	21/349, 6% (3.5% to 8.5%)				M	HH	Son	Dead	MP	PPr	C+B	2
42	Bodhidatta et al., 2013	CS	TH	2002 to 2003	N	37/40, 92.5% (84.3% to 100.7%)				RM	RO	NM	NM	SP	NM	C+B	2

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43	Chaisatit et al., 2012	CS	TH	2010 to 2011	N	14/75, 18.7% (9.9% to 27.5%)				RM	SS	NM	NM	SP	SPr	C+B+P	2
44	Chotinun et al., 2014	CS	TH	2011 to 2012	N	6/41, 14.6% (3.8% to 25.5%)				Cl	SH	NM	NM	SP	NM	C+B	2
45	Chotinun et al., 2014	CS	TH	2011 to 2012	N	16/41, 39% (24.1% to 54%)				Car	SH	NM	NM	SP	NM	C+B	2
46	Nguyen et al., 2012	CS	V	2012 to 2015	N	47/72, 65.3% (54.3% to 76.3%)				RM	SH	NM	NM		NM	C+B+P	2
47	Dahal et al., 2008	CS	BH	2006 to 2007	N	52/400, 13% (9.7% to 16.3%)				Car	RO	EB	NM	SP	SPr	C+B	2
48	Das et al., 2012	CS	IND	NM	N	12/32, 37.5% (20.7% to 54.3%)				RM	SH	NM	NM	D	NM	C+B+P	2
49	Das et al., 2012	CS	IND	NM	N	6/25, 24% (7.3% to 40.7%)				E	RO	NA	NA	D	NM	C+B+P	2
50	Kumar et al., 2015	CS	IND	NM	N	7/52, 13.5% (4.2% to 22.7%)				Li	Fa	EL	NM	MP	SPr	C+B+Se	1
51	Kumar et al., 2015	CS	IND	NM	N	3/188, 1.6% (-0.2% to 3.4%)				Cl	Fa	EL	NM	MP	SPr	C+B+Se	1
52	Ellerbroek et al., 2010	CS	V	NM	N	52/400, 13% (9.7% to 16.3%)				Sk	NM	NM	NM	NM	NM	C+B	2
53	Fardows and Shamsuzzaman, 2015	CS	BD	NM	N	4/8, 50% (15.4% to 84.7%)				ES	Fa	NA	NA	D	SPr	C+B	2

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54	Fardows and Shamsuzzaman, 2015	CS	BD	NM	N	1/8, 12.5% (-10.4% to 35.4%)				EC	RO	NA	NA	D	SPr	C+B	2
55	Gautam et al., 2017	CS	IND	NM	N	25/48, 52.1% (38% to 66.2%)				RM	SS	NM	NM	D	NM	C+B	2
56	Gautam et al., 2017	CS	IND	NM	N	1/39, 2.6% (-2.4% to 7.5%)				PM	SS	NM	NM	D	NM	C+B	2
57	Geidam et al., 2012	CS	MY	2011	N		1/3, 33.3% (0.8% to 90.6%)			Cl	Fa	NM	NM	D	NM	C+B	2
58	Dao et al., 2006	CS	V	NM	N	5/60, 8.3% (1.3% to 15.3%)				RM	Re	NM	NM	SP	NM	C+B	2
59	Hanh et al., 2006	CS	V	2001 to 2004	N	28/907, 3.1% (2% to 4.2%)				M	Fa	Br	NM	MP	SPr	C+B	2
60	Hanh et al., 2006	CS	V	2001 to 2004	N	26/412, 6.3% (4% to 8.7%)				DE	Fa	Br	Dead	MP	SPr	C+B	2
61	Huong et al., 2006	CS	V	2004 to 2005	N	128/262, 48.9% (42.8% to 54.9%)				RM	LBM	NM	NM	SP	Pr	C+B+Se	2
62	Jajere et al., 2019	CS	MY	2016 to 2018	N	17/675, 2.5% (1.3% to 3.7%)				Cl	Fa	NM	NM	MP	NM	C+B	2
63	Jajere et al., 2019	CS	MY	2016 to 2018	N	0/62, 0% (0% to 0%)				E	Fa	NA	NA	MP	NM	C+B	2

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64	Kalupahana et al., 2017	CS	SL	NM	N	12/15, 80% (59.8% to 100.2%)				ES	RO	NA	NA	D	Pr	C+B+Se	2
65	Kalupahana et al., 2017	CS	SL	NM	N	3/15, 20% (-0.2% to 40.2%)				EC	RO	NA	NA	D	Pr	C+B+Se	2
66	Nagappa et al., 2007	CS	IND	NM	N	1/100, 1% (-1% to 3%)				RM	RO	NM	NM	D	NM	C+B+P	2
67	Nagappa et al., 2007	CS	IND	NM	N	3/100, 3% (-0.3% to 6.3%)				E	RO	NA	NA	D	NM	C+B+P	2
68	Kaushik et al., 2014	CS	IND	2010 to 2013	N	54/228, 23.7% (18.2% to 29.2%)				RM	RO	NM	NM	D	SPr	C+B+Se+P	2
69	Khan et al., 2015	CS	IND	NM	N	24/140, 17.1% (10.9% to 23.4%)				CC	Fa	EL	NM	D	NM	C+B+Se	2
70	Khan et al., 2015	CS	IND	NM	N	0/60, 0% (0% to 0%)				Cl	Fa	EL	NM	D	NM	C+B+Se	2
71	Khan et al., 2015	CS	IND	NM	N	0/12, 0% (0% to 0%)				RM	Fa	EL	NM	D	NM	C+B+Se	2
72	Khan et al., 2015	CS	IND	NM	N	0/20, 0% (0% to 0%)				EC	Fa	NA	NA	D	NM	C+B+Se	2
73	Khan t al., 2019	CS	PAK	NM	N	18/250, 7.2% (4% to 10.4%)				Cl	Fa	NM	CH	MP	NM	C+B+Se+P	2
74	Khan t al., 2019	CS	PAK	NM	N	30/100, 30% (21% to 39%)				In	LBM	NM	CH	MP	NM	C+B+Se+P	2
75	Khan t al., 2019	CS	PAK	NM	N	5/100, 5% (0.7% to 9.3%)				Li	LBM	NM	CH	MP	NM	C+B+Se+P	2

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76	Khan t al., 2019	CS	PAK	NM	N	0/100, 0% (0% to 0%)				K	LBM	NM	CH	MP	NM	C+B+Se+P	2
77	Khan t al., 2019	CS	PAK	NM	N	25/100, 25% (16.5% to 33.5%)				RM	LBM	NM	CH	MP	NM	C+B+Se+P	2
78	Kit et al., 2015	CS	MY	NM	N	1/27, 3.7% (-3.4% to 10.8%)				E	LBM	NA	NA	MP	Sys Pr	C+B	2
79	Kit et al., 2015	CS	MY	NM	N	1/27, 3.7% (-3.4% to 10.8%)				E	LBM	NA	NA	MP	Sys Pr	C+B	2
80	Kumar et al., 2010	CS	IND	2005 to 2008	N	105985/2000000, 6.6% (6.5% to 6.6%)				NM	Fa	EB	Sick	SP	Pur	C+B	2
81	Latha et al., 2017	CS	IND	NM	N	0/325, 0% (0% to 0%)				CM	Re	NM	NM	SP	NM	C+B+P	2
82	Lay et al., 2011	CS	CAM	2006 to 2007	N	134/152, 88.2% (83% to 93.3%)				Car	RO	NM	NM	D	Pr	C+B	2
83	Maharjan et al., 2006	CS	NP	2002 to 2003	N	8/55, 14.6% (5.2% to 23.9%)				RM	RO	NM	NM	D	NM	C+B+Se	2
84	Mahato, 2019	CS	NP	2017 to 2018	N	17/40, 42.5% (27.2% to 57.8%)				RM	RO	NM	NM	D	Pr	C+B	2
85	Mahmud et al., 2011	CS	BD	2009 to 2010	Y	71/416, 17.1% (13.5% to 20.7%)				Cl	Fa	NM	CH	D	NM	C+B+Agaose	2
86	Mahmud et al., 2011	CS	BD	2009 to 2010	Y	35/87, 40.2% (29.9% to 50.5%)				M	Fa	NM	Dead	D	NM	C+B+Agaose	2
87	Mallhi et al., 2019	CS	PAK	2017	N	4/30, 13.3% (1.2% to 25.5%)				RM	RO	NM	NM	D	NM	C+B	2

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88	Manguiat et al., 2013	CS	PH	2010 to 2011	N	21/69, 30.4% (19.6% to 41.3%)				CM	Re	NM	NM	SP	NM	C+B+P	2
89	Maripandi et al., 2010	CS	IND	2003 to 2005	N	92/578, 15.9% (12.9% to 18.9%)				RM	RO	NM	NM	D	NM	C+B	2
90	Mathew et al., 2009	CS	TH	NM	N	53/427, 12.4% (9.3% to 15.5%)				Cl	Fa	EB	NM	NM	NM	C+B+P	2
91	Menghistu et al., 2011	CS	IND	2008 to 2009	N	6/220, 2.7% (0.6% to 4.9%)				M	Lab	NM	Dead	D	Pr	C+B+P	2
92	Menghistu et al., 2011	CS	IND	2008 to 2009	N	1/40, 2.5% (-2.3% to 7.3%)				E	RO	NA	NA	D	Pr	C+B+P	2
93	Minami et al., 2010	CS	TH	2006 to 2007	N	4/7, 57.1% (20.5% to 93.8%)				RM	SS	NM	NM	MP	Con	C+B+P+Se	2
94	Minami et al., 2010	CS	TH	2006 to 2007	N	13/27, 48.2% (29.3% to 67%)				RM	RO	NM	NM	MP	Con	C+B+P+Se	2
95	Mir et al., 2010	CS	IND	2007 to 2008	N	23/51, 45.1% (31.4% to 58.8%)				In	Fa	NM	Dead	SP	NM	C+B+Se+PFGE	2
96	Mir et al., 2015	CS	IND	2013 to 2014	N	18/202, 8.9% (5% to 12.8%)				CC	SH	NM	NM	SP	NM	C+B+P+Se	2
97	Mridha et al., 2020	CS	BD	2017	N	59/128, 46.1% (37.5% to 54.7%)				Cl	Fa	EB	NM	MP	Con	C+B+P+Se	2
98	Murugkar et al., 2005	CS	IND	2003 to 2004	N	34/231, 14.7% (10.2% to 19.3%)				Cl	Fa	NM	Sick	MP	Pur	C+B+Se	2
99	Naik et al., 2015	CS	IND	2013 to 2014	N	7/200, 3.5% (1% to 6.1%)				RM	RO	NM	NM	SP	NM	C+B+P	2

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100	Neunchat et al., 2017	CS	TH	2015	N	54/123, 43.9% (35.1% to 52.7%)				RM	RO	NM	NM	SP	NM	C+B+Se	2
101	Neunchat et al., 2017	CS	TH	2015	N	9/404, 2.2% (0.8% to 3.7%)				ES	RO	NA	NA	SP	NM	C+B+Se	2
102	Nghiem et al.,2019	CS	V	NM	N	11/30, 36.7% (19.4% to 53.9%)				RM	LBM	NM	NM	SP	NM	C+B+P	2
103	Nhung et al., 2018	CS	V	2016 to 2017	N			18/20, 90% (68.3% to 98.8%)		RM	LBM	NM	NM	MP	NM	C+B+P	2
104	Nhung et al., 2018	CS	V	2016 to 2017	N				10/19, 52.6% (28.9% to 75.5%)	RM	SS	NM	NM	MP	NM	C+B+P	2
105	Nidaullah et al., 2017	CS	MY	2014 to 2015	N	30/30, 100% (100% to 100%)				Car	SH	NM	NM		NM	C+B+Se	2
106	Niyomdecha et al., 2016	CS	TH	2015	N	25/40, 62.5% (47.5% to 77.5%)				RM	RO	NM	NM	MP	NM	C+B+S	2
107	Novera et al., 2020	CS	INDO	NM	N	30/107, 28% (19.5% to 36.6%)				CM	Re	NM	NM	NM	NM	C+B+P	2
108	Adesiji et al.,2018	CS	IND	NM	N	8/78, 10.3% (3.5% to 17%)				RM	RO	NM	NM	D	NM	C+B+P	2

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109	Padungtod et al., 2006	CS	TH	2000 to 2003	N	18/425, 4.2% (2.3% to 6.2%)				Cl	Fa	NM	NM	MP	NM	C+B+Se	2
110	Padungtod et al., 2006	CS	TH	2000 to 2003	N	31/73, 42.5% (31.1% to 53.8%)				Cl	SH	NM	NM	MP	NM	C+B+Se	2
111	Padungtod et al., 2006	CS	TH	2000 to 2003	N	41/72, 56.9% (45.5% to 68.4%)				RM	LBM	NM	NM	MP	NM	C+B+Se	2
112	Parvej et al., 2016	CS	BD	NM	N	11/150, 7.3% (3.2% to 11.5%)				Cl	Fa	NM	CH	D	NM	C+B+Se+P +PFGE	2
113	Patoli et al., 2019	CS	IND	2016 to 2017	N	7/10, 70% (41.6% to 98.4%)				ES	RO	NA	NA	D	NM	C+B	2
114	Patoli et al., 2019	CS	IND	2016 to 2017	N	14/50, 28% (15.6% to 40.5%)				RM	RO	NM	NM	D	NM	C+B	2
115	Prasertsee et al., 2019	CS	TH	2017	N	6/20, 30% (9.9% to 50.1%)				RM	SS	NM	NM	MP	Pr	C+B+P	1
116	Prasertsee et al., 2019	CS	TH	2017	N	5/30, 16.7% (3.3% to 30%)				RM	RO	NM	NM	MP	Pr	C+B+P	1
117	Prasertsee et al., 2019	CS	TH	2017	N	30/70, 42.9% (31.3% to 54.5%)				RM	LBM	NM	NM	MP	Pr	C+B+P	1
118	Puangburee et al.,2016	CS	TH	NM	N	4/20, 20% (2.5% to 37.5%)				EC	Re	NA	NA	NM	NM	C+B+P	2
119	Reddy et al., 2019	CS	TH	NM	N	42/135, 31.1% (23.3% to 38.9%)				Sk	SH	EB	NM	SP	NM	C+B	2
120	Reddy et al., 2019	CS	TH	NM	N	29/135, 21.5% (14.6% to 28.4%)				In	SH	EB	NM	SP	NM	C+B	2

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121	Reddy et al., 2019	CS	TH	NM	N	49/120, 40.8% (32% to 49.6%)				Car	RO	EB	NM	SP	NM	C+B	2
122	Ruban and fairoze, 2011	CS	IND	2008 to 2009	N	134/280, 47.9% (42% to 53.7%)				RM	SH	NM	NM	D	NM	C+B	2
123	Sajid et al., 2015	CS	PAK	2010 to 2013	N	13/207, 6.3% (3% to 9.6%)				Lu	M	NM	NM	MP	Con	C+B	2
124	Sajid et al., 2015	CS	PAK	2010 to 2013	N	9/132, 6.8% (2.5% to 11.1%)				hr	M	NM	NM	MP	Con	C+B	2
125	Sajid et al., 2015	CS	PAK	2010 to 2013	N	27/205, 13.2% (8.5% to 17.8%)				LI	M	NM	NM	MP	Con	C+B	2
126	Sajid et al., 2015	CS	PAK	2010 to 2013	N	8/158, 5.1% (1.6% to 8.5%)				Spl	M	NM	NM	MP	Con	C+B	2
127	Sajid et al., 2015	CS	PAK	2010 to 2013	N	6/127, 4.7% (1% to 8.4%)				K	M	NM	NM	MP	Con	C+B	2
128	Sajid et al., 2015	CS	PAK	2010 to 2013	N	23/240, 9.6% (5.9% to 13.3%)				O	M	NM	NM	MP	Con	C+B	2
129	Sajid et al., 2015	CS	PAK	2010 to 2013	N	22/228, 9.7% (5.8% to 13.5%)				E	H	NA	NA	MP	Con	C+B	2
130	Saha et al., 2016	CS	IND	2011	N	6/150, 4% (0.9% to 7.1%)				RM	RO	NM	NM	D	Pr	C+B	2
131	Saharan et al., 2020	CS	IND	2015 to 2018	N	58/80, 72.5% (62.7% to 82.3%)				CC	RO	NM	NM	SP	NM	C+B+P	2
132	Saikia and Joshi, 2010	CS	IND	2007 to 2008	N	22/110, 20% (12.5% to 27.5%)				M	RO	NM	NM	MP	NM	C+B	2

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133	Samad et al., 2018	CS	PAK	2016	N	24/100, 24% (15.6% to 32.4%)				RM	RO	NM	NM	D	Pr	C+B+P	2
134	Samad et al., 2018	CS	PAK	2016	N	28/100, 28% (19.2% to 36.8%)				PM	RO	NM	NM	D	Pr	C+B+P	2
135	Samad et al., 2018	CS	PAK	2016	N	66/200, 33% (26.5% to 39.5%)				RM	RO	NM	NM	D	Pr	C+B+P	2
136	Samanta et al., 2019	CS	IND	NM	N	6/40, 15% (3.9% to 26.1%)				Cl	HH	RIR	CH	SP	NM	C+B+P+Se	2
137	Saravanan et al., 2015	CS	IND	NM	N	1/21, 4.8% (-4.4% to 13.9%)				Yo	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
138	Saravanan et al., 2015	CS	IND	NM	N	5/104, 4.8% (0.7% to 8.9%)				LI	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
139	Saravanan et al., 2015	CS	IND	NM	N	2/96, 2.1% (-0.8% to 4.9%)				O	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
140	Saravanan et al., 2015	CS	IND	NM	N	2/103, 1.9% (-0.7% to 4.6%)				In	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
141	Saravanan et al., 2015	CS	IND	NM	N	0/11, 0% (0% to 0%)				Spl	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
142	Saravanan et al., 2015	CS	IND	NM	N	2/57, 3.5% (-1.3% to 8.3%)				M	Fa	EL	Dead	MP	NM	C+B+P+PFGE	2
143	Saravanan et al., 2015	CS	IND	NM	N	0/213, 0% (0% to 0%)				E	Fa	NA	NA	MP	NM	C+B+P+PFGE	2
144	Saravanan et al., 2015	CS	IND	NM	N	0/174, 0% (0% to 0%)				RM	Fa	EL	NM	MP	NM	C+B+P+PFGE	2

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145	Saud et al., 2019	CS	NP	2017	N	6/70, 8.6% (2% to 15.1%)				RM	RO	NM	NM	D	SPr	C+B	2
146	Selvaraj et al., 2010	CS	IND	NM	NM	2/38, 5.3% (-1.8% to 12.4%)				In	RO	NM	NM	NM	NM	C+B	2
147	Selvaraj et al., 2010	CS	IND	NM	NM	3/60, 5% (-0.5% to 10.5%)				M	RO	NM	NM	NM	NM	C+B	2
148	Selvaraj et al., 2010	CS	IND	NM	NM	2/25, 8% (-2.6% to 18.6%)				RM	RO	NM	NM	NM	NM	C+B	2
149	Selvaraj et al., 2010	CS	IND	NM	N	1/17, 5.9% (-5.3% to 17.1%)				ES	RO	NA	NA	NM	NM	C+B	2
150	Shafini et al., 2017	CS	MY	NM	N	52/72, 72.2% (61.9% to 82.6%)				RM	M	NM	NM	SP	NM	C+B+MALDI-TOF	2
151	Shafini et al., 2017	CS	MY	NM	N	7/30, 23.3% (8.2% to 38.5%)				RM	M	NM	NM	SP	NM	C+B+MALDI-TOF	2
152	Shafini et al., 2017	CS	MY	NM	N	3/54, 5.6% (-0.6% to 11.7%)				PM	M	NM	NM	SP	NM	C+B+MALDI_TOF	2
153	Sharma et al., 2019	CS	IND	2017	N	28/188, 14.9% (9.8% to 20%)				RM	RO	NM	NM	MP	NM	C+B+P	2
154	Singh et al., 2010	CS	IND	2006 to 2007	N	7/260, 2.7% (0.7% to 4.7%)				EC	Fa	NA	NA	MP	NM	C+B	2
155	Singh et al., 2010	CS	IND	2006 to 2007	N	2/260, 0.8% (-0.3% to 1.8%)				ES	Fa	NA	NA	MP	NM	C+B	2
156	Singh et al., 2010	CS	IND	2006 to 2007	N	2/300, 0.7% (-0.3% to 1.6%)				EC	RO	NA	NA	MP	NM	C+B	2

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157	Singh et al., 2010	CS	IND	2006 to 2007	N	7/300, 2.3% (0.6% to 4%)				ES	RO	NA	NA	MP	NM	C+B	2
158	Singh et al., 2013	CS	IND	NM	N	6/180, 3.3% (0.7% to 6%)				EC	Fa	NA	NA	D	NM	C+B+P	2
159	Singh et al., 2013	CS	IND	NM	N	8/180, 4.4% (1.4% to 7.5%)				Cl	Fa	EL	NM	D	NM	C+B+P	2
160	Soomro et al., 2010	CS	PAK	NM	N	38/100, 38% (28.5% to 47.5%)				RM	RO	NM	NM	SP	Pr	C+B	2
161	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	14/30, 46.7% (28.8% to 64.5%)				LI	Fa	EL	Dead	D	Pr	C+B+P	2
162	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	15/30, 50% (32.1% to 67.9%)				Spl	Fa	EL	Dead	D	Pr	C+B+P	2
163	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	17/30, 56.7% (38.9% to 74.4%)				Cl	Fa	EL	Dead	D	Pr	C+B+P	2
164	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	16/30, 53.3% (35.5% to 71.2%)				O	Fa	EL	Dead	D	Pr	C+B+P	2
165	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	17/30, 56.7% (38.9% to 74.4%)				OvI	Fa	EL	Dead	D	Pr	C+B+P	2
166	Srinivasan et al., 2014	CS	IND	2005 to 2008	N	5/40, 12.5% (2.3% to 22.8%)				Cl	Fa	EL	CH	D	Pr	C+B+P	2
167	Srinivasan et al., 2014	CS	IND	2005 to 2008	N		2/85, 2.3% (0.3 to 8.2%)			M	Fa	EL	Both	D	Pr	C+B+P	2

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168	Sripaurya et al., 2019	CS	TH	2016	N	17/36, 47.2% (30.9% to 63.5%)				RM	LBM	NM	NM	D	NM	C+B+P	2
169	Suresh et al., 2006	CS	IND	1997 to 1998	N	9/492, 1.8% (0.7% to 3%)				EC	RO	NA	NA	D	Pr	C+B	2
170	Suresh et al., 2006	CS	IND	1997 to 1998	N	30/492, 6.1% (4% to 8.2%)				ES	RO	NA	NA	D	Pr	C+B	2
171	Suresh et al., 2011	CS	IND	NM	N	11/214, 5.1% (2.2% to 8.1%)				Sk	RO	EB	NM	D	NM	C+B+Se	2
172	Suresh et al., 2011	CS	IND	NM	N	3/214, 1.4% (-0.2% to 3%)				Cl	RO	EB	NM	D	NM	C+B+Se	2
173	Suresh et al., 2011	CS	IND	NM	N	14/203, 6.9% (3.4% to 10.4%)				Cr	RO	EB	NM	D	NM	C+B+Se	2
174	Suresh et al., 2011	CS	IND	NM	N	10/198, 5.1% (2% to 8.1%)				CC	RO	EB	NM	D	NM	C+B+Se	2
175	Suresh et al., 2011	CS	IND	NM	N	8/198, 4% (1.3% to 6.8%)				In	RO	EB	NM	D	NM	C+B+Se	2
176	Suresh et al., 2011	CS	IND	NM	N	8/214, 3.7% (1.2% to 6.3%)				Mo	RO	EB	NM	D	NM	C+B+Se	2
177	Suresh et al., 2011	CS	IND	NM	N	54/214, 25.2% (19.4% to 31.1%)				M	RO	NM	NM	D	NM	C+B+Se	2
178	Ta et al., 2014	CS	V	NM	N	13/30, 43.3% (25.6% to 61.1%)				Car	SS	EB	NM	MP	NM	C+B+Se	2
179	Ta et al., 2014	CS	V	NM	N	133/270, 49.3% (43.3% to 55.2%)				Car	LBM	EB	NM	MP	NM	C+B+Se	2

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180	Hathai, 2012	CS	IND	2008 to 2009	N	63/148, 42.6% (34.6% to 50.5%)				RM	RO	NM	NM	MP	NM	C+B+Se	2
181	Phan et al., 2005	CS	V	2000 to 2001	N	42/200, 21% (15.4% to 26.7%)				RM	RO	NM	NM	MP	NM	C+B	2
182	Trongjit et al., 2014	CS	TH	2014 to 2015	N	10/90, 11.1% (4.6% to 17.6%)				RM	SH	EB	NM	SP	NM	C+B+P	2
183	Trongjit et al., 2014	CS	TH	2014 to 2015	N	69/105, 65.7% (56.6% to 74.8%)				Car	LBM	EB	NM	SP	NM	C+B+P	2
184	Trongjit et al., 2014	CS	CAM	2014 to 2015	N	6/100, 6% (1.4% to 10.7%)				RM	SH	EB	NM	SP	NM	C+B+P	2
185	Trongjit et al., 2014	CS	CAM	2014 to 2015	N	72/87, 82.8% (74.8% to 90.7%)				Car	LBM	EB	NM	SP	NM	C+B+P	2
186	Utrarachkij et al., 2012	CS	TH	2000	N	0/240, 0% (0% to 0%)				ES	Fa	NA	NA	SP	NM	C+B+PGFE	2
187	Utrarachkij et al., 2012	CS	TH	2000	N	0/240, 0% (0% to 0%)				EC	Fa	NA	NA	SP	NM	C+B+PGFE	2
188	Utrarachkij et al., 2012	CS	TH	2000	N	8/30, 26.7% (10.8% to 42.5%)				ES	RO	NA	NA	SP	NM	C+B+PGFE	2
189	Utrarachkij et al., 2012	CS	TH	2000	N	0/30, 0% (0% to 0%)				EC	RO	NA	NA	SP	NM	C+B+PGFE	2
190	Vadhanasin et al., 2004	CS	TH	NM	N	60/244, 24.6% (19.2% to 30%)				RM	SH	EB	NM	NM	NM	C+B+Se	2
191	Vaeteewootacharn et al., 2005	CS	TH	2002	N	81/84, 96.4% (92.5% to 100.4%)				RM	M	NM	NM	D	Pr	C+B+Se	2

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192	Van et al., 2007	CS	V	2004	N	16/30, 53.3% (35.5% to 71.2%)				RM	M	NM	NM	D	Pr	C+B+P+Se	2
193	Vindigni et al., 2007	CS	TH	2003	N	31/50, 62% (48.6% to 75.5%)				RM	M	NM	NM	SP	Con	C+B+Se	2
194	Vindigni et al., 2007	CS	TH	2003	N	7/50, 14% (4.4% to 23.6%)				E	M	NA	NA	SP	Con	C+B+Se	2
195	Waghamare et al., 2017	CS	IND	NM	N	3/12, 25% (0.5% to 49.5%)				Cl	Fa	NM	NM	D	NM	C+B+P	2
196	Waghamare et al., 2017	CS	IND	NM	N	1/6, 16.7% (-13.2% to 46.5%)				Cl	SH	NM	NM	D	NM	C+B+P	2
197	Wardhana et al., 2019	CS	INDO	NM	N	11/60, 18.3% (8.5% to 28.1%)				RM	LBM	NM	NM	SP	NM	C+B	2
198	Yang et al., 2018	CS	IND	2017	N	36/200, 18% (12.7% to 23.3%)				CC	SH	EB	NM	SP	Pr	C+B+PGFE	2
199	Yasmin et al., 2020	CS	PAK	NM	N	17/50, 34% (20.9% to 47.1%)				LI	NM	NM	NM	SP	NM	C+B+P	2
200	Yasmin et al., 2020	CS	PAK	NM	N	25/50, 50% (36.1% to 63.9%)				In	NM	NM	NM	SP	NM	C+B+P	2
201	Zwe et al., 2018	CS	SIN	2015 to 2016	N	30/120, 25% (17.3% to 32.8%)				RM	LBM	NM	NM	NM	NM	C+B+P	2
202	Zwe et al., 2018	CS	SIN	2015 to 2016	N	19/150, 12.7% (7.3% to 18%)				RM	SS	NM	NM	NM	NM	C+B+P	2
203	Murugadas et al., 2015	CS	IND	NM	N	4/75, 5.3% (0.3% to 10.4%)				Cl	RO	NM	NM	D	NM	C+B+P	2

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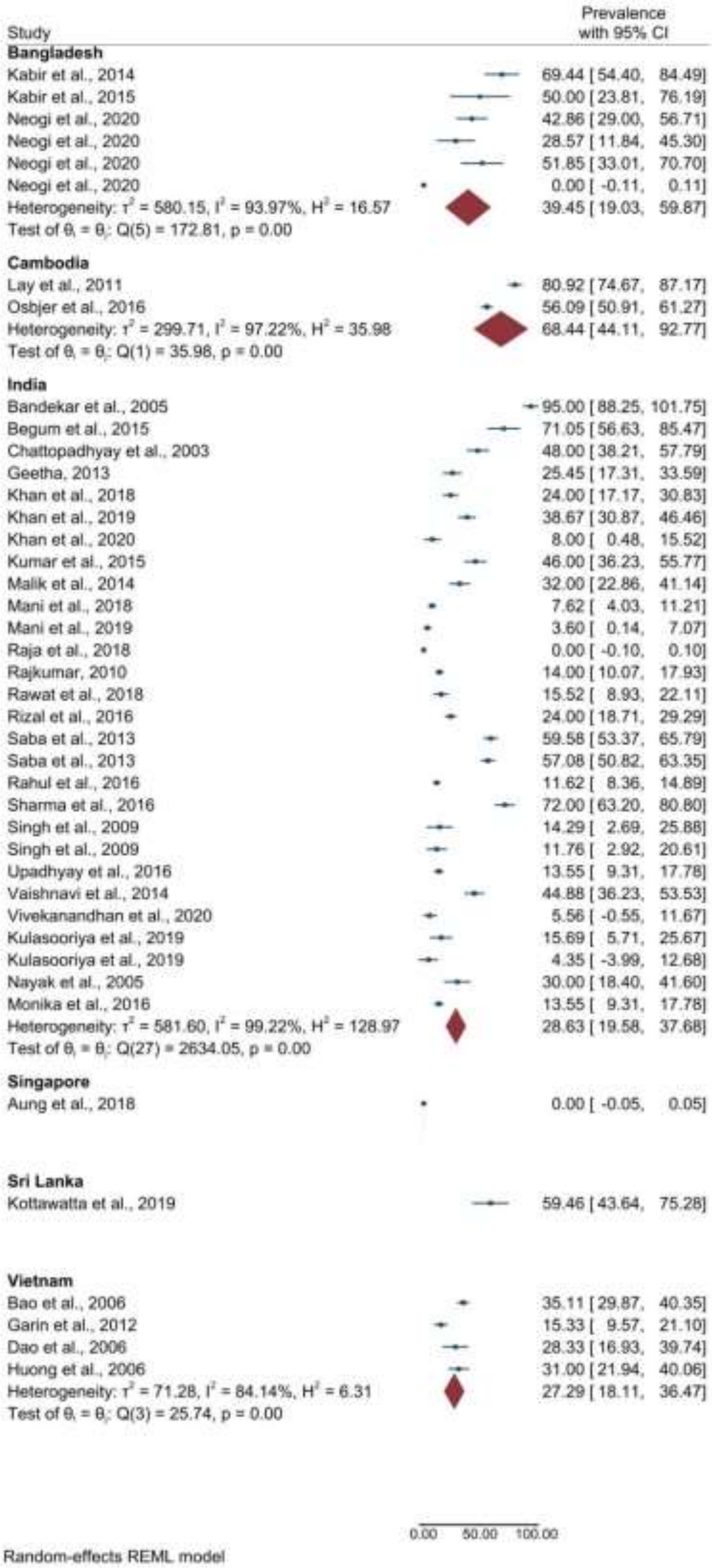
204	Murugadas et al., 2015	CS	IND	NM	N	2/69, 2.9% (-1.1% to 6.9%)				LI	RO	NM	NM	D	NM	C+B+P	2
205	Murugadas et al., 2015	CS	IND	NM	N	0/58, 0% (0% to 0%)				O	RO	NM	NM	D	NM	C+B+P	2
206	Murugadas et al., 2015	CS	IND	NM	N	0/80, 0% (0% to 0%)				In	RO	NM	NM	D	NM	C+B+P	2
207	Murugadas et al., 2015	CS	IND	NM	N	2/75, 2.7% (-1% to 6.3%)				RM	RO	NM	NM	D	NM	C+B+P	2
208	Murugadas et al., 2015	CS	IND	NM	N	3/65, 4.6% (-0.5% to 9.7%)				EC	RO	NA	NA	D	NM	C+B+P	2
209	Sudhanthirakodi et al., 2016	CS	IND	2012 to 2013	N	11/50, 22% (10.5% to 33.5%)				Cl	Fa	NM	NM	SP	Pr	C+B	2
210	Sudhanthirakodi et al., 2016	CS	IND	2012 to 2013	N	20/50, 40% (26.4% to 53.6%)				RM	RO	NM	NM	SP	Pr	C+B	2
211	Sudhanthirakodi et al., 2016	CS	IND	2012 to 2013	N	0/50, 0% (0% to 0%)				EC	RO	NA	NA	SP	Pr	C+B	2
212	Lertworapreecha et al., 2013	CS	TH	2010	N	27/40, 67.5% (53% to 82%)				RM	RO	NM	NM	SP	Pr	C+B	2
213	Al-Salauddin et al., 2015	CS	BD	2015	N	18/60, 30% (18.4% to 41.6%)				RM	LBM	EB	NM	MP	NM	C+B+P	2

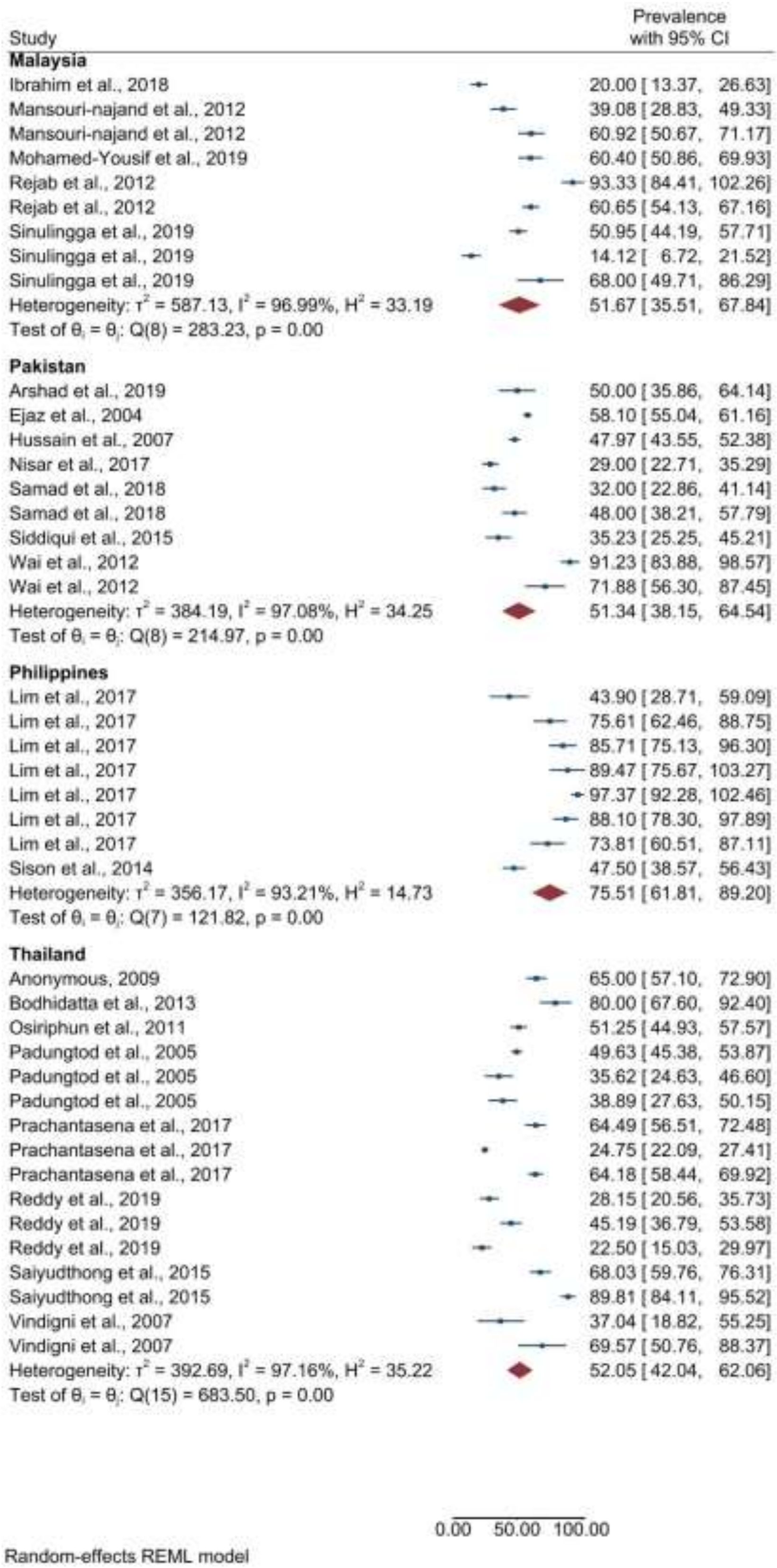
SD= Study design, CS= Cross-sectional,
C= Country, TH= Thailand, BD= Bangladesh, PAK= Pakistan, IND= India, MY=Malaysia, CAM= Cambodia, SL= Sri Lanka, PH= Philippines, V= Vietnam, SIN= Singapore, MM= Myanmar, NP=Nepal, INDO= Indonesia, BH= Bhutan
SP= Study period,
Po= Pooling, Y=Yes, N=No
n= Number of positive samples, N= Number of total samples, CI= Confidence interval
Sam= Sample unit, ST=Type of sample, RM= Raw meat, Cl= Cloacal swab, CC= Caecal content, Sk= Skin, Car= Carcass, CM=Cooked meat, RTE= Ready to eat meat, In= Intestine, Fea= Feather, PM= Processed meat, Li= Liver, Mec= Chick meconium, Gi= Gizzard, M= Mixed, ES= Egg surface swab, EC= Egg content, E= Egg (shell or content not specified), BE= Boiled egg, Hr= Heart, K= Kidney, Yo= Yolk sac, O= Ovary, Spl= Spleen, Lu= Lungs, DE= Dead embryo, Ovi= Oviduct, Cr= Crop, Mo= Mouth
S= Study site, LBM= Live bird market, SH= Slaughter house, Fa=Farm, RO= Retail outlet, SS= Supershop, Re= Restaurant, HH= Household, H= Hatchery
PT= Production type, EB= Exotic broiler, EL= Exotic layer, I= Indigenous, Br= Breeder, Coc= Cockerel, HB= Hybrid broiler, Son= Sonai, Lab=Laboratory
HS= Health status, CH= Clinically healthy, Both= Dead and clinically healthy, NA= Not applicable
L= Study level, D= District, SP= Single province, MP= Multiple provinces, NM= Not mentioned
SA= Sampling approach, Pr= Probabilistic sampling, SPr= Simple probabilistic, SysPr= Systematic probabilistic, PrP= Proportionate probabilistic, Con= Convenient sampling, Pur= Purposive
MC= Method of confirmation, C= Culture, B= Biochemical tests, P= Polymerase chain reaction S= Serotyping, MALDI-TOF= Matrix-assisted laser desorption/ionization-time of flight, PFGE= Pulse field gel electrophoresis Agarose = Agarose gel diffusion
Q= Quality of study, 1= Quality 1, 2= Quality 2

214	Kulasooriya et al., 2019	CS	SL	2014	N	7/51, 13.7% (4.3% to 23.2%)				RM	RO	NM	NM	D	NM	C+B	2
215	Kulasooriya et al., 2019	CS	SL	2014	N	2/48, 4.2% (-1.5% to 9.8%)				PM	RO	NM	NM	D	NM	C+B	2
216	Kulasooriya et al., 2019	CS	SL	2014	N	0/22, 0% (0% to 0%)				CM	Re	NM	NM	D	Pr	C+B	2
217	Maqdhurangi et al., 2013	CS	SL	2013	N	15/83, 18.1% (9.8% to 26.4%)				RM	RO	NM	NM	D	Pr	C+B	2
218	Bao et al., 2006	CS	V	2004 to 2005	N	136/319, 42.6% (37.2% to 48.1%)				Car	SH	NM	NM	D	NM	C+B+P	2
219	Islam et al., 2018	CS	BD	NM	N	14/20, 70% (49.9% to 90.1%)				RM	LBM	EB	CH	MP	Pr	C+B+P	1
220	Wajid et al., 2018	CS	PAK	NM	N	239/340, 70.3% (65.4% to 75.2%)				M	Fa	NM	Sick	D	NM	C+B+P+P GFE+MAL DI-TOF	2

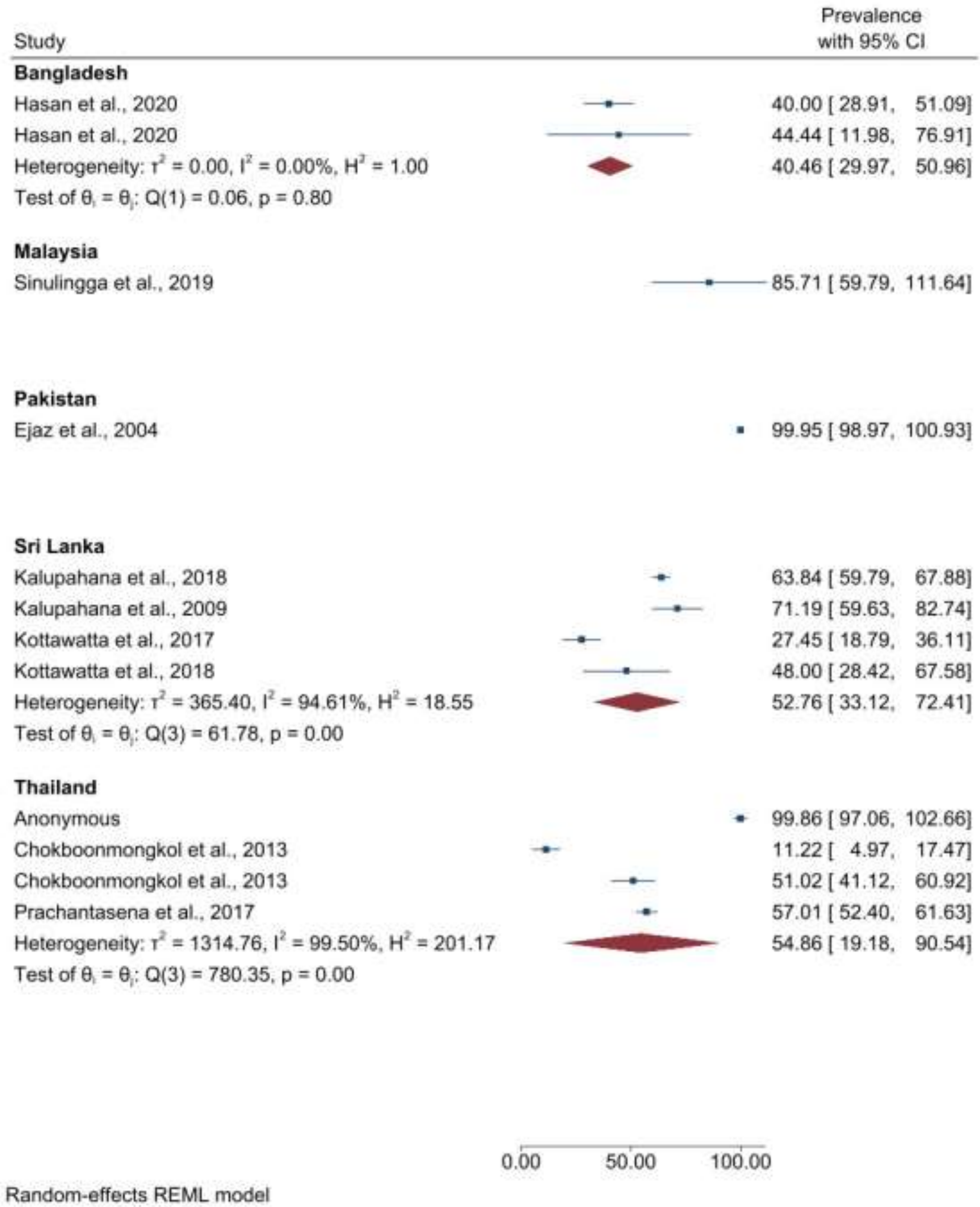
SD= Study design, CS= Cross-sectional,
C= Country, TH= Thailand, BD= Bangladesh, PAK= Pakistan, IND= India, MY=Malaysia, CAM= Cambodia, SL= Sri Lanka, PH= Philippines, V= Vietnam, SIN= Singapore, MM= Myanmar, NP=Nepal, INDO= Indonesia, BH= Bhutan
SP= Study period,
Po= Pooling, Y=Yes, N=No
n= Number of positive samples, N= Number of total samples, CI= Confidence interval
Sam= Sample unit, ST=Type of sample, RM= Raw meat, Cl= Cloacal swab, CC= Caecal content, Sk= Skin, Car= Carcass, CM=Cooked meat, RTE= Ready to eat meat, In= Intestine, Fea= Feather, PM= Processed meat, Li= Liver, Mec= Chick meconium, Gi= Gizzard, M= Mixed, ES= Egg surface swab, EC= Egg content, E= Egg (shell or content not specified), BE= Boiled egg, Hr= Heart, K= Kidney, Yo= Yolk sac, O= Ovary, Spl= Spleen, Lu= Lungs, DE= Dead embryo, Ovi= Oviduct, Cr= Crop, Mo= Mouth
S= Study site, LBM= Live bird market, SH= Slaughter house, Fa=Farm, RO= Retail outlet, SS= Supershop, Re= Restaurant, HH= Household, H= Hatchery
PT= Production type, EB= Exotic broiler, EL= Exotic layer, I= Indigenous, Br= Breeder, Coc= Cockerel, HB= Hybrid broiler, Son= Sonai, Lab=Laboratory
HS= Health status, CH= Clinically healthy, Both= Dead and clinically healthy, NA= Not applicable
L= Study level, D= District, SP= Single province, MP= Multiple provinces, NM= Not mentioned
SA= Sampling approach, Pr= Probabilistic sampling, SPr= Simple probabilistic, SysPr= Systematic probabilistic, PrP= Proportionate probabilistic, Con= Convenient sampling, Pur= Purposive
MC= Method of confirmation, C= Culture, B= Biochemical tests, P= Polymerase chain reaction S= Serotyping, MALDI-TOF= Matrix-assisted laser desorption/ionization-time of flight, PFGE= Pulse field gel electrophoresis Agarose = Agarose gel diffusion
Q= Quality of study, 1= Quality 1, 2= Quality 2

Appendix C. Forest plot for pooled prevalence (sample unit) of *Campylobacter* in chickens across different south and southeast Asian countries

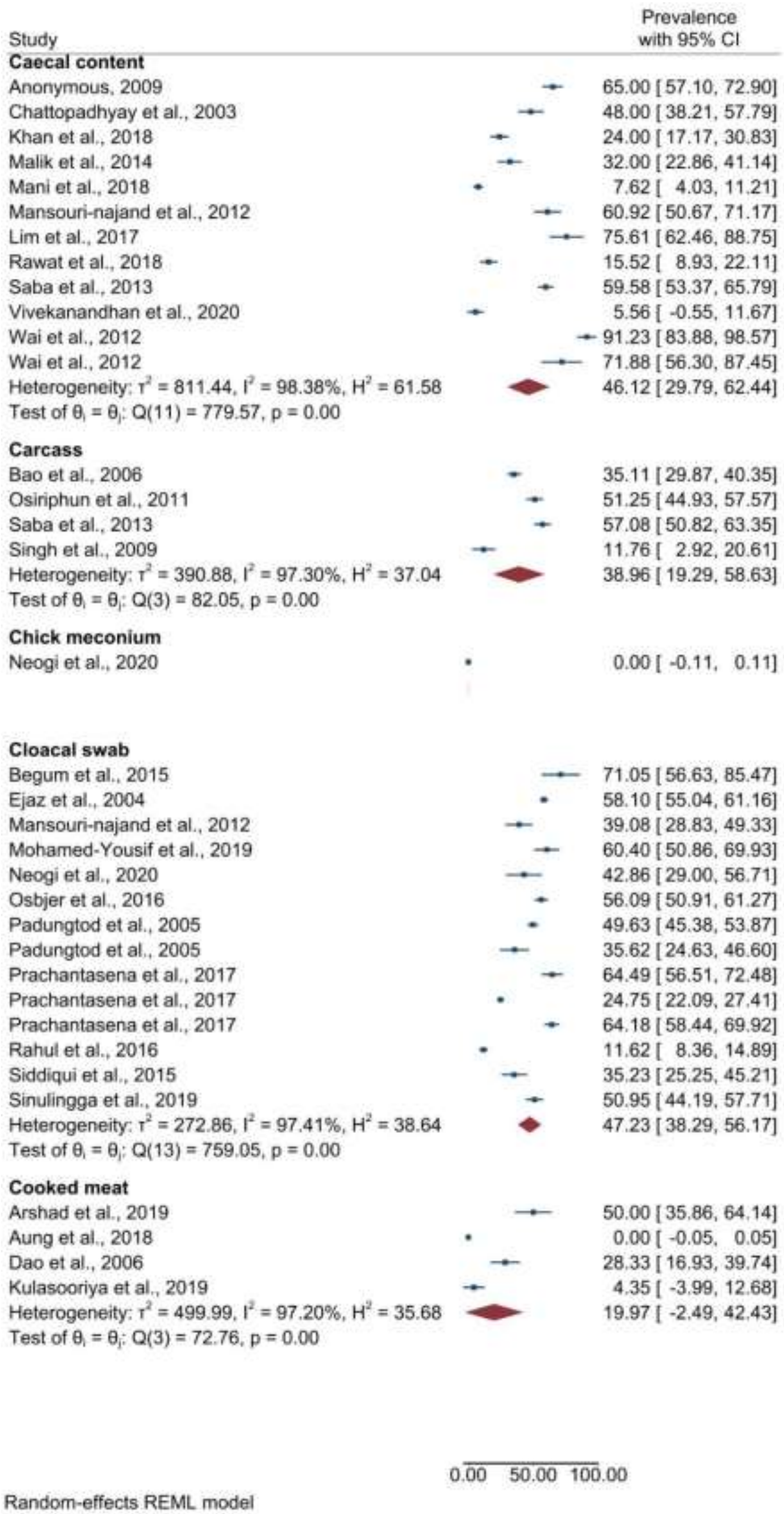


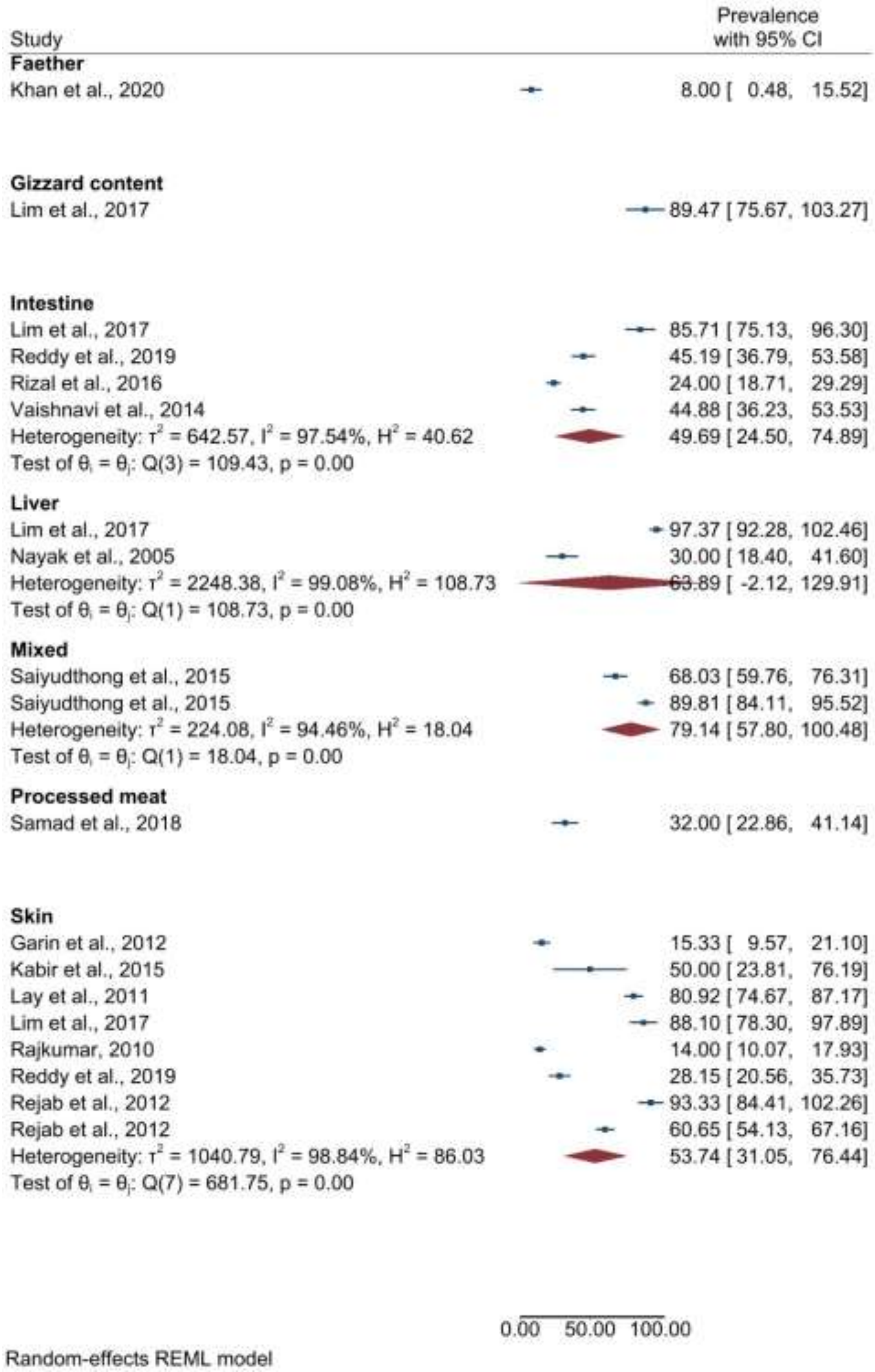

Study
Prevalence with 95% CI
Malaysia
Ibrahim et al., 2018 20.00 [13.37, 26.63]
Mansouri-najand et al., 2012 39.08 [28.83, 49.33]
Mansouri-najand et al., 2012 60.92 [50.67, 71.17]
Mohamed-Yousif et al., 2019 60.40 [50.86, 69.93]
Rejab et al., 2012 93.33 [84.41, 102.26]
Rejab et al., 2012 60.65 [54.13, 67.16]
Sinulingga et al., 2019 50.95 [44.19, 57.71]
Sinulingga et al., 2019 14.12 [6.72, 21.52]
Sinulingga et al., 2019 68.00 [49.71, 86.29]
Heterogeneity: τ^2 = 587.13, I^2 = 96.99%, H^2 = 33.19 51.67 [35.51, 67.84]
Test of $\theta_i = \theta_j$: Q(8) = 283.23, p = 0.00
Pakistan
Arshad et al., 2019 50.00 [35.86, 64.14]
Ejaz et al., 2004 58.10 [55.04, 61.16]
Hussain et al., 2007 47.97 [43.55, 52.38]
Nisar et al., 2017 29.00 [22.71, 35.29]
Samad et al., 2018 32.00 [22.86, 41.14]
Samad et al., 2018 48.00 [38.21, 57.79]
Siddiqui et al., 2015 35.23 [25.25, 45.21]
Wai et al., 2012 91.23 [83.88, 98.57]
Wai et al., 2012 71.88 [56.30, 87.45]
Heterogeneity: τ^2 = 384.19, I^2 = 97.08%, H^2 = 34.25 51.34 [38.15, 64.54]
Test of $\theta_i = \theta_j$: Q(8) = 214.97, p = 0.00
Philippines
Lim et al., 2017 43.90 [28.71, 59.09]
Lim et al., 2017 75.61 [62.46, 88.75]
Lim et al., 2017 85.71 [75.13, 96.30]
Lim et al., 2017 89.47 [75.67, 103.27]
Lim et al., 2017 97.37 [92.28, 102.46]
Lim et al., 2017 88.10 [78.30, 97.89]
Lim et al., 2017 73.81 [60.51, 87.11]
Sison et al., 2014 47.50 [38.57, 56.43]
Heterogeneity: τ^2 = 356.17, I^2 = 93.21%, H^2 = 14.73 75.51 [61.81, 89.20]
Test of $\theta_i = \theta_j$: Q(7) = 121.82, p = 0.00
Thailand
Anonymous, 2009 65.00 [57.10, 72.90]
Bodhidatta et al., 2013 80.00 [67.60, 92.40]
Osiriphun et al., 2011 51.25 [44.93, 57.57]
Padungtod et al., 2005 49.63 [45.38, 53.87]
Padungtod et al., 2005 35.62 [24.63, 46.60]
Padungtod et al., 2005 38.89 [27.63, 50.15]
Prachantasena et al., 2017 64.49 [56.51, 72.48]
Prachantasena et al., 2017 24.75 [22.09, 27.41]
Prachantasena et al., 2017 64.18 [58.44, 69.92]
Reddy et al., 2019 28.15 [20.56, 35.73]
Reddy et al., 2019 45.19 [36.79, 53.58]
Reddy et al., 2019 22.50 [15.03, 29.97]
Saiyudthong et al., 2015 68.03 [59.76, 76.31]
Saiyudthong et al., 2015 89.81 [84.11, 95.52]
Vindigni et al., 2007 37.04 [18.82, 55.25]
Vindigni et al., 2007 69.57 [50.76, 88.37]
Heterogeneity: τ^2 = 392.69, I^2 = 97.16%, H^2 = 35.22 52.05 [42.04, 62.06]
Test of $\theta_i = \theta_j$: Q(15) = 683.50, p = 0.00
0.00 50.00 100.00
Random-effects REML model

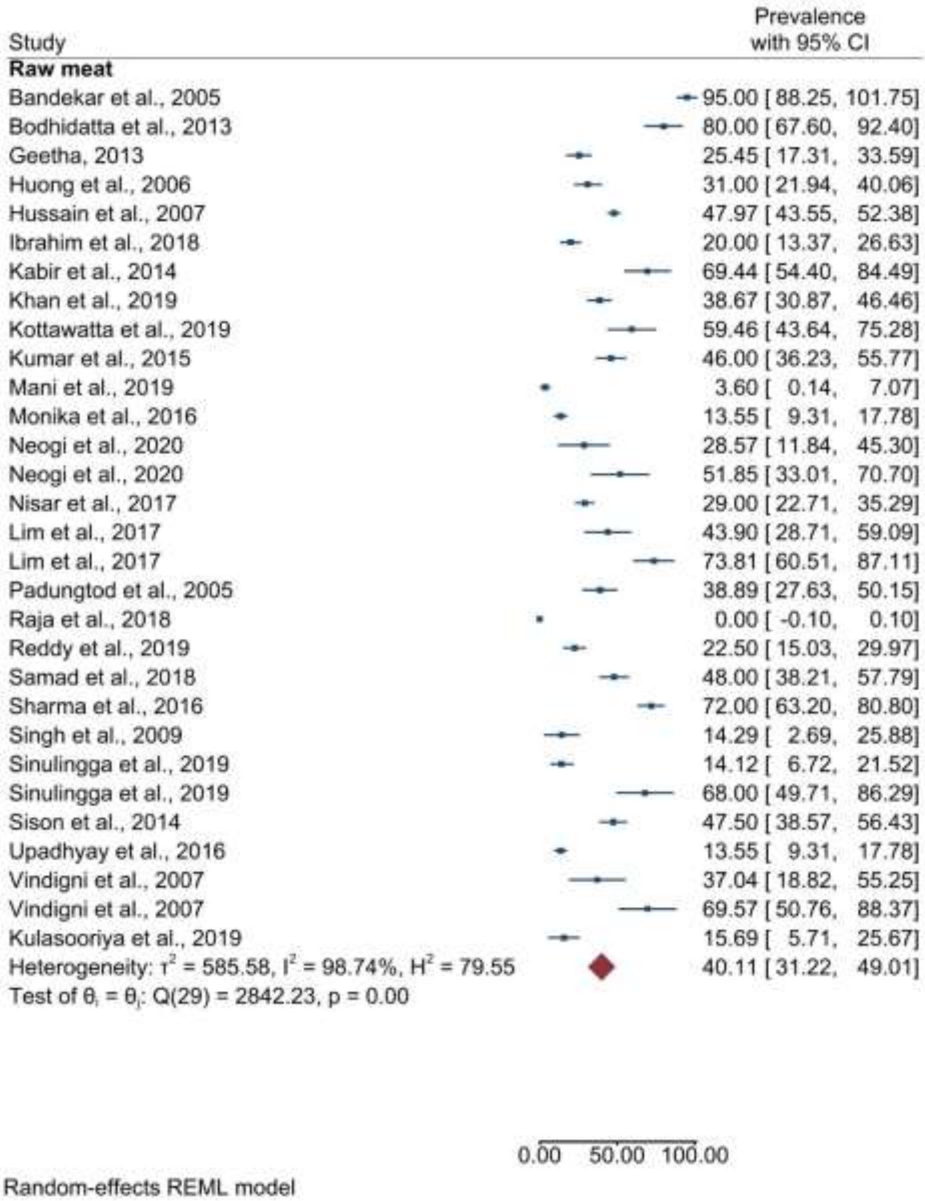
Appendix D. Forest plot for pooled prevalence (farm unit) of *Campylobacter* in chickens across different south and southeast Asian countries



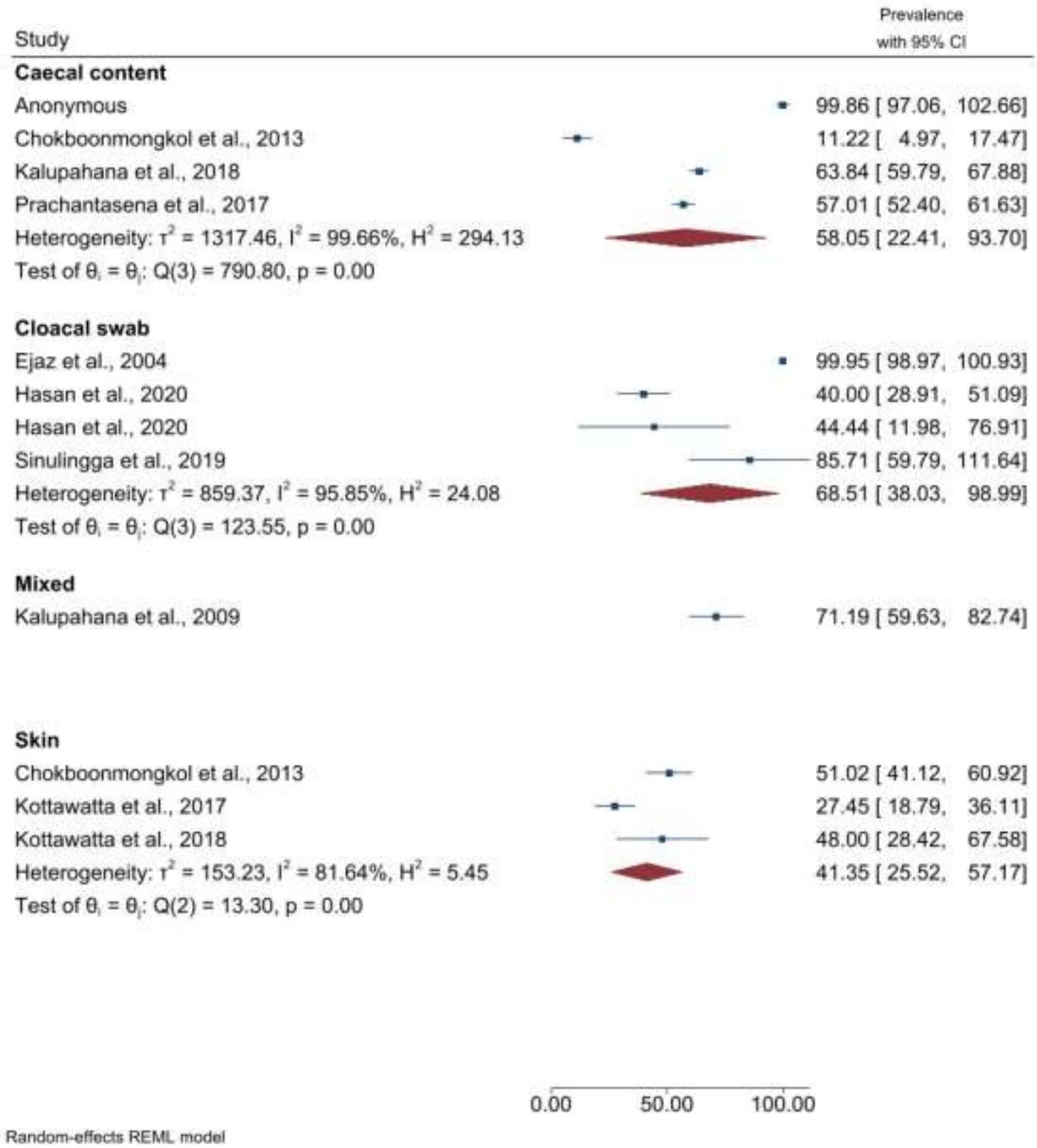
Appendix E. Forest plot for pooled prevalence (sample unit) of *Campylobacter* in different chicken samples in south and southeast Asia



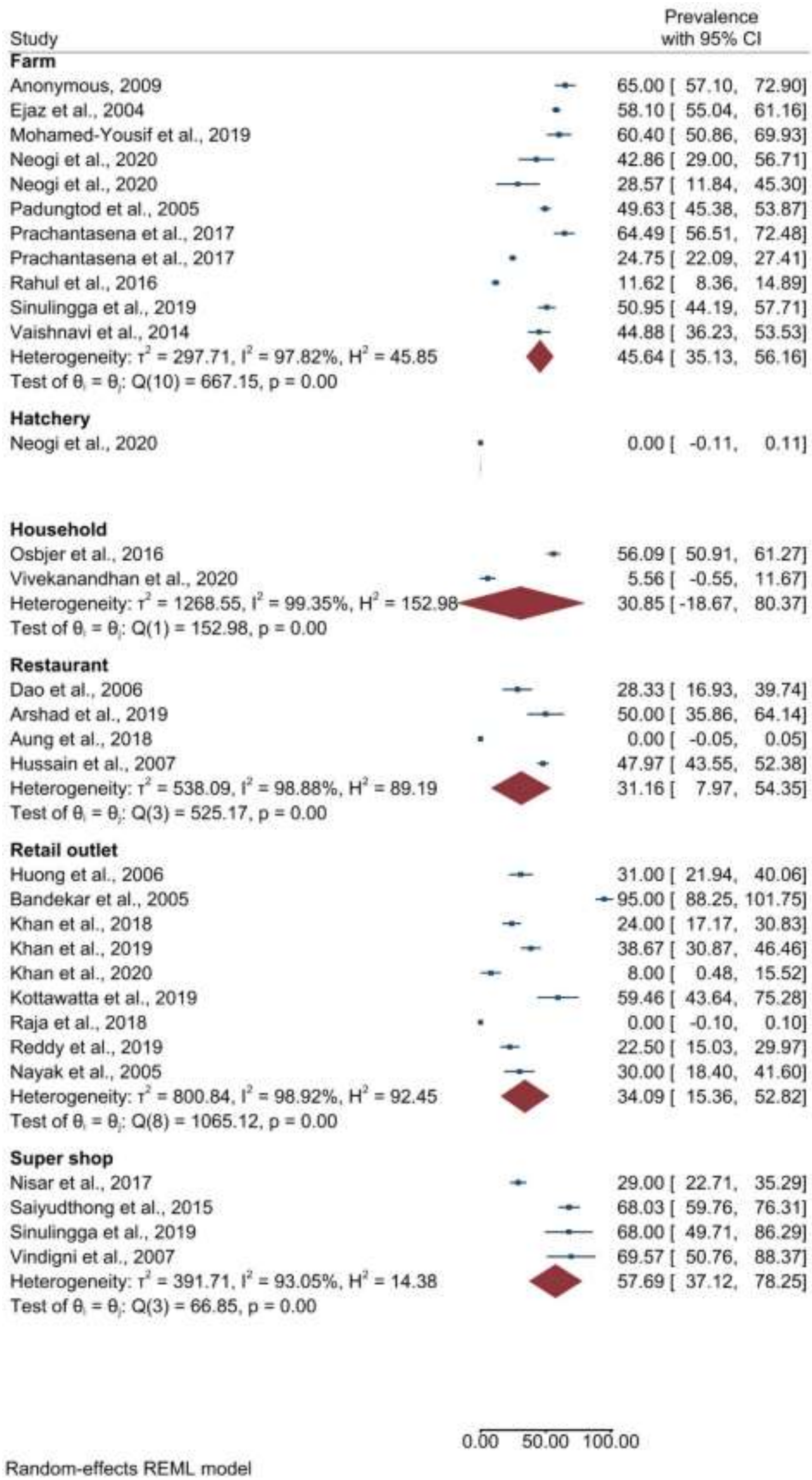

Study
Prevalence with 95% CI
Faether
Khan et al., 2020 8.00 [0.48, 15.52]
Gizzard content
Lim et al., 2017 89.47 [75.67, 103.27]
Intestine
Lim et al., 2017 85.71 [75.13, 96.30]
Reddy et al., 2019 45.19 [36.79, 53.58]
Rizal et al., 2016 24.00 [18.71, 29.29]
Vaishnavi et al., 2014 44.88 [36.23, 53.53]
Heterogeneity: τ^2 = 642.57, I^2 = 97.54%, H^2 = 40.62 49.69 [24.50, 74.89]
Test of $\theta_i = \theta_j$: Q(3) = 109.43, p = 0.00
Liver
Lim et al., 2017 97.37 [92.28, 102.46]
Nayak et al., 2005 30.00 [18.40, 41.60]
Heterogeneity: τ^2 = 2248.38, I^2 = 99.08%, H^2 = 108.73 63.89 [-2.12, 129.91]
Test of $\theta_i = \theta_j$: Q(1) = 108.73, p = 0.00
Mixed
Saiyudthong et al., 2015 68.03 [59.76, 76.31]
Saiyudthong et al., 2015 89.81 [84.11, 95.52]
Heterogeneity: τ^2 = 224.08, I^2 = 94.46%, H^2 = 18.04 79.14 [57.80, 100.48]
Test of $\theta_i = \theta_j$: Q(1) = 18.04, p = 0.00
Processed meat
Samad et al., 2018 32.00 [22.86, 41.14]
Skin
Garin et al., 2012 15.33 [9.57, 21.10]
Kabir et al., 2015 50.00 [23.81, 76.19]
Lay et al., 2011 80.92 [74.67, 87.17]
Lim et al., 2017 88.10 [78.30, 97.89]
Rajkumar, 2010 14.00 [10.07, 17.93]
Reddy et al., 2019 28.15 [20.56, 35.73]
Rejab et al., 2012 93.33 [84.41, 102.26]
Rejab et al., 2012 60.65 [54.13, 67.16]
Heterogeneity: τ^2 = 1040.79, I^2 = 98.84%, H^2 = 86.03 53.74 [31.05, 76.44]
Test of $\theta_i = \theta_j$: Q(7) = 681.75, p = 0.00
0.00 50.00 100.00
Random-effects REML model

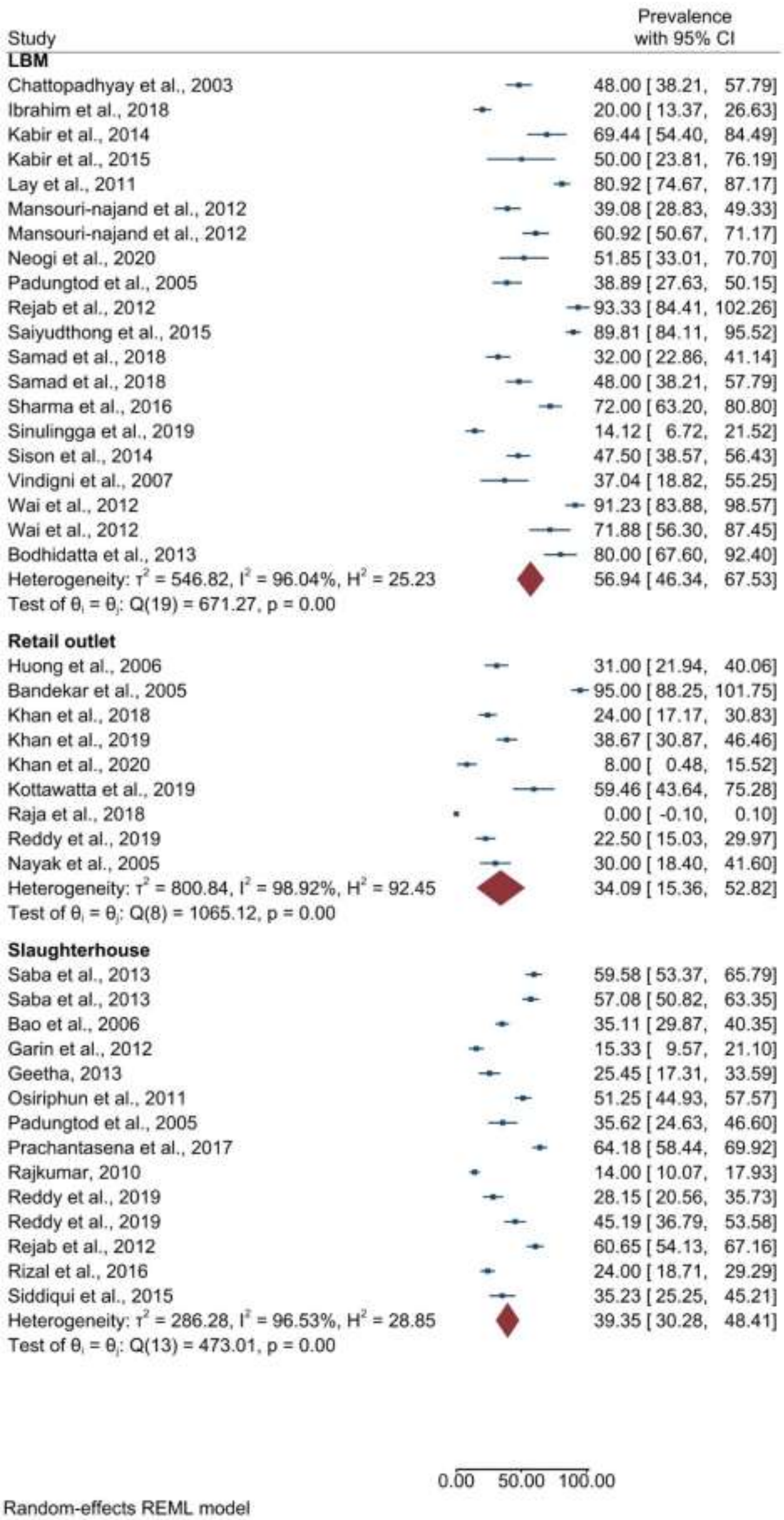

Study
Prevalence with 95% CI
Raw meat
Bandekar et al., 2005 95.00 [88.25, 101.75]
Bodhidatta et al., 2013 80.00 [67.60, 92.40]
Geetha, 2013 25.45 [17.31, 33.59]
Huong et al., 2006 31.00 [21.94, 40.06]
Hussain et al., 2007 47.97 [43.55, 52.38]
Ibrahim et al., 2018 20.00 [13.37, 26.63]
Kabir et al., 2014 69.44 [54.40, 84.49]
Khan et al., 2019 38.67 [30.87, 46.46]
Kottawatta et al., 2019 59.46 [43.64, 75.28]
Kumar et al., 2015 46.00 [36.23, 55.77]
Mani et al., 2019 3.60 [0.14, 7.07]
Monika et al., 2016 13.55 [9.31, 17.78]
Neogi et al., 2020 28.57 [11.84, 45.30]
Neogi et al., 2020 51.85 [33.01, 70.70]
Nisar et al., 2017 29.00 [22.71, 35.29]
Lim et al., 2017 43.90 [28.71, 59.09]
Lim et al., 2017 73.81 [60.51, 87.11]
Padungtod et al., 2005 38.89 [27.63, 50.15]
Raja et al., 2018 0.00 [-0.10, 0.10]
Reddy et al., 2019 22.50 [15.03, 29.97]
Samad et al., 2018 48.00 [38.21, 57.79]
Sharma et al., 2016 72.00 [63.20, 80.80]
Singh et al., 2009 14.29 [2.69, 25.88]
Sinulingga et al., 2019 14.12 [6.72, 21.52]
Sinulingga et al., 2019 68.00 [49.71, 86.29]
Sison et al., 2014 47.50 [38.57, 56.43]
Upadhyay et al., 2016 13.55 [9.31, 17.78]
Vindigni et al., 2007 37.04 [18.82, 55.25]
Vindigni et al., 2007 69.57 [50.76, 88.37]
Kulasooriya et al., 2019 15.69 [5.71, 25.67]
Heterogeneity: τ^2 = 585.58, I^2 = 98.74%, H^2 = 79.55 40.11 [31.22, 49.01]
Test of $\theta_i = \theta_j$: Q(29) = 2842.23, p = 0.00
0.00 50.00 100.00
Random-effects REML model

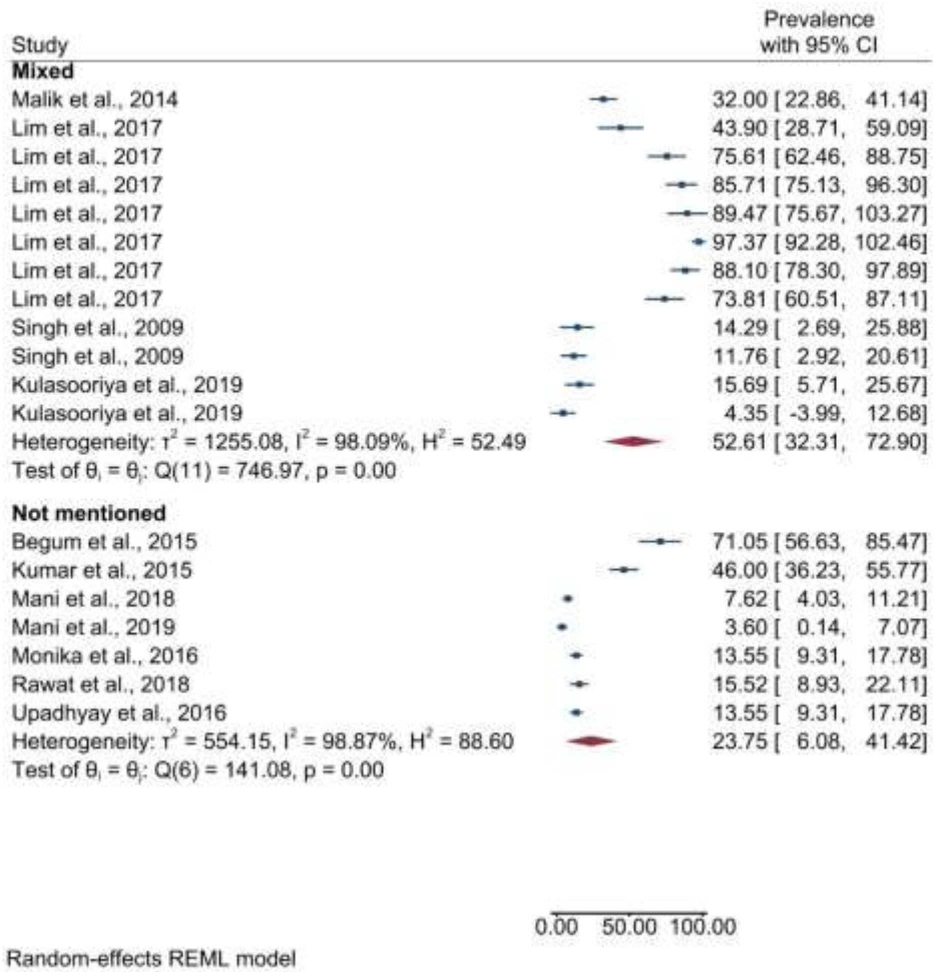
Appendix F. Forest plot for pooled prevalence (farm unit) of *Campylobacter* in different chicken samples in south and southeast Asia



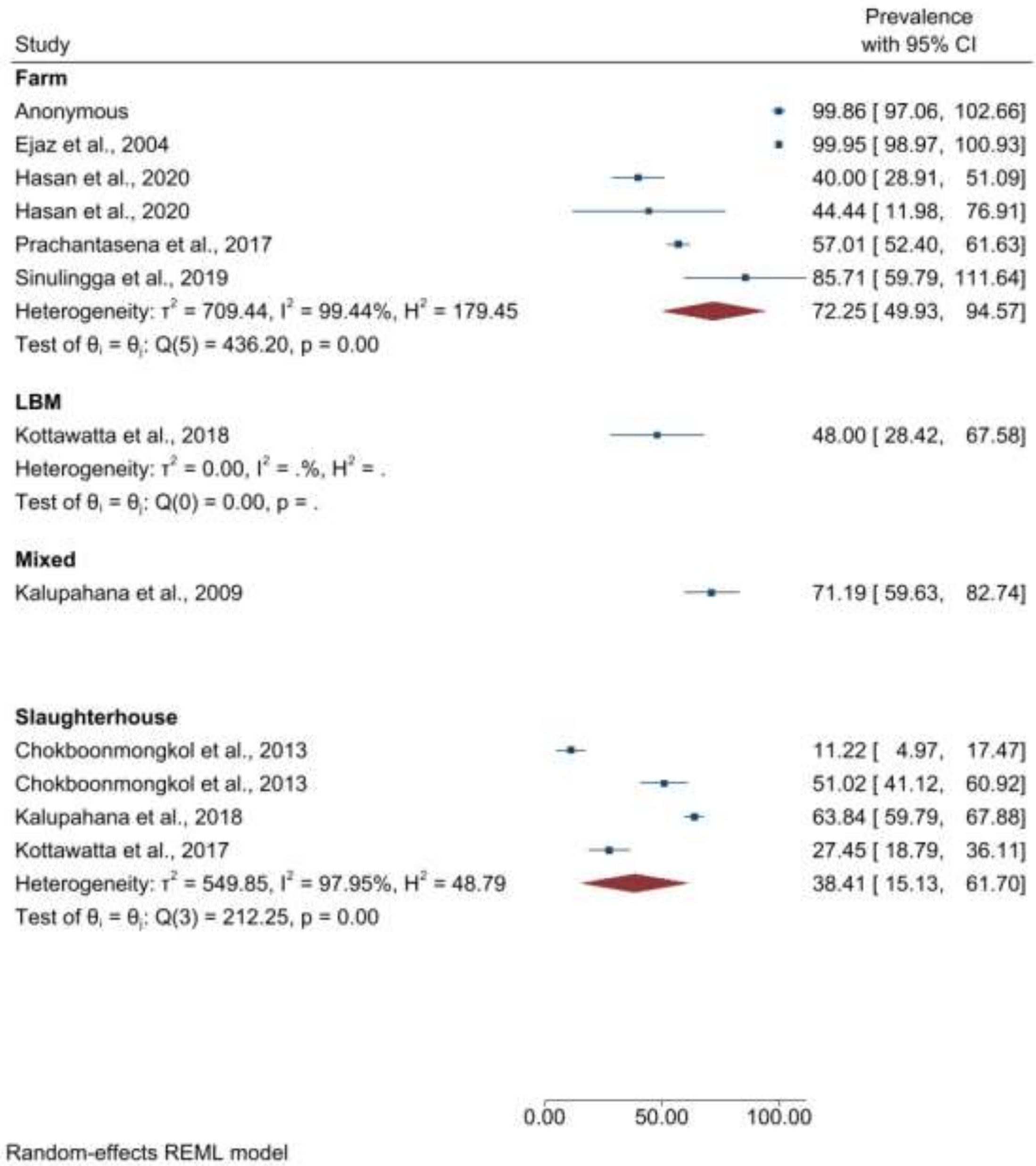
Appendix G. Forest plot for pooled prevalence (sample unit) of *Campylobacter* in chicken in different study sites in south and southeast Asia



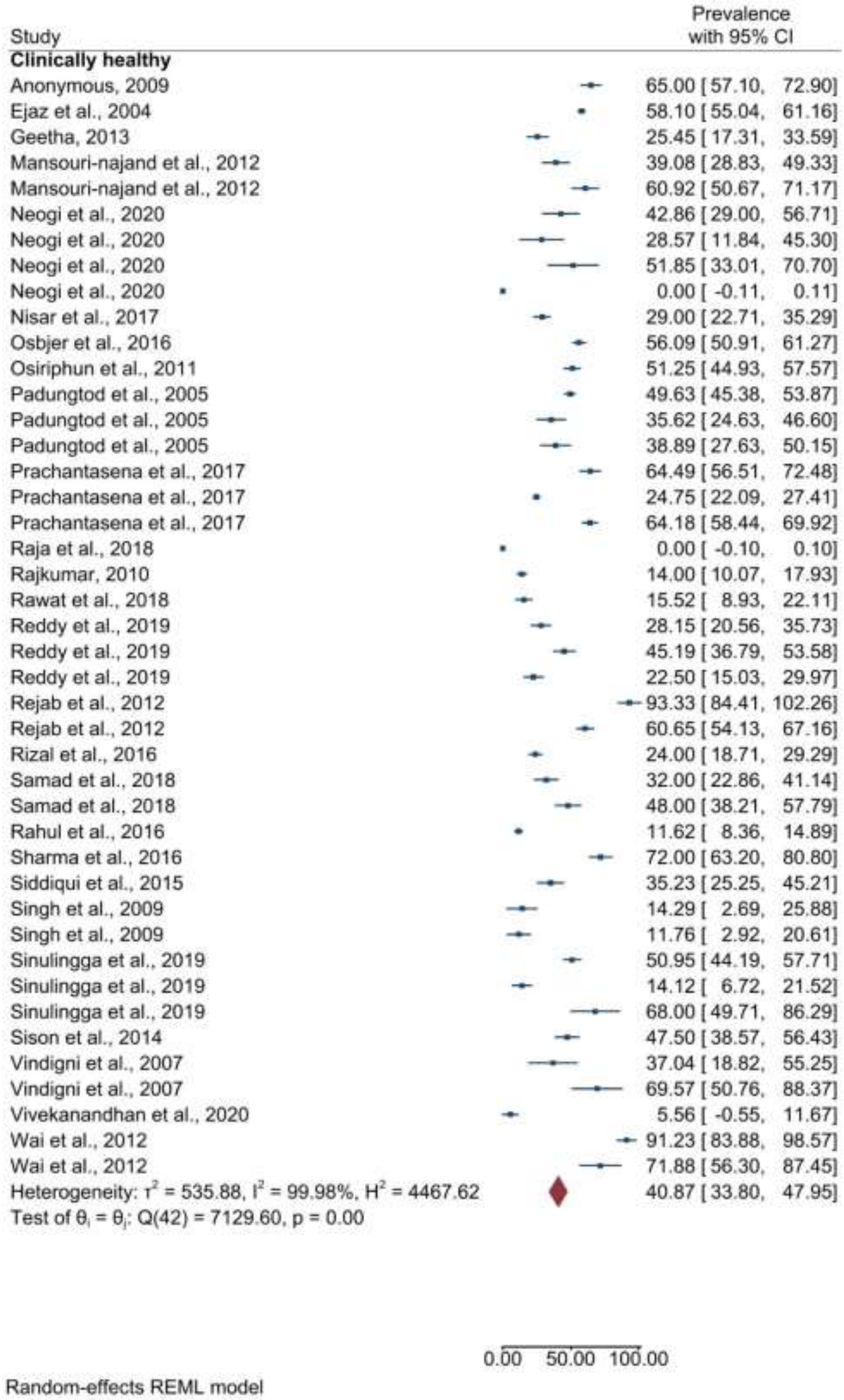

Study
Prevalence with 95% CI
LBM
Chattopadhyay et al., 2003 48.00 [38.21, 57.79]
Ibrahim et al., 2018 20.00 [13.37, 26.63]
Kabir et al., 2014 69.44 [54.40, 84.49]
Kabir et al., 2015 50.00 [23.81, 76.19]
Lay et al., 2011 80.92 [74.67, 87.17]
Mansouri-najand et al., 2012 39.08 [28.83, 49.33]
Mansouri-najand et al., 2012 60.92 [50.67, 71.17]
Neogi et al., 2020 51.85 [33.01, 70.70]
Padungtod et al., 2005 38.89 [27.63, 50.15]
Rejab et al., 2012 93.33 [84.41, 102.26]
Saiyudthong et al., 2015 89.81 [84.11, 95.52]
Samad et al., 2018 32.00 [22.86, 41.14]
Samad et al., 2018 48.00 [38.21, 57.79]
Sharma et al., 2016 72.00 [63.20, 80.80]
Sinulingga et al., 2019 14.12 [6.72, 21.52]
Sison et al., 2014 47.50 [38.57, 56.43]
Vindigni et al., 2007 37.04 [18.82, 55.25]
Wai et al., 2012 91.23 [83.88, 98.57]
Wai et al., 2012 71.88 [56.30, 87.45]
Bodhidatta et al., 2013 80.00 [67.60, 92.40]
Heterogeneity: τ^2 = 546.82, I^2 = 96.04%, H^2 = 25.23 56.94 [46.34, 67.53]
Test of $\theta_i = \theta_j$: Q(19) = 671.27, p = 0.00
Retail outlet
Huong et al., 2006 31.00 [21.94, 40.06]
Bandekar et al., 2005 95.00 [88.25, 101.75]
Khan et al., 2018 24.00 [17.17, 30.83]
Khan et al., 2019 38.67 [30.87, 46.46]
Khan et al., 2020 8.00 [0.48, 15.52]
Kottawatta et al., 2019 59.46 [43.64, 75.28]
Raja et al., 2018 0.00 [-0.10, 0.10]
Reddy et al., 2019 22.50 [15.03, 29.97]
Nayak et al., 2005 30.00 [18.40, 41.60]
Heterogeneity: τ^2 = 800.84, I^2 = 98.92%, H^2 = 92.45 34.09 [15.36, 52.82]
Test of $\theta_i = \theta_j$: Q(8) = 1065.12, p = 0.00
Slaughterhouse
Saba et al., 2013 59.58 [53.37, 65.79]
Saba et al., 2013 57.08 [50.82, 63.35]
Bao et al., 2006 35.11 [29.87, 40.35]
Garin et al., 2012 15.33 [9.57, 21.10]
Geetha, 2013 25.45 [17.31, 33.59]
Osiriphun et al., 2011 51.25 [44.93, 57.57]
Padungtod et al., 2005 35.62 [24.63, 46.60]
Prachantasena et al., 2017 64.18 [58.44, 69.92]
Rajkumar, 2010 14.00 [10.07, 17.93]
Reddy et al., 2019 28.15 [20.56, 35.73]
Reddy et al., 2019 45.19 [36.79, 53.58]
Rejab et al., 2012 60.65 [54.13, 67.16]
Rizal et al., 2016 24.00 [18.71, 29.29]
Siddiqui et al., 2015 35.23 [25.25, 45.21]
Heterogeneity: τ^2 = 286.28, I^2 = 96.53%, H^2 = 28.85 39.35 [30.28, 48.41]
Test of $\theta_i = \theta_j$: Q(13) = 473.01, p = 0.00
0.00 50.00 100.00
Random-effects REML model

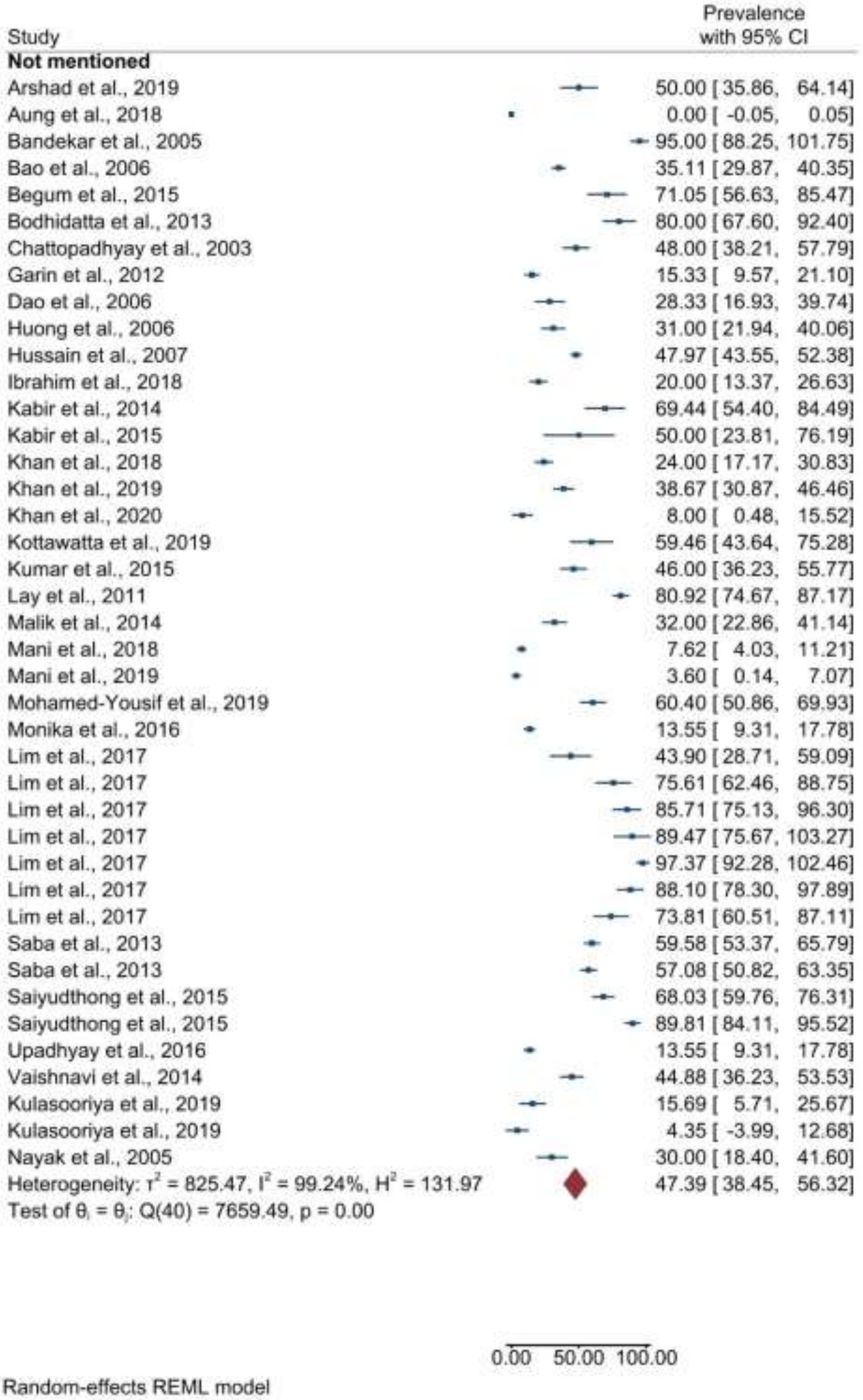

Study
Prevalence with 95% CI
Mixed
Malik et al., 2014 32.00 [22.86, 41.14]
Lim et al., 2017 43.90 [28.71, 59.09]
Lim et al., 2017 75.61 [62.46, 88.75]
Lim et al., 2017 85.71 [75.13, 96.30]
Lim et al., 2017 89.47 [75.67, 103.27]
Lim et al., 2017 97.37 [92.28, 102.46]
Lim et al., 2017 88.10 [78.30, 97.89]
Lim et al., 2017 73.81 [60.51, 87.11]
Singh et al., 2009 14.29 [2.69, 25.88]
Singh et al., 2009 11.76 [2.92, 20.61]
Kulasooriya et al., 2019 15.69 [5.71, 25.67]
Kulasooriya et al., 2019 4.35 [-3.99, 12.68]
Heterogeneity: τ^2 = 1255.08, I^2 = 98.09%, H^2 = 52.49 52.61 [32.31, 72.90]
Test of $\theta_i = \theta_j$: Q(11) = 746.97, p = 0.00
Not mentioned
Begum et al., 2015 71.05 [56.63, 85.47]
Kumar et al., 2015 46.00 [36.23, 55.77]
Mani et al., 2018 7.62 [4.03, 11.21]
Mani et al., 2019 3.60 [0.14, 7.07]
Monika et al., 2016 13.55 [9.31, 17.78]
Rawat et al., 2018 15.52 [8.93, 22.11]
Upadhyay et al., 2016 13.55 [9.31, 17.78]
Heterogeneity: τ^2 = 554.15, I^2 = 98.87%, H^2 = 88.60 23.75 [6.08, 41.42]
Test of $\theta_i = \theta_j$: Q(6) = 141.08, p = 0.00
0.00 50.00 100.00
Random-effects REML model

Appendix H. Forest plot for pooled prevalence (farm unit) of *Campylobacter* in chicken in different study sites in south and southeast Asia

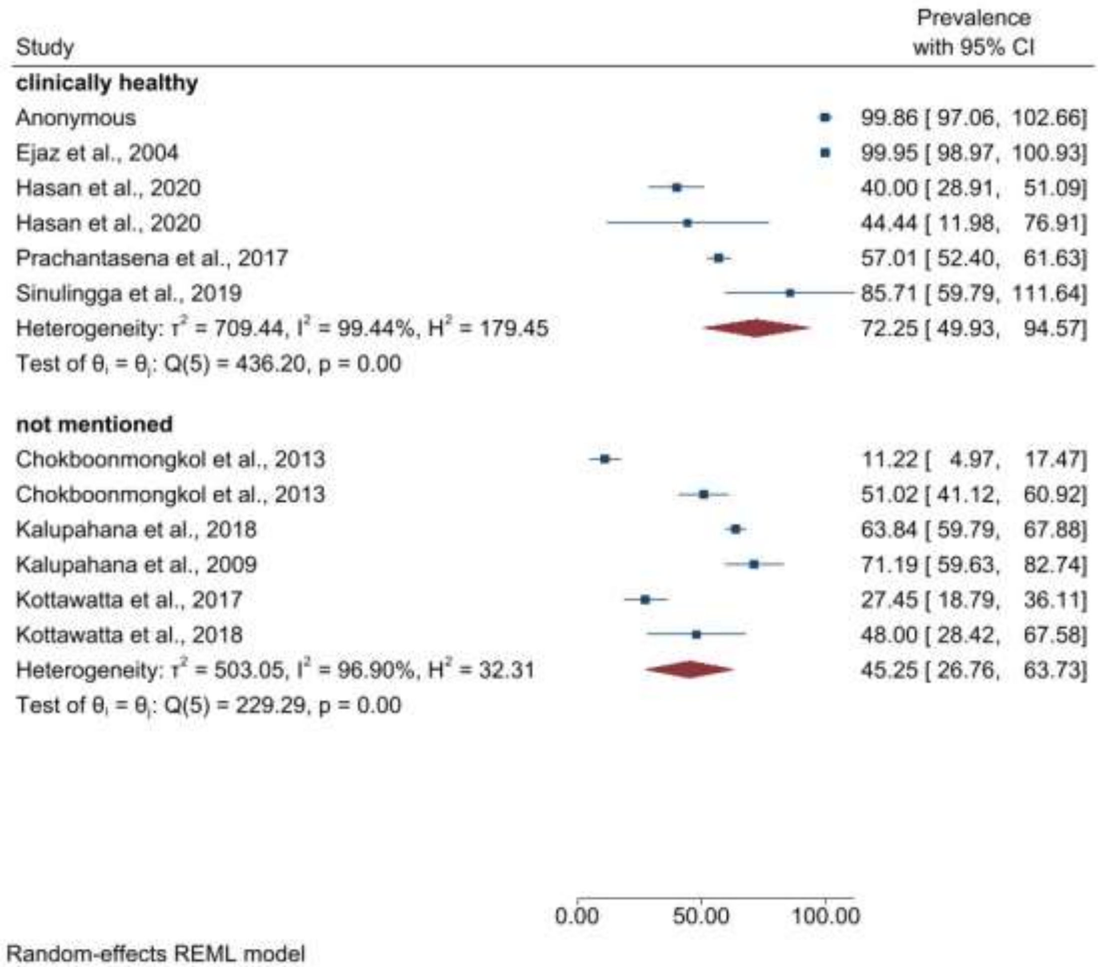


Appendix I. Forest plot for pooled prevalence (sample unit) of *Campylobacter* according to health status of chicken in south and southeast Asia

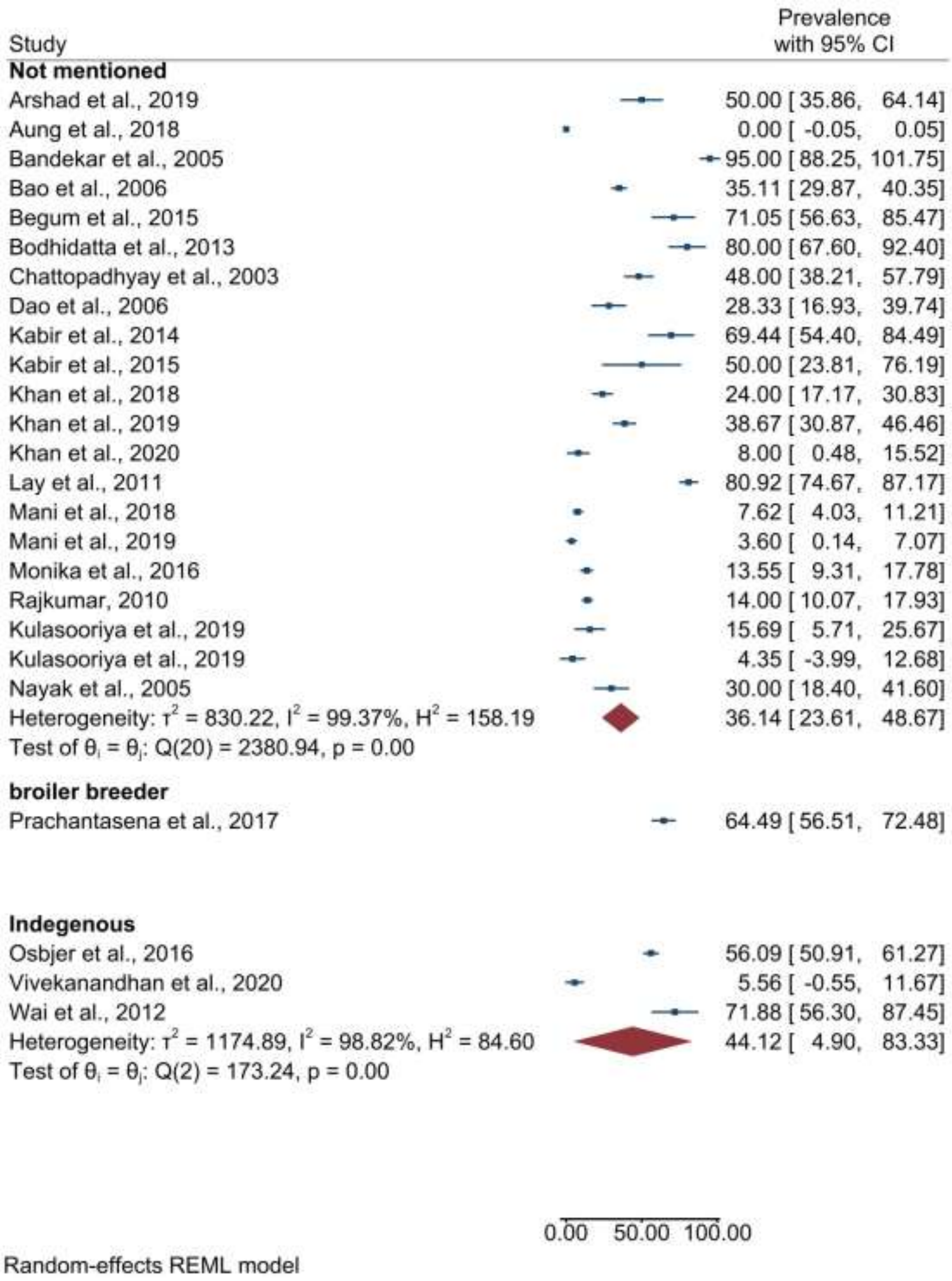


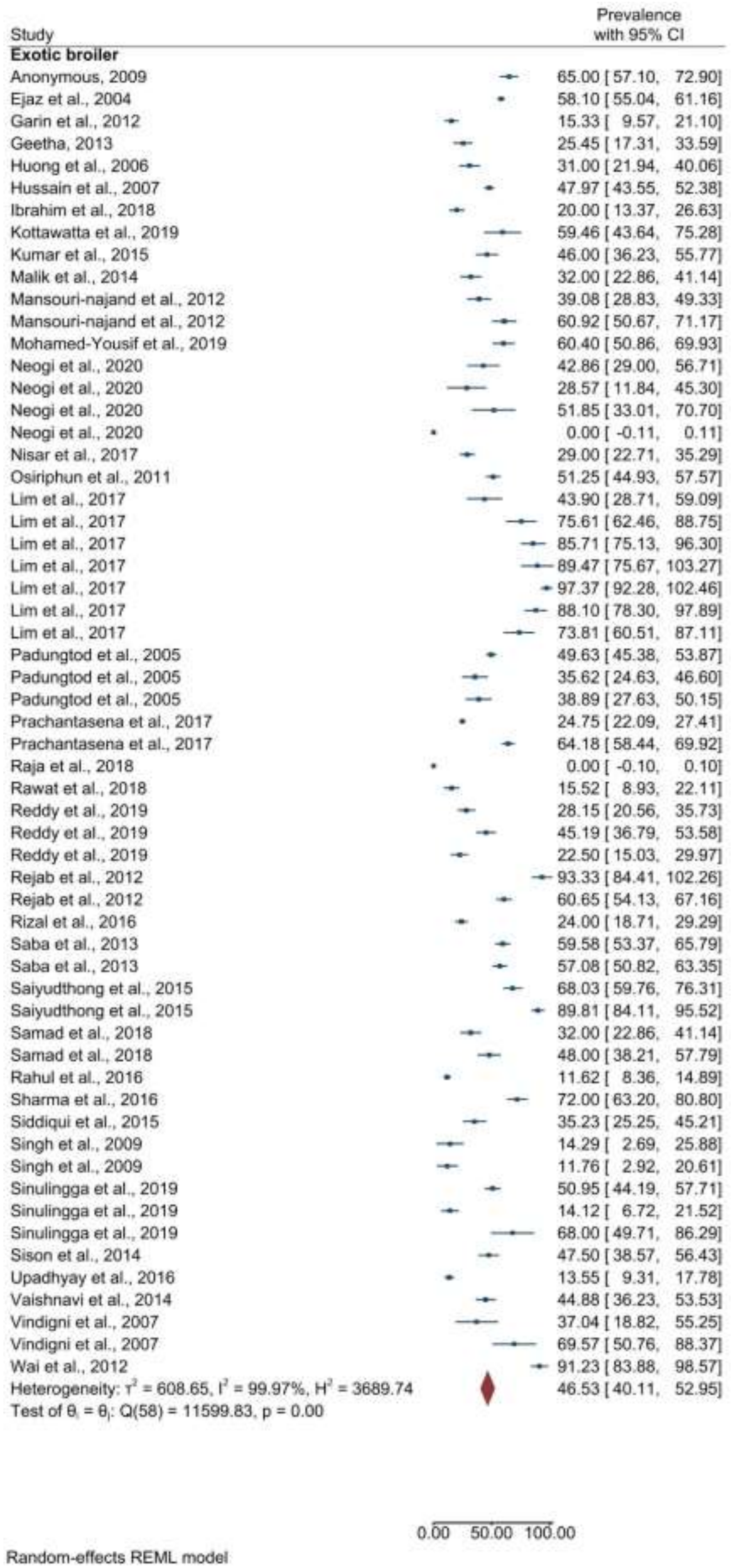

Study
Prevalence with 95% CI
Not mentioned
Arshad et al., 2019 50.00 [35.86, 64.14]
Aung et al., 2018 0.00 [-0.05, 0.05]
Bandekar et al., 2005 95.00 [88.25, 101.75]
Bao et al., 2006 35.11 [29.87, 40.35]
Begum et al., 2015 71.05 [56.63, 85.47]
Bodhidatta et al., 2013 80.00 [67.60, 92.40]
Chattopadhyay et al., 2003 48.00 [38.21, 57.79]
Garin et al., 2012 15.33 [9.57, 21.10]
Dao et al., 2006 28.33 [16.93, 39.74]
Huong et al., 2006 31.00 [21.94, 40.06]
Hussain et al., 2007 47.97 [43.55, 52.38]
Ibrahim et al., 2018 20.00 [13.37, 26.63]
Kabir et al., 2014 69.44 [54.40, 84.49]
Kabir et al., 2015 50.00 [23.81, 76.19]
Khan et al., 2018 24.00 [17.17, 30.83]
Khan et al., 2019 38.67 [30.87, 46.46]
Khan et al., 2020 8.00 [0.48, 15.52]
Kottawatta et al., 2019 59.46 [43.64, 75.28]
Kumar et al., 2015 46.00 [36.23, 55.77]
Lay et al., 2011 80.92 [74.67, 87.17]
Malik et al., 2014 32.00 [22.86, 41.14]
Mani et al., 2018 7.62 [4.03, 11.21]
Mani et al., 2019 3.60 [0.14, 7.07]
Mohamed-Yousif et al., 2019 60.40 [50.86, 69.93]
Monika et al., 2016 13.55 [9.31, 17.78]
Lim et al., 2017 43.90 [28.71, 59.09]
Lim et al., 2017 75.61 [62.46, 88.75]
Lim et al., 2017 85.71 [75.13, 96.30]
Lim et al., 2017 89.47 [75.67, 103.27]
Lim et al., 2017 97.37 [92.28, 102.46]
Lim et al., 2017 88.10 [78.30, 97.89]
Lim et al., 2017 73.81 [60.51, 87.11]
Saba et al., 2013 59.58 [53.37, 65.79]
Saba et al., 2013 57.08 [50.82, 63.35]
Saiyudthong et al., 2015 68.03 [59.76, 76.31]
Saiyudthong et al., 2015 89.81 [84.11, 95.52]
Upadhyay et al., 2016 13.55 [9.31, 17.78]
Vaishnavi et al., 2014 44.88 [36.23, 53.53]
Kulasooriya et al., 2019 15.69 [5.71, 25.67]
Kulasooriya et al., 2019 4.35 [-3.99, 12.68]
Nayak et al., 2005 30.00 [18.40, 41.60]
Heterogeneity: τ^2 = 825.47, I^2 = 99.24%, H^2 = 131.97 47.39 [38.45, 56.32]
Test of $\theta_i = \theta_j$: Q(40) = 7659.49, p = 0.00
0.00 50.00 100.00
Random-effects REML model

Appendix J. Forest plot for pooled prevalence (farm unit) of *Campylobacter* according to health status of chicken in south and southeast Asia

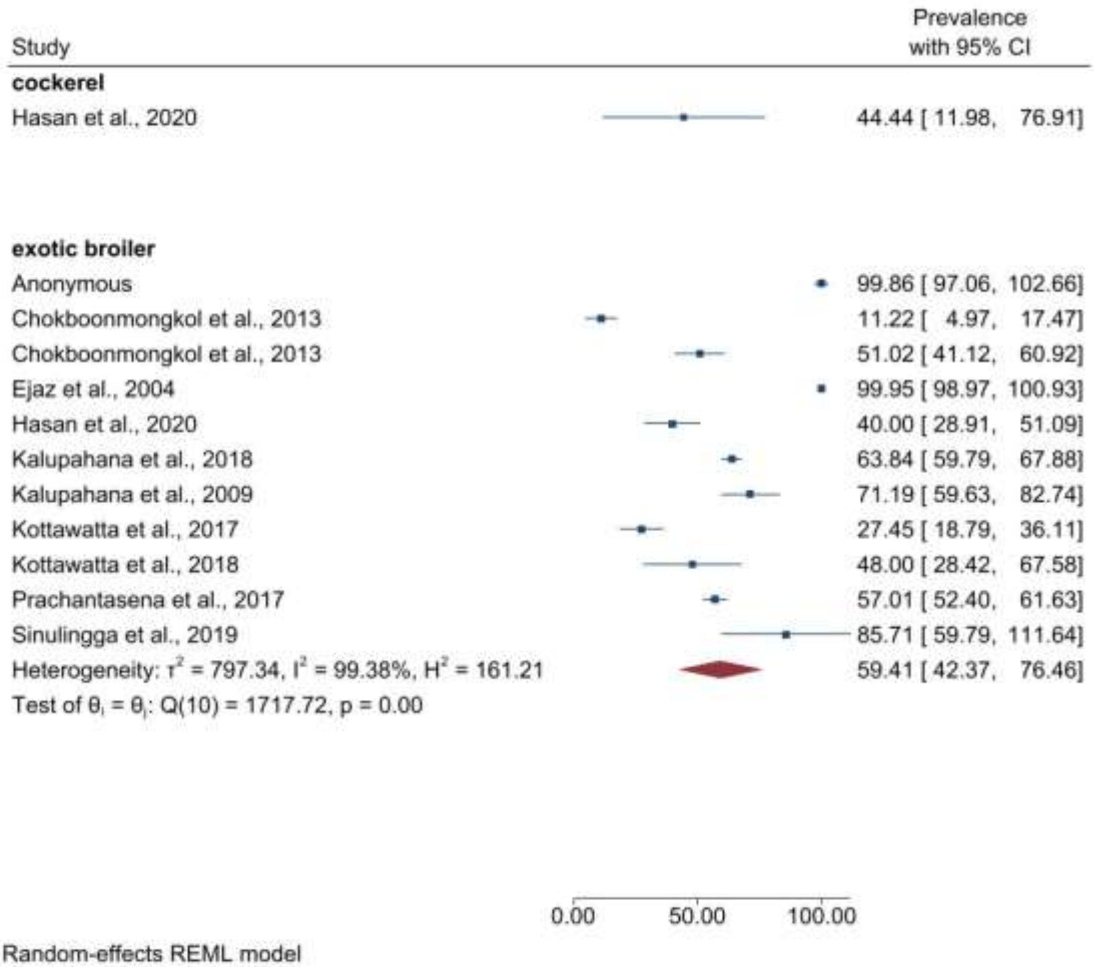


Appendix K. Forest plot for pooled prevalence (sample unit) of *Campylobacter* in chicken in different production type in south and southeast Asia

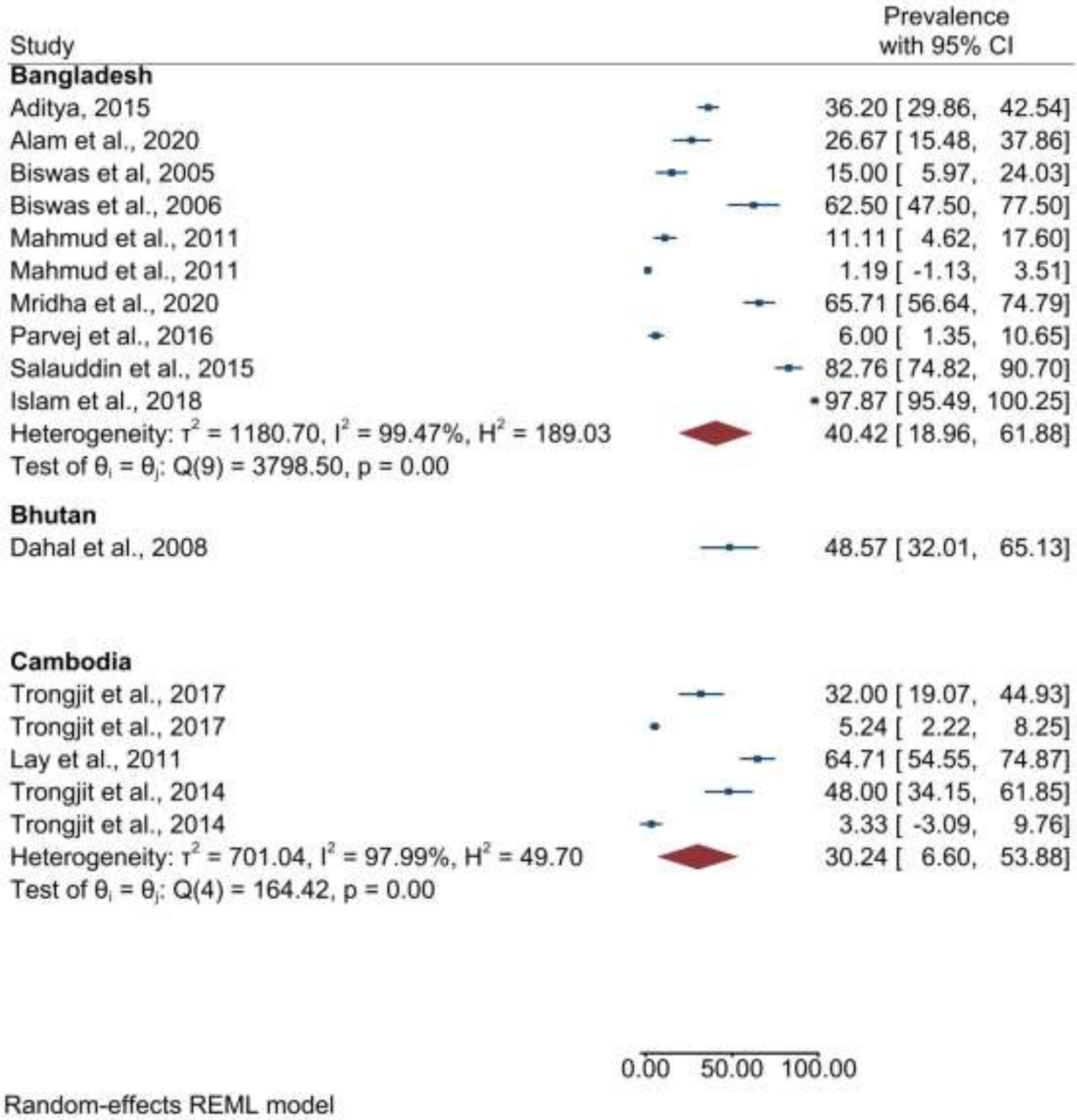


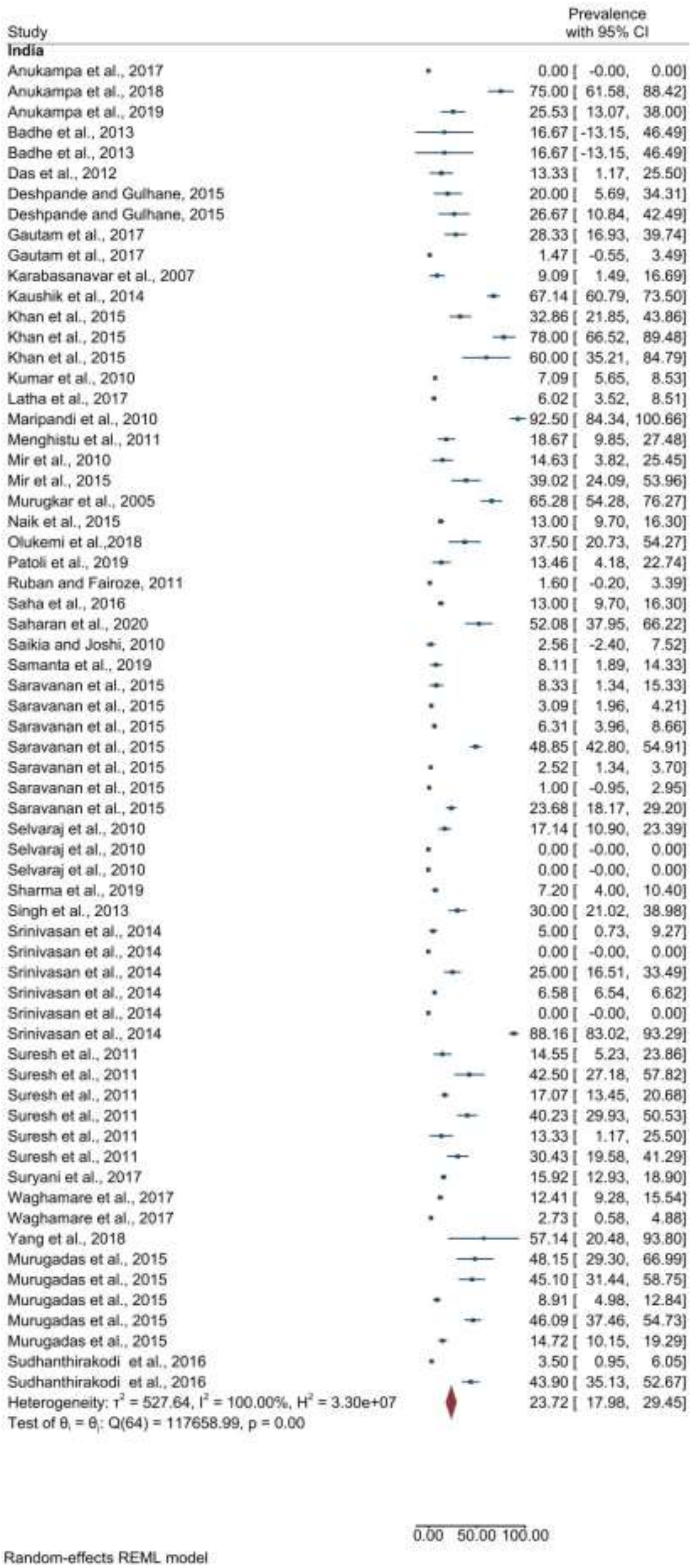

Study
Prevalence with 95% CI
Exotic broiler
Anonymous, 2009 65.00 [57.10, 72.90]
Ejaz et al., 2004 58.10 [55.04, 61.16]
Garin et al., 2012 15.33 [9.57, 21.10]
Geetha, 2013 25.45 [17.31, 33.59]
Huong et al., 2006 31.00 [21.94, 40.06]
Hussain et al., 2007 47.97 [43.55, 52.38]
Ibrahim et al., 2018 20.00 [13.37, 26.63]
Kottawatta et al., 2019 59.46 [43.64, 75.28]
Kumar et al., 2015 46.00 [36.23, 55.77]
Malik et al., 2014 32.00 [22.86, 41.14]
Mansouri-najand et al., 2012 39.08 [28.83, 49.33]
Mansouri-najand et al., 2012 60.92 [50.67, 71.17]
Mohamed-Yousif et al., 2019 60.40 [50.86, 69.93]
Neogi et al., 2020 42.86 [29.00, 56.71]
Neogi et al., 2020 28.57 [11.84, 45.30]
Neogi et al., 2020 51.85 [33.01, 70.70]
Neogi et al., 2020 0.00 [-0.11, 0.11]
Nisar et al., 2017 29.00 [22.71, 35.29]
Osiriphun et al., 2011 51.25 [44.93, 57.57]
Lim et al., 2017 43.90 [28.71, 59.09]
Lim et al., 2017 75.61 [62.46, 88.75]
Lim et al., 2017 85.71 [75.13, 96.30]
Lim et al., 2017 89.47 [75.67, 103.27]
Lim et al., 2017 97.37 [92.28, 102.46]
Lim et al., 2017 88.10 [78.30, 97.89]
Lim et al., 2017 73.81 [60.51, 87.11]
Padungtod et al., 2005 49.63 [45.38, 53.87]
Padungtod et al., 2005 35.62 [24.63, 46.60]
Padungtod et al., 2005 38.89 [27.63, 50.15]
Prachantasena et al., 2017 24.75 [22.09, 27.41]
Prachantasena et al., 2017 64.18 [58.44, 69.92]
Raja et al., 2018 0.00 [-0.10, 0.10]
Rawat et al., 2018 15.52 [8.93, 22.11]
Reddy et al., 2019 28.15 [20.56, 35.73]
Reddy et al., 2019 45.19 [36.79, 53.58]
Reddy et al., 2019 22.50 [15.03, 29.97]
Rejab et al., 2012 93.33 [84.41, 102.26]
Rejab et al., 2012 60.65 [54.13, 67.16]
Rizal et al., 2016 24.00 [18.71, 29.29]
Saba et al., 2013 59.58 [53.37, 65.79]
Saba et al., 2013 57.08 [50.82, 63.35]
Saiyudthong et al., 2015 68.03 [59.76, 76.31]
Saiyudthong et al., 2015 89.81 [84.11, 95.52]
Samad et al., 2018 32.00 [22.86, 41.14]
Samad et al., 2018 48.00 [38.21, 57.79]
Rahul et al., 2016 11.62 [8.36, 14.89]
Sharma et al., 2016 72.00 [63.20, 80.80]
Siddiqui et al., 2015 35.23 [25.25, 45.21]
Singh et al., 2009 14.29 [2.69, 25.88]
Singh et al., 2009 11.76 [2.92, 20.61]
Sinulingga et al., 2019 50.95 [44.19, 57.71]
Sinulingga et al., 2019 14.12 [6.72, 21.52]
Sinulingga et al., 2019 68.00 [49.71, 86.29]
Sison et al., 2014 47.50 [38.57, 56.43]
Upadhyay et al., 2016 13.55 [9.31, 17.78]
Vaishnavi et al., 2014 44.88 [36.23, 53.53]
Vindigni et al., 2007 37.04 [18.82, 55.25]
Vindigni et al., 2007 69.57 [50.76, 88.37]
Wai et al., 2012 91.23 [83.88, 98.57]
Heterogeneity: τ^2 = 608.65, I^2 = 99.97%, H^2 = 3689.74 46.53 [40.11, 52.95]
Test of $\theta_i = \theta_j$: Q(58) = 11599.83, p = 0.00
0.00 50.00 100.00
Random-effects REML model

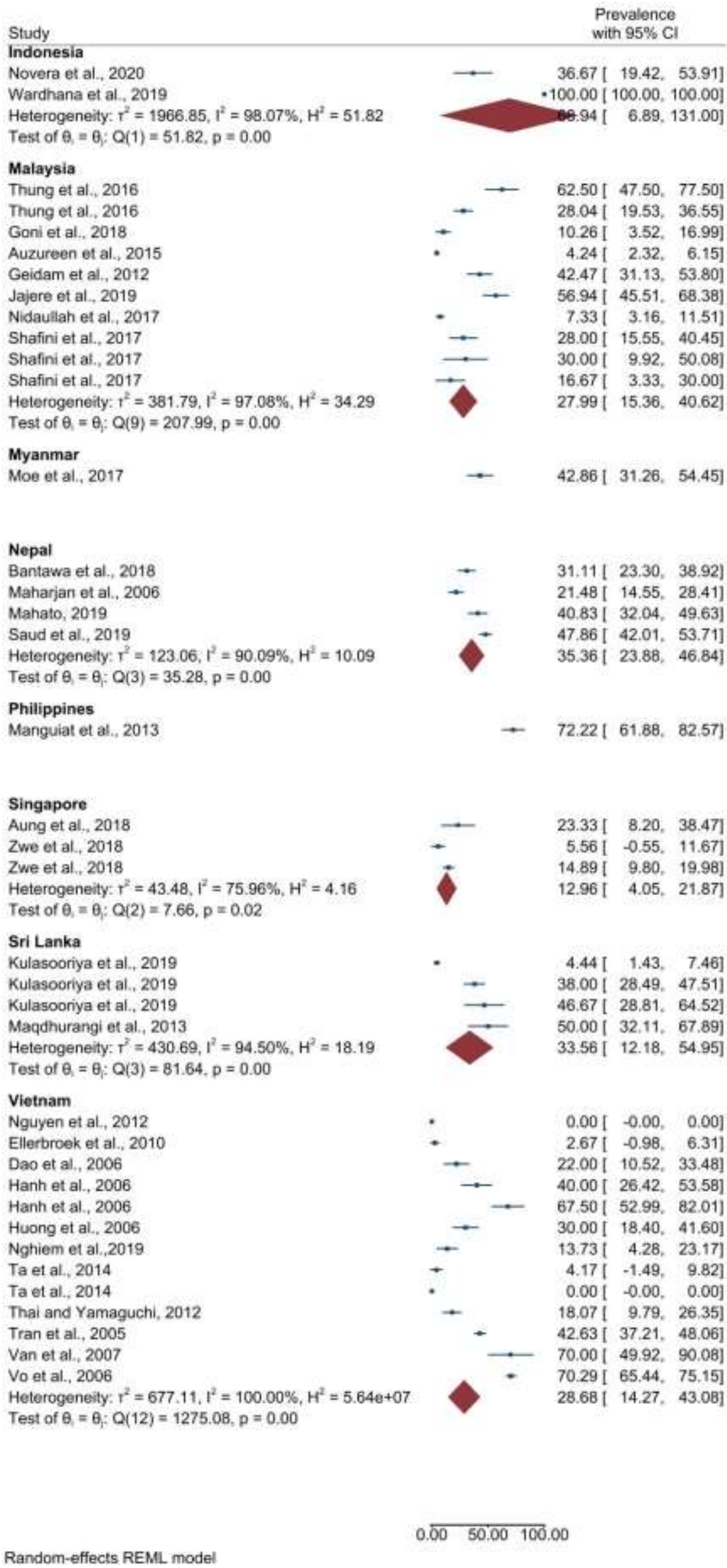
Appendix L. Forest plot for pooled prevalence (farm unit) of *Campylobacter* in chicken in different production type in south and southeast Asia

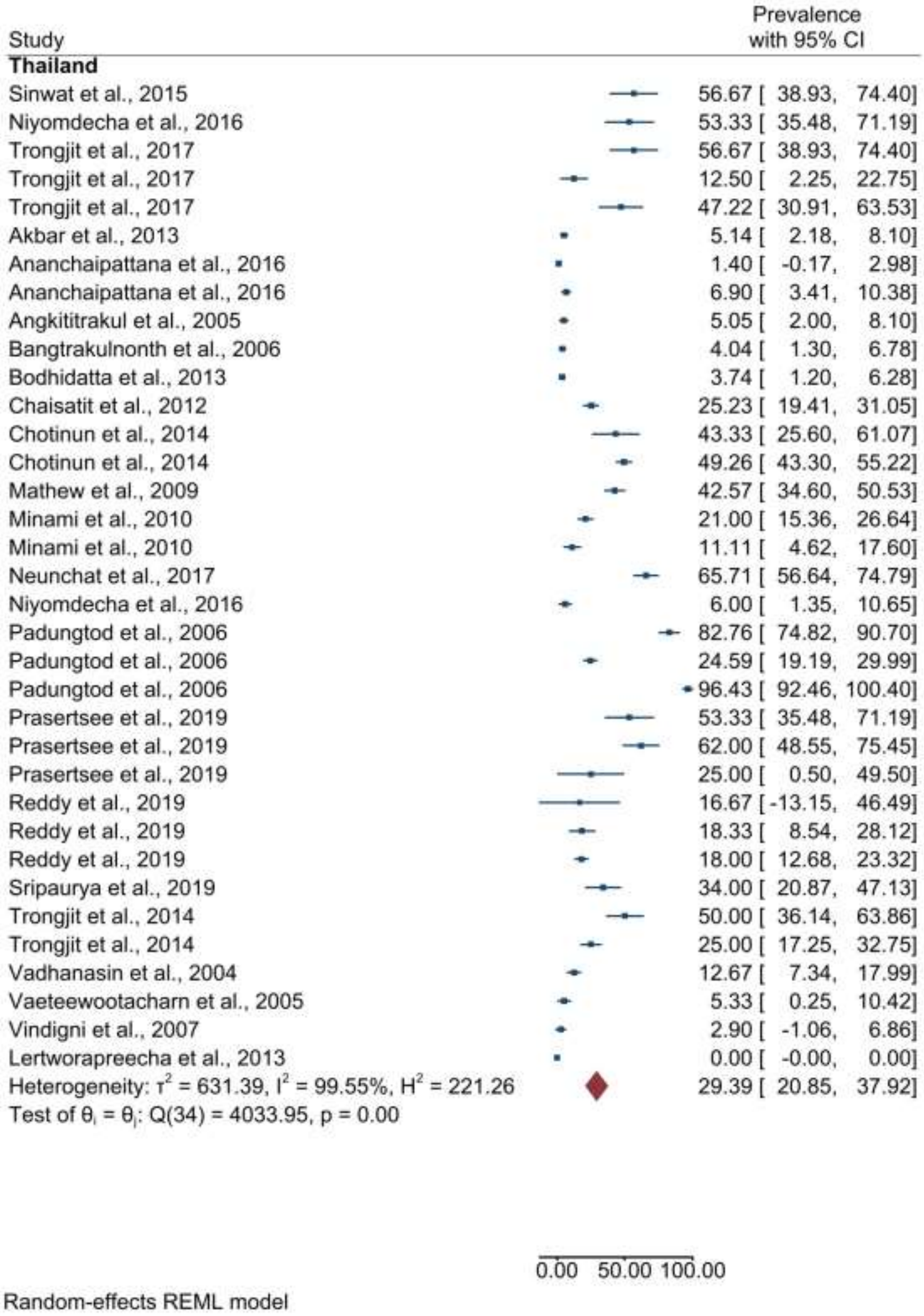


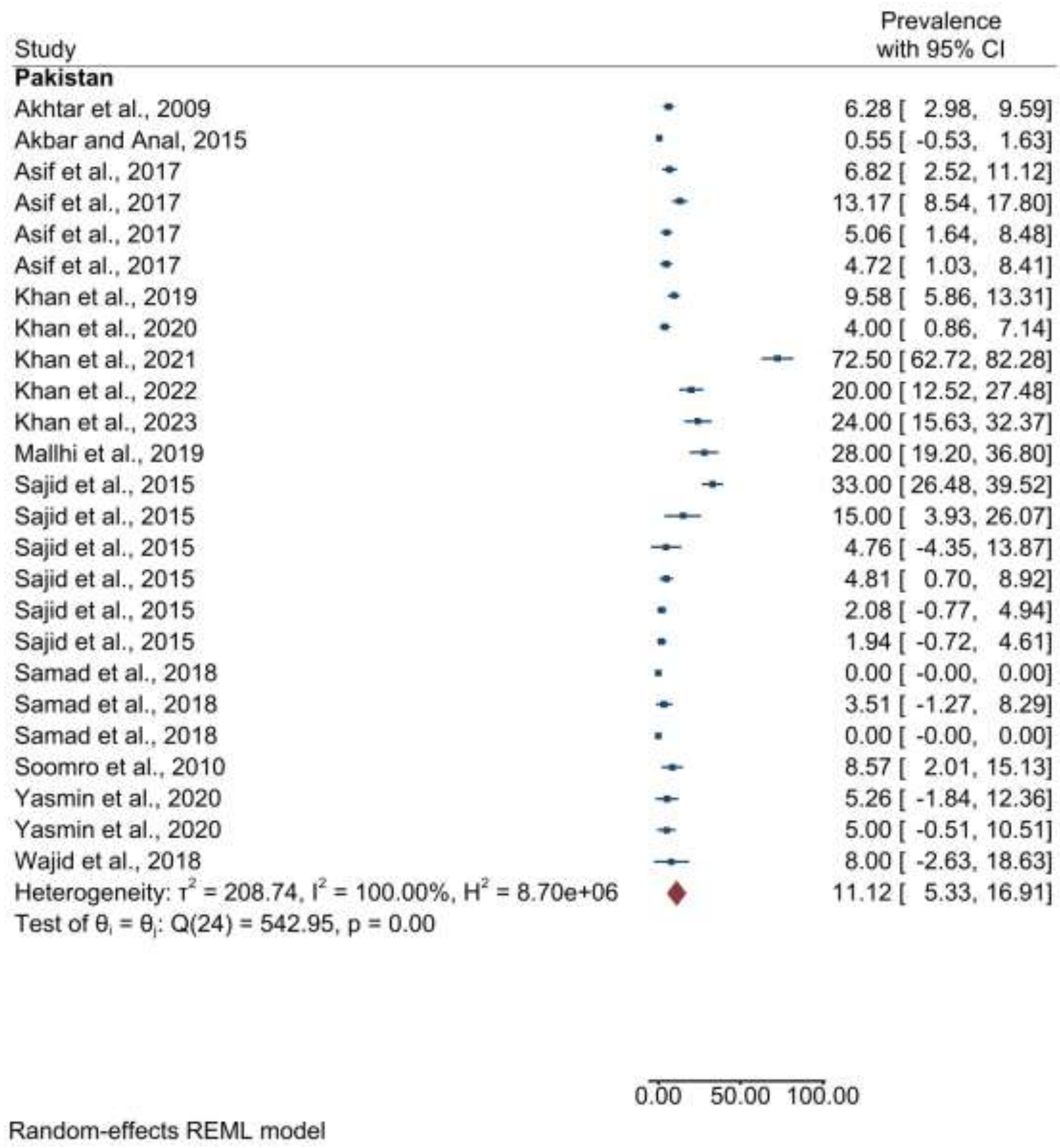
Appendix M. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in chickens across different south and southeast Asian countries



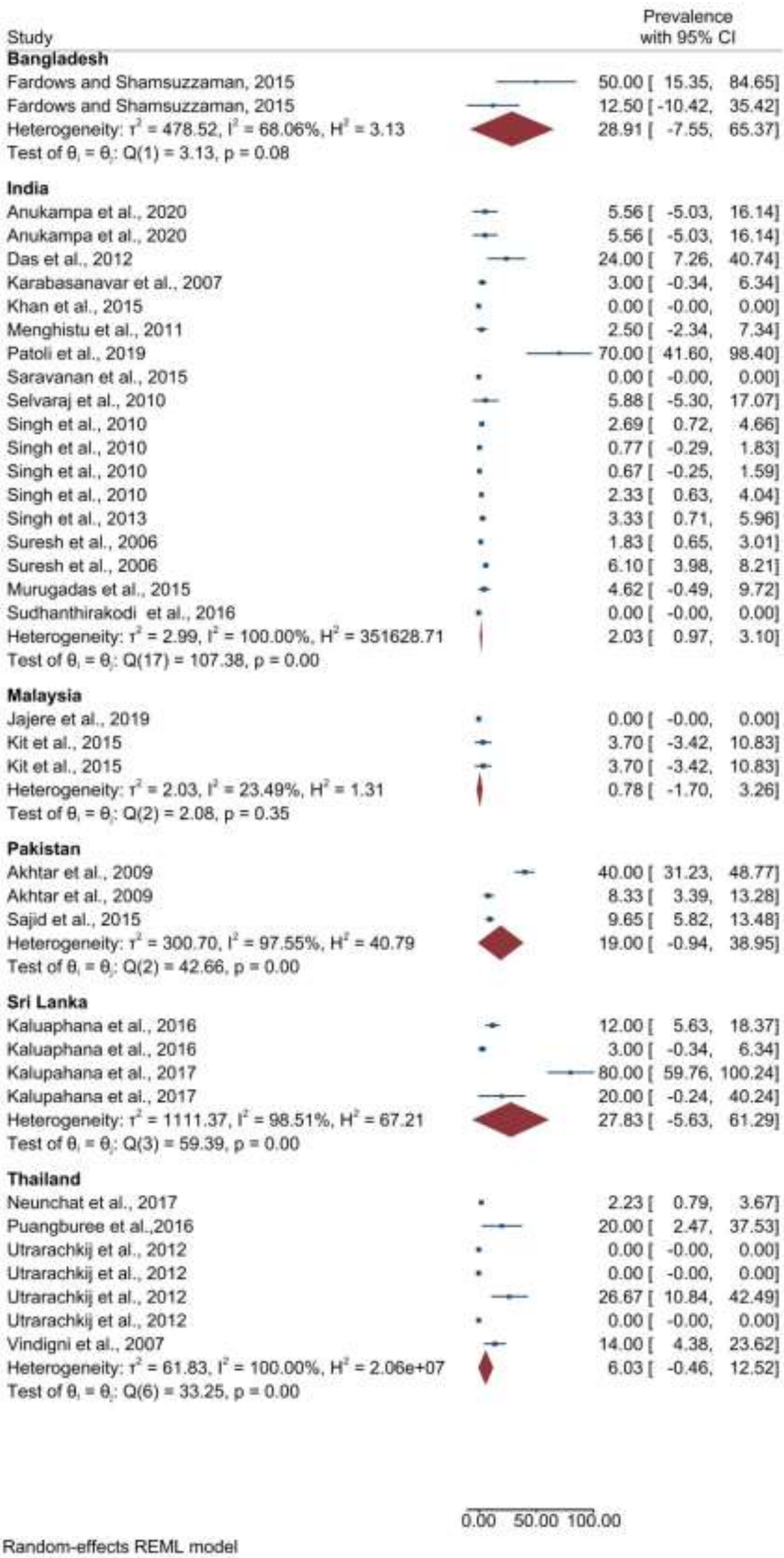

Study
Prevalence with 95% CI
India
Anukampa et al., 2017 0.00 [-0.00, 0.00]
Anukampa et al., 2018 75.00 [61.58, 88.42]
Anukampa et al., 2019 25.53 [13.07, 38.00]
Badhe et al., 2013 16.67 [-13.15, 46.49]
Badhe et al., 2013 16.67 [-13.15, 46.49]
Das et al., 2012 13.33 [1.17, 25.50]
Deshpande and Gulhane, 2015 20.00 [5.69, 34.31]
Deshpande and Gulhane, 2015 26.67 [10.84, 42.49]
Gautam et al., 2017 28.33 [16.93, 39.74]
Gautam et al., 2017 1.47 [-0.55, 3.49]
Karabasanavar et al., 2007 9.09 [1.49, 16.69]
Kaushik et al., 2014 67.14 [60.79, 73.50]
Khan et al., 2015 32.86 [21.85, 43.86]
Khan et al., 2015 78.00 [66.52, 89.48]
Khan et al., 2015 60.00 [35.21, 84.79]
Kumar et al., 2010 7.09 [5.65, 8.53]
Latha et al., 2017 6.02 [3.52, 8.51]
Maripandi et al., 2010 92.50 [84.34, 100.66]
Menghistu et al., 2011 18.67 [9.85, 27.48]
Mir et al., 2010 14.63 [3.82, 25.45]
Mir et al., 2015 39.02 [24.09, 53.96]
Murugkar et al., 2005 65.28 [54.28, 76.27]
Naik et al., 2015 13.00 [9.70, 16.30]
Olukemi et al.,2018 37.50 [20.73, 54.27]
Patoli et al., 2019 13.46 [4.18, 22.74]
Ruban and Fairoze, 2011 1.60 [-0.20, 3.39]
Saha et al., 2016 13.00 [9.70, 16.30]
Saharan et al., 2020 52.08 [37.95, 66.22]
Saikia and Joshi, 2010 2.56 [-2.40, 7.52]
Samanta et al., 2019 8.11 [1.89, 14.33]
Saravanan et al., 2015 8.33 [1.34, 15.33]
Saravanan et al., 2015 3.09 [1.96, 4.21]
Saravanan et al., 2015 6.31 [3.96, 8.66]
Saravanan et al., 2015 48.85 [42.80, 54.91]
Saravanan et al., 2015 2.52 [1.34, 3.70]
Saravanan et al., 2015 1.00 [-0.95, 2.95]
Saravanan et al., 2015 23.68 [18.17, 29.20]
Selvaraj et al., 2010 17.14 [10.90, 23.39]
Selvaraj et al., 2010 0.00 [-0.00, 0.00]
Selvaraj et al., 2010 0.00 [-0.00, 0.00]
Sharma et al., 2019 7.20 [4.00, 10.40]
Singh et al., 2013 30.00 [21.02, 38.98]
Srinivasan et al., 2014 5.00 [0.73, 9.27]
Srinivasan et al., 2014 0.00 [-0.00, 0.00]
Srinivasan et al., 2014 25.00 [16.51, 33.49]
Srinivasan et al., 2014 6.58 [6.54, 6.62]
Srinivasan et al., 2014 0.00 [-0.00, 0.00]
Srinivasan et al., 2014 88.16 [83.02, 93.29]
Suresh et al., 2011 14.55 [5.23, 23.86]
Suresh et al., 2011 42.50 [27.18, 57.82]
Suresh et al., 2011 17.07 [13.45, 20.68]
Suresh et al., 2011 40.23 [29.93, 50.53]
Suresh et al., 2011 13.33 [1.17, 25.50]
Suresh et al., 2011 30.43 [19.58, 41.29]
Suryani et al., 2017 15.92 [12.93, 18.90]
Waghamare et al., 2017 12.41 [9.28, 15.54]
Waghamare et al., 2017 2.73 [0.58, 4.88]
Yang et al., 2018 57.14 [20.48, 93.80]
Murugadas et al., 2015 48.15 [29.30, 66.99]
Murugadas et al., 2015 45.10 [31.44, 58.75]
Murugadas et al., 2015 8.91 [4.98, 12.84]
Murugadas et al., 2015 46.09 [37.46, 54.73]
Murugadas et al., 2015 14.72 [10.15, 19.29]
Sudhanthirakodi et al., 2016 3.50 [0.95, 6.05]
Sudhanthirakodi et al., 2016 43.90 [35.13, 52.67]
Heterogeneity: τ² = 527.64, I² = 100.00%, H² = 3.30e+07 23.72 [17.98, 29.45]
Test of θᵢ = θⱼ: Q(64) = 117658.99, p = 0.00
0.00 50.00 100.00
Random-effects REML model


Study
Prevalence with 95% CI
Indonesia
Novera et al., 2020 36.67 [19.42, 53.91]
Wardhana et al., 2019 100.00 [100.00, 100.00]
Heterogeneity: τ^2 = 1966.85, I^2 = 98.07%, H^2 = 51.82 68.94 [6.89, 131.00]
Test of $\theta_i = \theta_j$: Q(1) = 51.82, p = 0.00
Malaysia
Thung et al., 2016 62.50 [47.50, 77.50]
Thung et al., 2016 28.04 [19.53, 36.55]
Goni et al., 2018 10.26 [3.52, 16.99]
Auzureen et al., 2015 4.24 [2.32, 6.15]
Geidam et al., 2012 42.47 [31.13, 53.80]
Jajere et al., 2019 56.94 [45.51, 68.38]
Nidaullah et al., 2017 7.33 [3.16, 11.51]
Shafini et al., 2017 28.00 [15.55, 40.45]
Shafini et al., 2017 30.00 [9.92, 50.08]
Shafini et al., 2017 16.67 [3.33, 30.00]
Heterogeneity: τ^2 = 381.79, I^2 = 97.08%, H^2 = 34.29 27.99 [15.36, 40.62]
Test of $\theta_i = \theta_j$: Q(9) = 207.99, p = 0.00
Myanmar
Moe et al., 2017 42.86 [31.26, 54.45]
Nepal
Bantawa et al., 2018 31.11 [23.30, 38.92]
Maharjan et al., 2006 21.48 [14.55, 28.41]
Mahato, 2019 40.83 [32.04, 49.63]
Saud et al., 2019 47.86 [42.01, 53.71]
Heterogeneity: τ^2 = 123.06, I^2 = 90.09%, H^2 = 10.09 35.36 [23.88, 46.84]
Test of $\theta_i = \theta_j$: Q(3) = 35.28, p = 0.00
Philippines
Manguiat et al., 2013 72.22 [61.88, 82.57]
Singapore
Aung et al., 2018 23.33 [8.20, 38.47]
Zwe et al., 2018 5.56 [-0.55, 11.67]
Zwe et al., 2018 14.89 [9.80, 19.98]
Heterogeneity: τ^2 = 43.48, I^2 = 75.96%, H^2 = 4.16 12.96 [4.05, 21.87]
Test of $\theta_i = \theta_j$: Q(2) = 7.66, p = 0.02
Sri Lanka
Kulasooriya et al., 2019 4.44 [1.43, 7.46]
Kulasooriya et al., 2019 38.00 [28.49, 47.51]
Kulasooriya et al., 2019 46.67 [28.81, 64.52]
Maqdhurangi et al., 2013 50.00 [32.11, 67.89]
Heterogeneity: τ^2 = 430.69, I^2 = 94.50%, H^2 = 18.19 33.56 [12.18, 54.95]
Test of $\theta_i = \theta_j$: Q(3) = 81.64, p = 0.00
Vietnam
Nguyen et al., 2012 0.00 [-0.00, 0.00]
Ellerbroek et al., 2010 2.67 [-0.98, 6.31]
Dao et al., 2006 22.00 [10.52, 33.48]
Hanh et al., 2006 40.00 [26.42, 53.58]
Hanh et al., 2006 67.50 [52.99, 82.01]
Huong et al., 2006 30.00 [18.40, 41.60]
Nghiem et al.,2019 13.73 [4.28, 23.17]
Ta et al., 2014 4.17 [-1.49, 9.82]
Ta et al., 2014 0.00 [-0.00, 0.00]
Thai and Yamaguchi, 2012 18.07 [9.79, 26.35]
Tran et al., 2005 42.63 [37.21, 48.06]
Van et al., 2007 70.00 [49.92, 90.08]
Vo et al., 2006 70.29 [65.44, 75.15]
Heterogeneity: τ^2 = 677.11, I^2 = 100.00%, H^2 = 5.64e+07 28.68 [14.27, 43.08]
Test of $\theta_i = \theta_j$: Q(12) = 1275.08, p = 0.00
0.00 50.00 100.00
Random-effects REML model

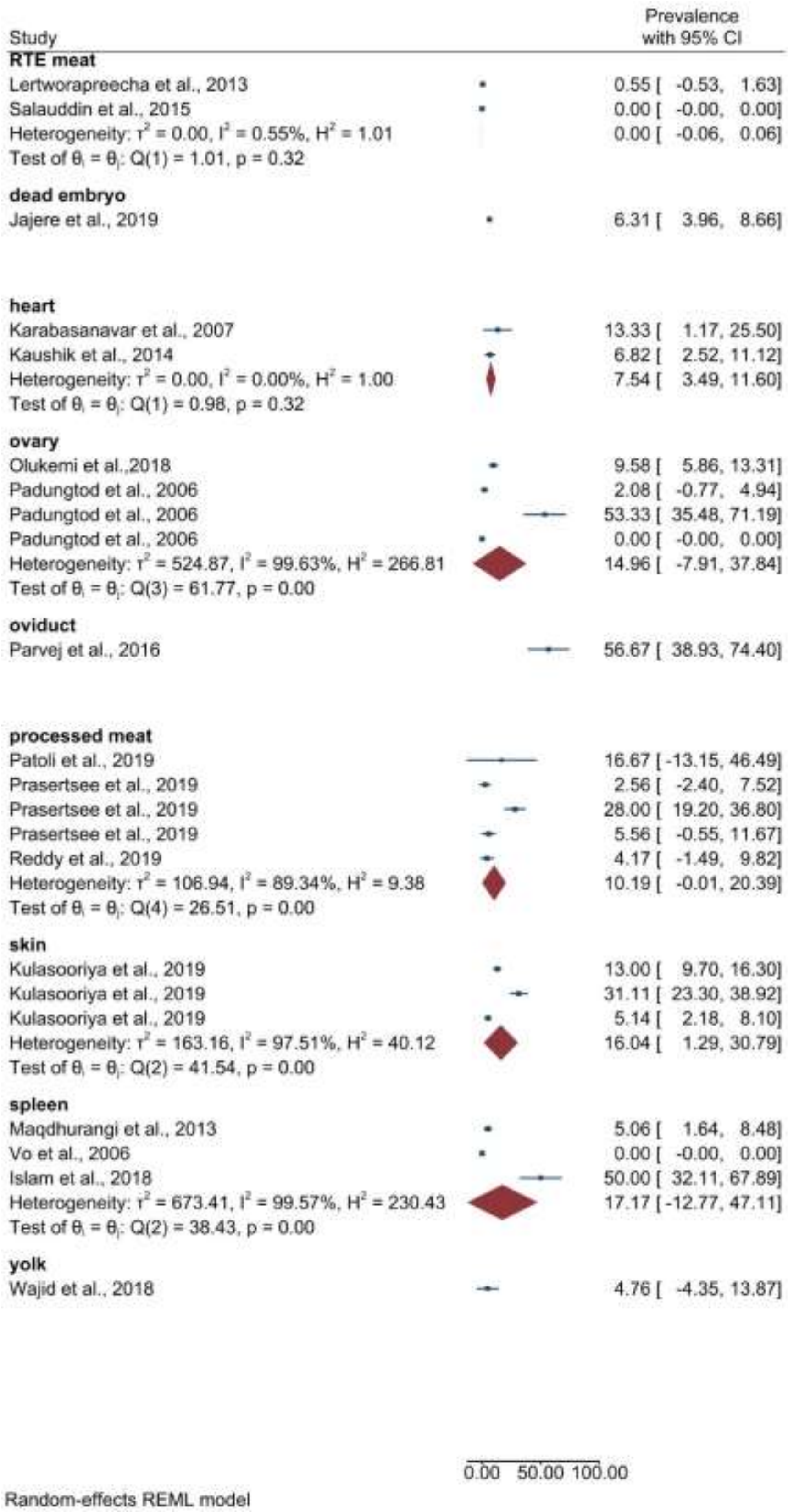

Study
Prevalence with 95% CI
Thailand
Sinwat et al., 2015 56.67 [38.93, 74.40]
Niyomdecha et al., 2016 53.33 [35.48, 71.19]
Trongjit et al., 2017 56.67 [38.93, 74.40]
Trongjit et al., 2017 12.50 [2.25, 22.75]
Trongjit et al., 2017 47.22 [30.91, 63.53]
Akbar et al., 2013 5.14 [2.18, 8.10]
Ananchaipattana et al., 2016 1.40 [-0.17, 2.98]
Ananchaipattana et al., 2016 6.90 [3.41, 10.38]
Angkititrakul et al., 2005 5.05 [2.00, 8.10]
Bangtrakulnonth et al., 2006 4.04 [1.30, 6.78]
Bodhidatta et al., 2013 3.74 [1.20, 6.28]
Chaisatit et al., 2012 25.23 [19.41, 31.05]
Chotinun et al., 2014 43.33 [25.60, 61.07]
Chotinun et al., 2014 49.26 [43.30, 55.22]
Mathew et al., 2009 42.57 [34.60, 50.53]
Minami et al., 2010 21.00 [15.36, 26.64]
Minami et al., 2010 11.11 [4.62, 17.60]
Neunchat et al., 2017 65.71 [56.64, 74.79]
Niyomdecha et al., 2016 6.00 [1.35, 10.65]
Padungtod et al., 2006 82.76 [74.82, 90.70]
Padungtod et al., 2006 24.59 [19.19, 29.99]
Padungtod et al., 2006 96.43 [92.46, 100.40]
Prasertsee et al., 2019 53.33 [35.48, 71.19]
Prasertsee et al., 2019 62.00 [48.55, 75.45]
Prasertsee et al., 2019 25.00 [0.50, 49.50]
Reddy et al., 2019 16.67 [-13.15, 46.49]
Reddy et al., 2019 18.33 [8.54, 28.12]
Reddy et al., 2019 18.00 [12.68, 23.32]
Sripaurya et al., 2019 34.00 [20.87, 47.13]
Trongjit et al., 2014 50.00 [36.14, 63.86]
Trongjit et al., 2014 25.00 [17.25, 32.75]
Vadhanasin et al., 2004 12.67 [7.34, 17.99]
Vaeteewootacharn et al., 2005 5.33 [0.25, 10.42]
Vindigni et al., 2007 2.90 [-1.06, 6.86]
Lertworapreecha et al., 2013 0.00 [-0.00, 0.00]
Heterogeneity: τ² = 631.39, I² = 99.55%, H² = 221.26 29.39 [20.85, 37.92]
Test of θi = θj: Q(34) = 4033.95, p = 0.00
0.00 50.00 100.00
Random-effects REML model

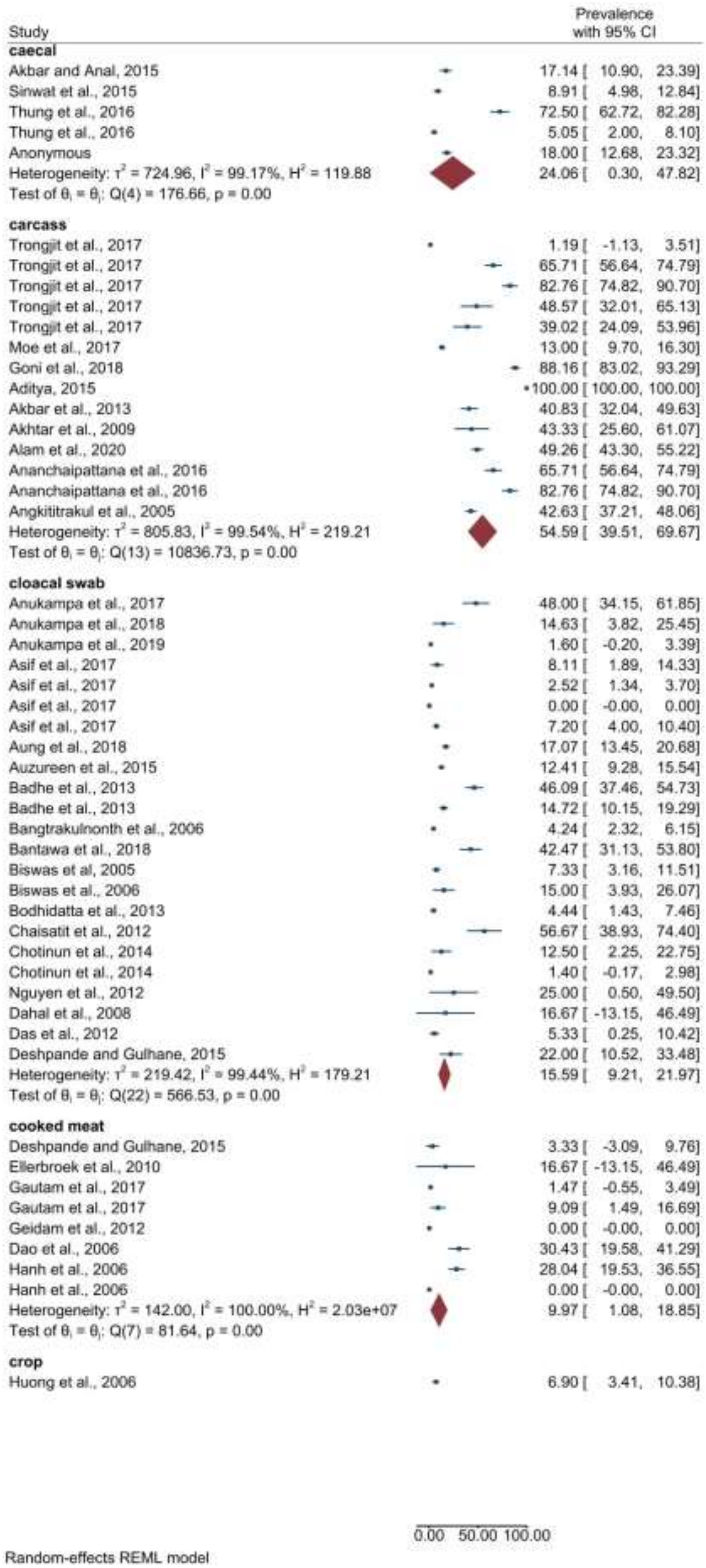

Study
Prevalence with 95% CI
Pakistan
Akhtar et al., 2009 6.28 [2.98, 9.59]
Akbar and Anal, 2015 0.55 [-0.53, 1.63]
Asif et al., 2017 6.82 [2.52, 11.12]
Asif et al., 2017 13.17 [8.54, 17.80]
Asif et al., 2017 5.06 [1.64, 8.48]
Asif et al., 2017 4.72 [1.03, 8.41]
Khan et al., 2019 9.58 [5.86, 13.31]
Khan et al., 2020 4.00 [0.86, 7.14]
Khan et al., 2021 72.50 [62.72, 82.28]
Khan et al., 2022 20.00 [12.52, 27.48]
Khan et al., 2023 24.00 [15.63, 32.37]
Mallhi et al., 2019 28.00 [19.20, 36.80]
Sajid et al., 2015 33.00 [26.48, 39.52]
Sajid et al., 2015 15.00 [3.93, 26.07]
Sajid et al., 2015 4.76 [-4.35, 13.87]
Sajid et al., 2015 4.81 [0.70, 8.92]
Sajid et al., 2015 2.08 [-0.77, 4.94]
Sajid et al., 2015 1.94 [-0.72, 4.61]
Samad et al., 2018 0.00 [-0.00, 0.00]
Samad et al., 2018 3.51 [-1.27, 8.29]
Samad et al., 2018 0.00 [-0.00, 0.00]
Soomro et al., 2010 8.57 [2.01, 15.13]
Yasmin et al., 2020 5.26 [-1.84, 12.36]
Yasmin et al., 2020 5.00 [-0.51, 10.51]
Wajid et al., 2018 8.00 [-2.63, 18.63]
Heterogeneity: τ^2 = 208.74, I^2 = 100.00%, H^2 = 8.70e+06 11.12 [5.33, 16.91]
Test of $\theta_i = \theta_j$: Q(24) = 542.95, p = 0.00
0.00 50.00 100.00
Random-effects REML model

Appendix N. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in eggs across different south and southeast Asian countries

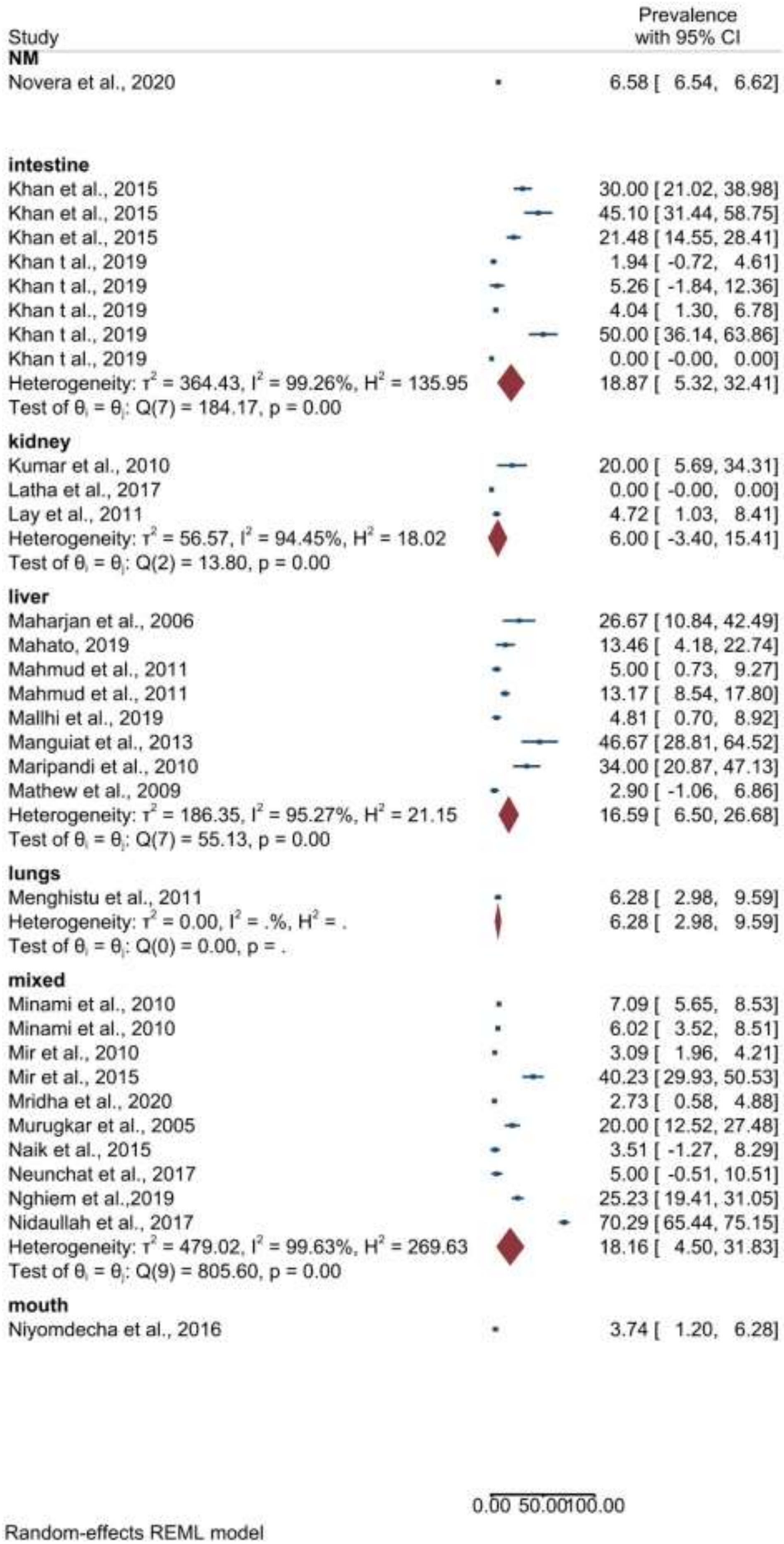


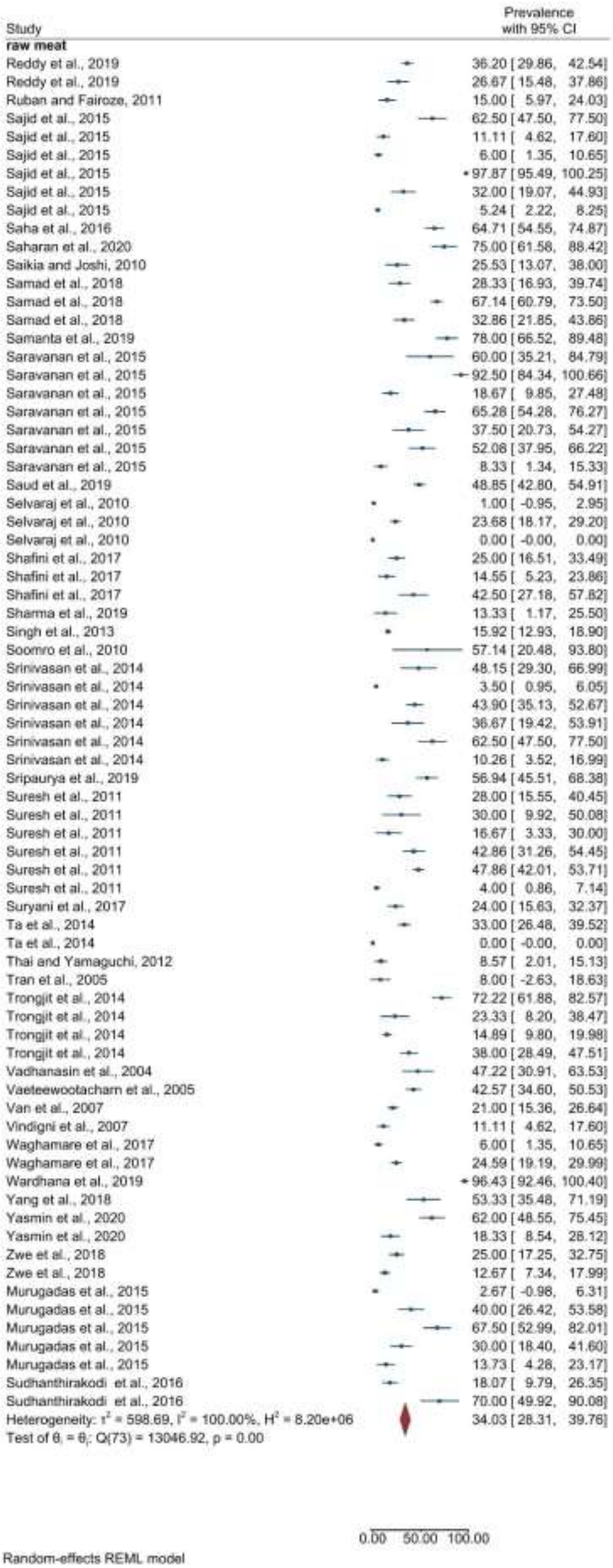
Appendix O. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in different chicken samples in south and southeast Asia



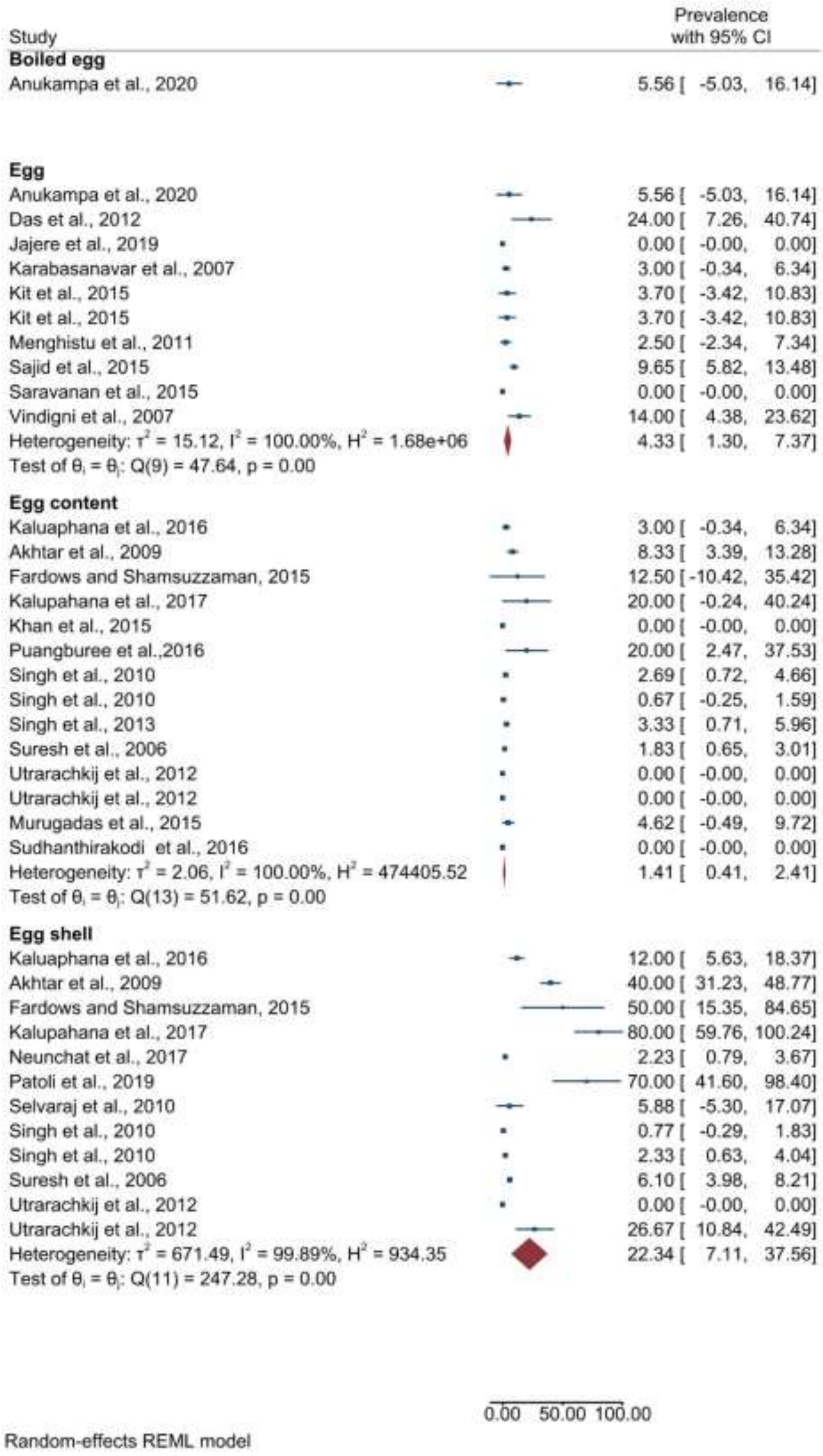


Study
Prevalence with 95% CI
caecal
Akbar and Anal, 2015 17.14 [10.90, 23.39]
Sinwat et al., 2015 8.91 [4.98, 12.84]
Thung et al., 2016 72.50 [62.72, 82.28]
Thung et al., 2016 5.05 [2.00, 8.10]
Anonymous 18.00 [12.68, 23.32]
Heterogeneity: τ^2 = 724.96, I^2 = 99.17%, H^2 = 119.88 24.06 [0.30, 47.82]
Test of $\theta_i = \theta_j$: Q(4) = 176.66, p = 0.00
carcass
Trongjit et al., 2017 1.19 [-1.13, 3.51]
Trongjit et al., 2017 65.71 [56.64, 74.79]
Trongjit et al., 2017 82.76 [74.82, 90.70]
Trongjit et al., 2017 48.57 [32.01, 65.13]
Trongjit et al., 2017 39.02 [24.09, 53.96]
Moe et al., 2017 13.00 [9.70, 16.30]
Goni et al., 2018 88.16 [83.02, 93.29]
Aditya, 2015 100.00 [100.00, 100.00]
Akbar et al., 2013 40.83 [32.04, 49.63]
Akhtar et al., 2009 43.33 [25.60, 61.07]
Alam et al., 2020 49.26 [43.30, 55.22]
Ananchaipattana et al., 2016 65.71 [56.64, 74.79]
Ananchaipattana et al., 2016 82.76 [74.82, 90.70]
Angkititrakul et al., 2005 42.63 [37.21, 48.06]
Heterogeneity: τ^2 = 805.83, I^2 = 99.54%, H^2 = 219.21 54.59 [39.51, 69.67]
Test of $\theta_i = \theta_j$: Q(13) = 10836.73, p = 0.00
cloacal swab
Anukampa et al., 2017 48.00 [34.15, 61.85]
Anukampa et al., 2018 14.63 [3.82, 25.45]
Anukampa et al., 2019 1.60 [-0.20, 3.39]
Asif et al., 2017 8.11 [1.89, 14.33]
Asif et al., 2017 2.52 [1.34, 3.70]
Asif et al., 2017 0.00 [-0.00, 0.00]
Asif et al., 2017 7.20 [4.00, 10.40]
Aung et al., 2018 17.07 [13.45, 20.68]
Auzureen et al., 2015 12.41 [9.28, 15.54]
Badhe et al., 2013 46.09 [37.46, 54.73]
Badhe et al., 2013 14.72 [10.15, 19.29]
Bangtrakulnonth et al., 2006 4.24 [2.32, 6.15]
Bantawa et al., 2018 42.47 [31.13, 53.80]
Biswas et al, 2005 7.33 [3.16, 11.51]
Biswas et al., 2006 15.00 [3.93, 26.07]
Bodhidatta et al., 2013 4.44 [1.43, 7.46]
Chaisatit et al., 2012 56.67 [38.93, 74.40]
Chotinun et al., 2014 12.50 [2.25, 22.75]
Chotinun et al., 2014 1.40 [-0.17, 2.98]
Nguyen et al., 2012 25.00 [0.50, 49.50]
Dahal et al., 2008 16.67 [-13.15, 46.49]
Das et al., 2012 5.33 [0.25, 10.42]
Deshpande and Gulhane, 2015 22.00 [10.52, 33.48]
Heterogeneity: τ^2 = 219.42, I^2 = 99.44%, H^2 = 179.21 15.59 [9.21, 21.97]
Test of $\theta_i = \theta_j$: Q(22) = 566.53, p = 0.00
cooked meat
Deshpande and Gulhane, 2015 3.33 [-3.09, 9.76]
Ellerbroek et al., 2010 16.67 [-13.15, 46.49]
Gautam et al., 2017 1.47 [-0.55, 3.49]
Gautam et al., 2017 9.09 [1.49, 16.69]
Geidam et al., 2012 0.00 [-0.00, 0.00]
Dao et al., 2006 30.43 [19.58, 41.29]
Hanh et al., 2006 28.04 [19.53, 36.55]
Hanh et al., 2006 0.00 [-0.00, 0.00]
Heterogeneity: τ^2 = 142.00, I^2 = 100.00%, H^2 = 2.03e+07 9.97 [1.08, 18.85]
Test of $\theta_i = \theta_j$: Q(7) = 81.64, p = 0.00
crop
Huong et al., 2006 6.90 [3.41, 10.38]
0.00 50.00 100.00
Random-effects REML model

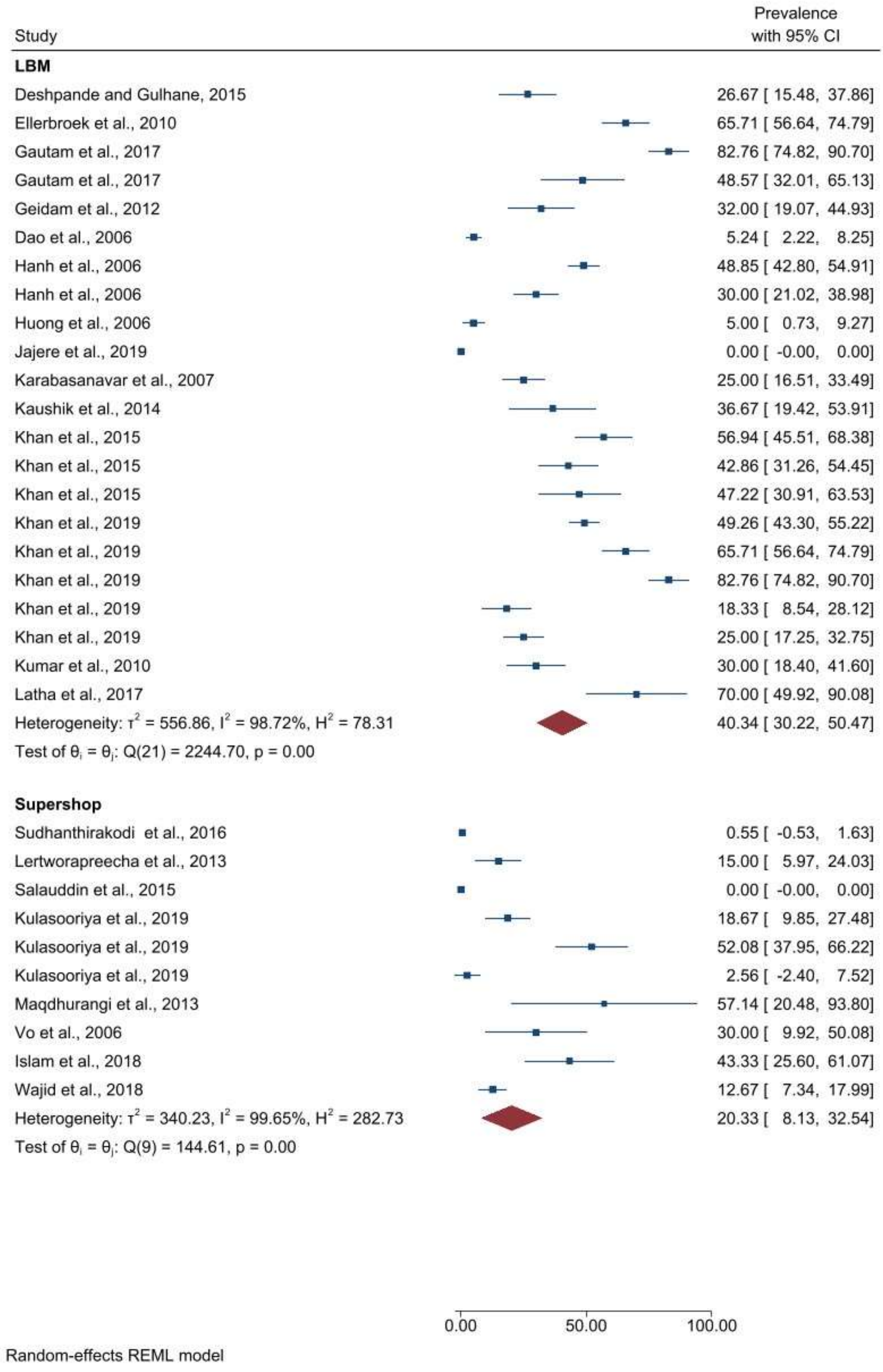

Study
Prevalence with 95% CI
NM
Novera et al., 2020 6.58 [6.54, 6.62]
intestine
Khan et al., 2015 30.00 [21.02, 38.98]
Khan et al., 2015 45.10 [31.44, 58.75]
Khan et al., 2015 21.48 [14.55, 28.41]
Khan t al., 2019 1.94 [-0.72, 4.61]
Khan t al., 2019 5.26 [-1.84, 12.36]
Khan t al., 2019 4.04 [1.30, 6.78]
Khan t al., 2019 50.00 [36.14, 63.86]
Khan t al., 2019 0.00 [-0.00, 0.00]
Heterogeneity: τ^2 = 364.43, I^2 = 99.26%, H^2 = 135.95 18.87 [5.32, 32.41]
Test of $\theta_i = \theta_j$: Q(7) = 184.17, p = 0.00
kidney
Kumar et al., 2010 20.00 [5.69, 34.31]
Latha et al., 2017 0.00 [-0.00, 0.00]
Lay et al., 2011 4.72 [1.03, 8.41]
Heterogeneity: τ^2 = 56.57, I^2 = 94.45%, H^2 = 18.02 6.00 [-3.40, 15.41]
Test of $\theta_i = \theta_j$: Q(2) = 13.80, p = 0.00
liver
Maharjan et al., 2006 26.67 [10.84, 42.49]
Mahato, 2019 13.46 [4.18, 22.74]
Mahmud et al., 2011 5.00 [0.73, 9.27]
Mahmud et al., 2011 13.17 [8.54, 17.80]
Mallhi et al., 2019 4.81 [0.70, 8.92]
Manguiat et al., 2013 46.67 [28.81, 64.52]
Maripandi et al., 2010 34.00 [20.87, 47.13]
Mathew et al., 2009 2.90 [-1.06, 6.86]
Heterogeneity: τ^2 = 186.35, I^2 = 95.27%, H^2 = 21.15 16.59 [6.50, 26.68]
Test of $\theta_i = \theta_j$: Q(7) = 55.13, p = 0.00
lungs
Menghistu et al., 2011 6.28 [2.98, 9.59]
Heterogeneity: τ^2 = 0.00, I^2 = .%, H^2 = . 6.28 [2.98, 9.59]
Test of $\theta_i = \theta_j$: Q(0) = 0.00, p = .
mixed
Minami et al., 2010 7.09 [5.65, 8.53]
Minami et al., 2010 6.02 [3.52, 8.51]
Mir et al., 2010 3.09 [1.96, 4.21]
Mir et al., 2015 40.23 [29.93, 50.53]
Mridha et al., 2020 2.73 [0.58, 4.88]
Murugkar et al., 2005 20.00 [12.52, 27.48]
Naik et al., 2015 3.51 [-1.27, 8.29]
Neunchat et al., 2017 5.00 [-0.51, 10.51]
Nghiem et al.,2019 25.23 [19.41, 31.05]
Nidaullah et al., 2017 70.29 [65.44, 75.15]
Heterogeneity: τ^2 = 479.02, I^2 = 99.63%, H^2 = 269.63 18.16 [4.50, 31.83]
Test of $\theta_i = \theta_j$: Q(9) = 805.60, p = 0.00
mouth
Niyomdecha et al., 2016 3.74 [1.20, 6.28]
0.00 50.00 100.00
Random-effects REML model

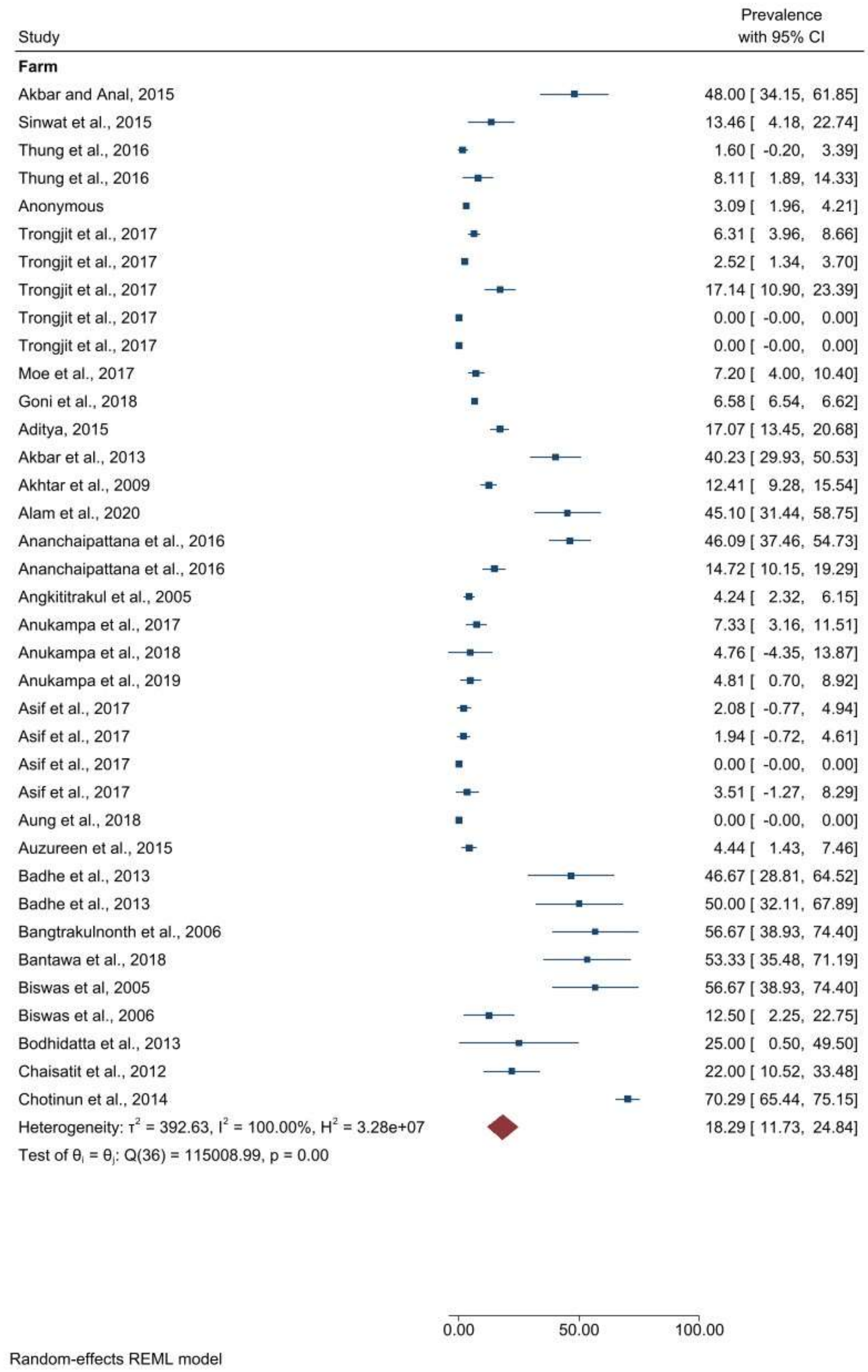

Study
Prevalence with 95% CI
raw meat
Reddy et al., 2019 36.20 [29.86, 42.54]
Reddy et al., 2019 26.67 [15.48, 37.86]
Ruban and Fairoze, 2011 15.00 [5.97, 24.03]
Sajid et al., 2015 62.50 [47.50, 77.50]
Sajid et al., 2015 11.11 [4.62, 17.60]
Sajid et al., 2015 6.00 [1.35, 10.65]
Sajid et al., 2015 97.87 [95.49, 100.25]
Sajid et al., 2015 32.00 [19.07, 44.93]
Sajid et al., 2015 5.24 [2.22, 8.25]
Saha et al., 2016 64.71 [54.55, 74.87]
Saharan et al., 2020 75.00 [61.58, 88.42]
Saikia and Joshi, 2010 25.53 [13.07, 38.00]
Samad et al., 2018 28.33 [16.93, 39.74]
Samad et al., 2018 67.14 [60.79, 73.50]
Samad et al., 2018 32.86 [21.85, 43.86]
Samanta et al., 2019 78.00 [66.52, 89.48]
Saravanan et al., 2015 60.00 [35.21, 84.79]
Saravanan et al., 2015 92.50 [84.34, 100.66]
Saravanan et al., 2015 18.67 [9.85, 27.48]
Saravanan et al., 2015 65.28 [54.28, 76.27]
Saravanan et al., 2015 37.50 [20.73, 54.27]
Saravanan et al., 2015 52.08 [37.95, 66.22]
Saravanan et al., 2015 8.33 [1.34, 15.33]
Saud et al., 2019 48.85 [42.80, 54.91]
Selvaraj et al., 2010 1.00 [-0.95, 2.95]
Selvaraj et al., 2010 23.68 [18.17, 29.20]
Selvaraj et al., 2010 0.00 [-0.00, 0.00]
Shafini et al., 2017 25.00 [16.51, 33.49]
Shafini et al., 2017 14.55 [5.23, 23.86]
Shafini et al., 2017 42.50 [27.18, 57.82]
Sharma et al., 2019 13.33 [1.17, 25.50]
Singh et al., 2013 15.92 [12.93, 18.90]
Soomro et al., 2010 57.14 [20.48, 93.80]
Srinivasan et al., 2014 48.15 [29.30, 66.99]
Srinivasan et al., 2014 3.50 [0.95, 6.05]
Srinivasan et al., 2014 43.90 [35.13, 52.67]
Srinivasan et al., 2014 36.67 [19.42, 53.91]
Srinivasan et al., 2014 62.50 [47.50, 77.50]
Srinivasan et al., 2014 10.26 [3.52, 16.99]
Sripaurya et al., 2019 56.94 [45.51, 68.38]
Suresh et al., 2011 28.00 [15.55, 40.45]
Suresh et al., 2011 30.00 [9.92, 50.08]
Suresh et al., 2011 16.67 [3.33, 30.00]
Suresh et al., 2011 42.86 [31.26, 54.45]
Suresh et al., 2011 47.86 [42.01, 53.71]
Suresh et al., 2011 4.00 [0.86, 7.14]
Suryani et al., 2017 24.00 [15.63, 32.37]
Ta et al., 2014 33.00 [26.48, 39.52]
Ta et al., 2014 0.00 [-0.00, 0.00]
Thai and Yamaguchi, 2012 8.57 [2.01, 15.13]
Tran et al., 2005 8.00 [-2.63, 18.63]
Trongjit et al., 2014 72.22 [61.88, 82.57]
Trongjit et al., 2014 23.33 [8.20, 38.47]
Trongjit et al., 2014 14.89 [9.80, 19.98]
Trongjit et al., 2014 38.00 [28.49, 47.51]
Vadhanasin et al., 2004 47.22 [30.91, 63.53]
Vaeteewootacharn et al., 2005 42.57 [34.60, 50.53]
Van et al., 2007 21.00 [15.36, 26.64]
Vindigni et al., 2007 11.11 [4.62, 17.60]
Waghamare et al., 2017 6.00 [1.35, 10.65]
Waghamare et al., 2017 24.59 [19.19, 29.99]
Wardhana et al., 2019 96.43 [92.46, 100.40]
Yang et al., 2018 53.33 [35.48, 71.19]
Yasmin et al., 2020 62.00 [48.55, 75.45]
Yasmin et al., 2020 18.33 [8.54, 28.12]
Zwe et al., 2018 25.00 [17.25, 32.75]
Zwe et al., 2018 12.67 [7.34, 17.99]
Murugadas et al., 2015 2.67 [-0.98, 6.31]
Murugadas et al., 2015 40.00 [26.42, 53.58]
Murugadas et al., 2015 67.50 [52.99, 82.01]
Murugadas et al., 2015 30.00 [18.40, 41.60]
Murugadas et al., 2015 13.73 [4.28, 23.17]
Sudhanthirakodi et al., 2016 18.07 [9.79, 26.35]
Sudhanthirakodi et al., 2016 70.00 [49.92, 90.08]
Heterogeneity: τ² = 598.69, I² = 100.00%, H² = 8.20e+06 34.03 [28.31, 39.76]
Test of θi = θj: Q(73) = 13046.92, p = 0.00
0.00 50.00 100.00
Random-effects REML model

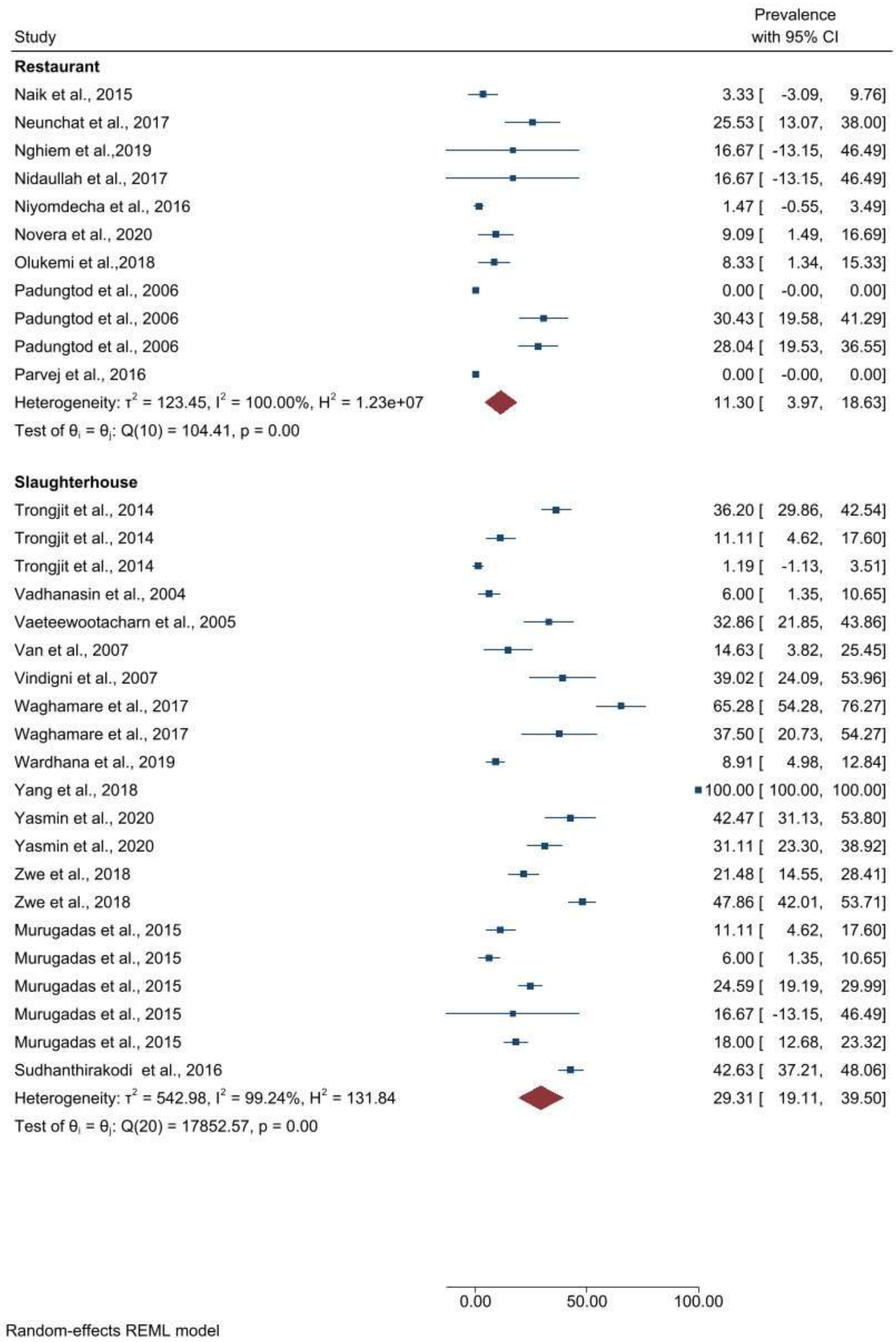
Appendix P. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in different egg samples in south and southeast Asia



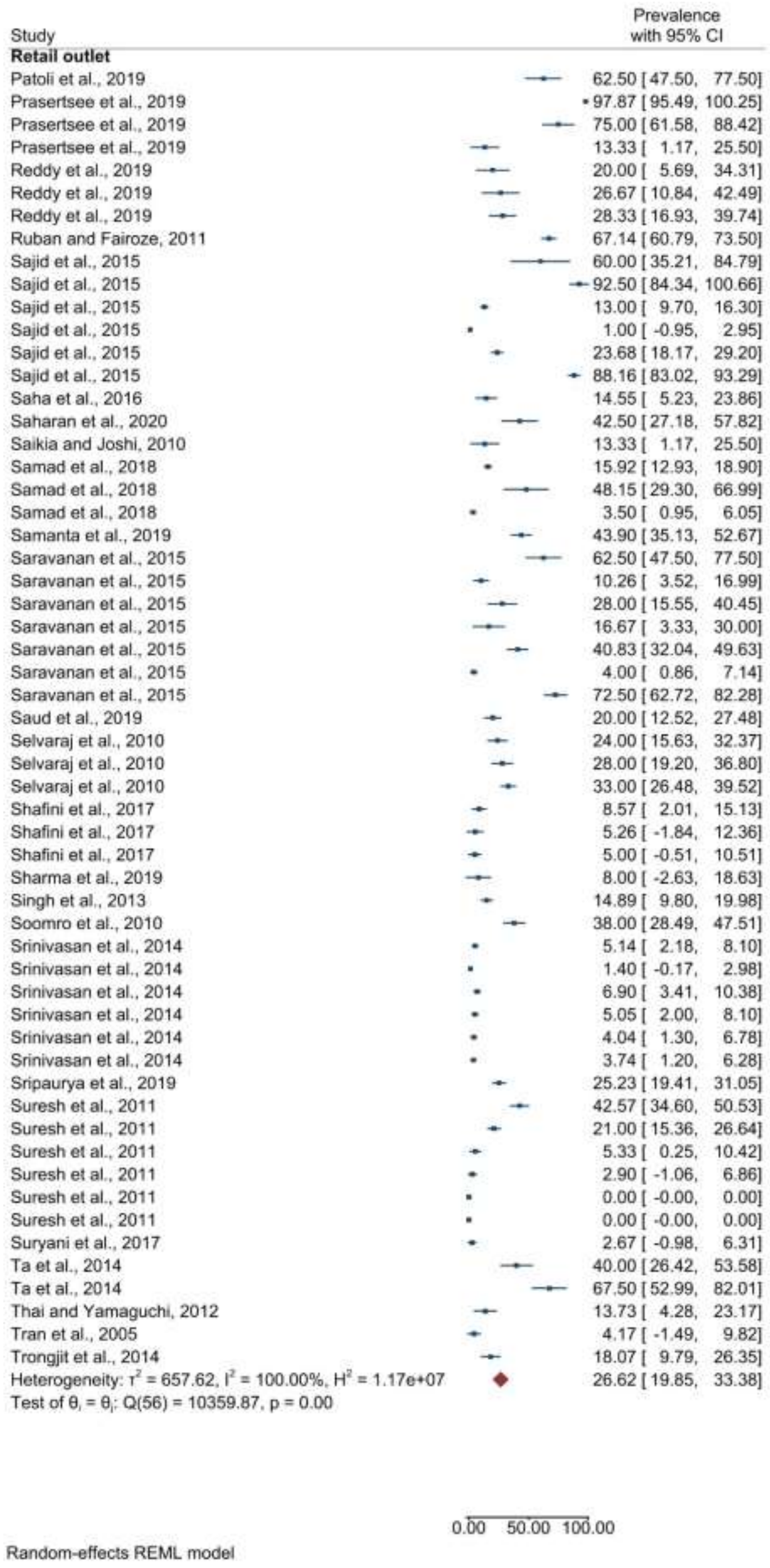
Appendix Q. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in chickens in different study sites in south and southeast Asia

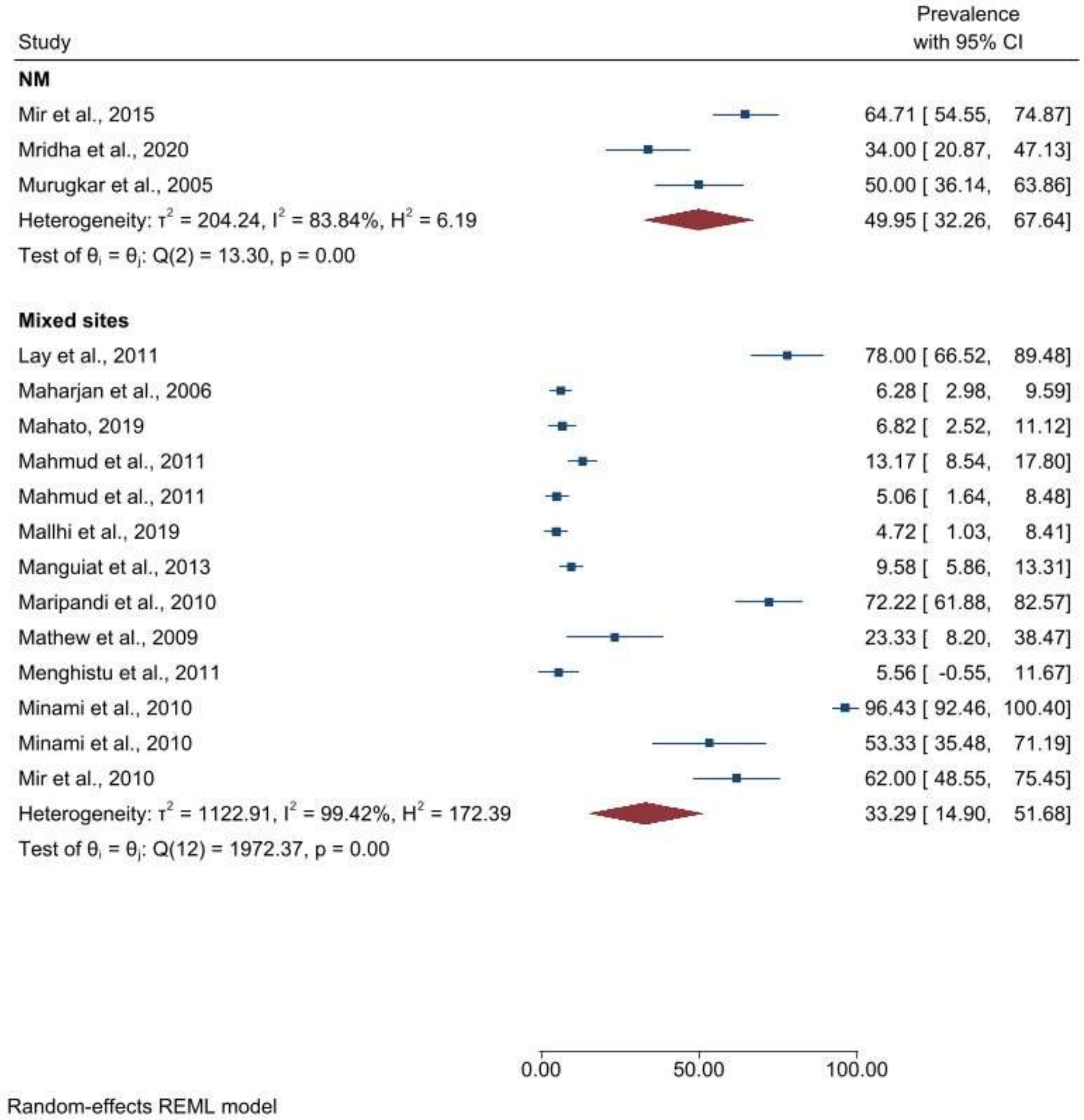



Study
Prevalence with 95% CI
Farm
Akbar and Anal, 2015 48.00 [34.15, 61.85]
Sinwat et al., 2015 13.46 [4.18, 22.74]
Thung et al., 2016 1.60 [-0.20, 3.39]
Thung et al., 2016 8.11 [1.89, 14.33]
Anonymous 3.09 [1.96, 4.21]
Trongjit et al., 2017 6.31 [3.96, 8.66]
Trongjit et al., 2017 2.52 [1.34, 3.70]
Trongjit et al., 2017 17.14 [10.90, 23.39]
Trongjit et al., 2017 0.00 [-0.00, 0.00]
Trongjit et al., 2017 0.00 [-0.00, 0.00]
Moe et al., 2017 7.20 [4.00, 10.40]
Goni et al., 2018 6.58 [6.54, 6.62]
Aditya, 2015 17.07 [13.45, 20.68]
Akbar et al., 2013 40.23 [29.93, 50.53]
Akhtar et al., 2009 12.41 [9.28, 15.54]
Alam et al., 2020 45.10 [31.44, 58.75]
Ananchaipattana et al., 2016 46.09 [37.46, 54.73]
Ananchaipattana et al., 2016 14.72 [10.15, 19.29]
Angkititrakul et al., 2005 4.24 [2.32, 6.15]
Anukampa et al., 2017 7.33 [3.16, 11.51]
Anukampa et al., 2018 4.76 [-4.35, 13.87]
Anukampa et al., 2019 4.81 [0.70, 8.92]
Asif et al., 2017 2.08 [-0.77, 4.94]
Asif et al., 2017 1.94 [-0.72, 4.61]
Asif et al., 2017 0.00 [-0.00, 0.00]
Asif et al., 2017 3.51 [-1.27, 8.29]
Aung et al., 2018 0.00 [-0.00, 0.00]
Auzureen et al., 2015 4.44 [1.43, 7.46]
Badhe et al., 2013 46.67 [28.81, 64.52]
Badhe et al., 2013 50.00 [32.11, 67.89]
Bangtrakulnonth et al., 2006 56.67 [38.93, 74.40]
Bantawa et al., 2018 53.33 [35.48, 71.19]
Biswas et al, 2005 56.67 [38.93, 74.40]
Biswas et al., 2006 12.50 [2.25, 22.75]
Bodhidatta et al., 2013 25.00 [0.50, 49.50]
Chaisatit et al., 2012 22.00 [10.52, 33.48]
Chotinun et al., 2014 70.29 [65.44, 75.15]
Heterogeneity: τ^2 = 392.63, I^2 = 100.00%, H^2 = 3.28e+07 18.29 [11.73, 24.84]
Test of $\theta_i = \theta_j$: Q(36) = 115008.99, p = 0.00
0.00
50.00
100.00
Random-effects REML model

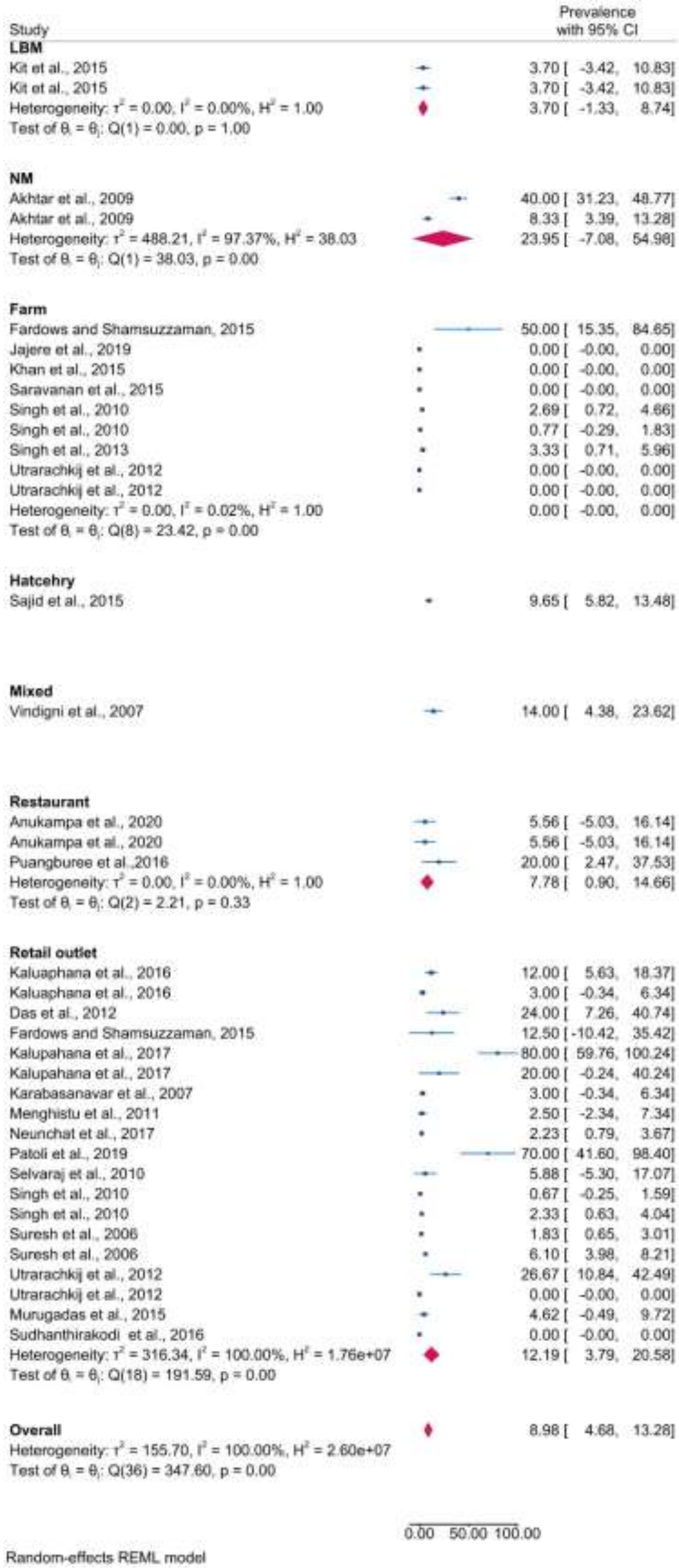


Study
Prevalence with 95% CI
Restaurant
Naik et al., 2015 3.33 [-3.09, 9.76]
Neunchat et al., 2017 25.53 [13.07, 38.00]
Nghiem et al.,2019 16.67 [-13.15, 46.49]
Nidaullah et al., 2017 16.67 [-13.15, 46.49]
Niyomdecha et al., 2016 1.47 [-0.55, 3.49]
Novera et al., 2020 9.09 [1.49, 16.69]
Olukemi et al.,2018 8.33 [1.34, 15.33]
Padungtod et al., 2006 0.00 [-0.00, 0.00]
Padungtod et al., 2006 30.43 [19.58, 41.29]
Padungtod et al., 2006 28.04 [19.53, 36.55]
Parvej et al., 2016 0.00 [-0.00, 0.00]
Heterogeneity: τ^2 = 123.45, I^2 = 100.00%, H^2 = 1.23e+07 11.30 [3.97, 18.63]
Test of $\theta_i = \theta_j$: Q(10) = 104.41, p = 0.00
Slaughterhouse
Trongjit et al., 2014 36.20 [29.86, 42.54]
Trongjit et al., 2014 11.11 [4.62, 17.60]
Trongjit et al., 2014 1.19 [-1.13, 3.51]
Vadhanasin et al., 2004 6.00 [1.35, 10.65]
Vaeteewootacharn et al., 2005 32.86 [21.85, 43.86]
Van et al., 2007 14.63 [3.82, 25.45]
Vindigni et al., 2007 39.02 [24.09, 53.96]
Waghamare et al., 2017 65.28 [54.28, 76.27]
Waghamare et al., 2017 37.50 [20.73, 54.27]
Wardhana et al., 2019 8.91 [4.98, 12.84]
Yang et al., 2018 100.00 [100.00, 100.00]
Yasmin et al., 2020 42.47 [31.13, 53.80]
Yasmin et al., 2020 31.11 [23.30, 38.92]
Zwe et al., 2018 21.48 [14.55, 28.41]
Zwe et al., 2018 47.86 [42.01, 53.71]
Murugadas et al., 2015 11.11 [4.62, 17.60]
Murugadas et al., 2015 6.00 [1.35, 10.65]
Murugadas et al., 2015 24.59 [19.19, 29.99]
Murugadas et al., 2015 16.67 [-13.15, 46.49]
Murugadas et al., 2015 18.00 [12.68, 23.32]
Sudhanthirakodi et al., 2016 42.63 [37.21, 48.06]
Heterogeneity: τ^2 = 542.98, I^2 = 99.24%, H^2 = 131.84 29.31 [19.11, 39.50]
Test of $\theta_i = \theta_j$: Q(20) = 17852.57, p = 0.00
0.00
50.00
100.00
Random-effects REML model

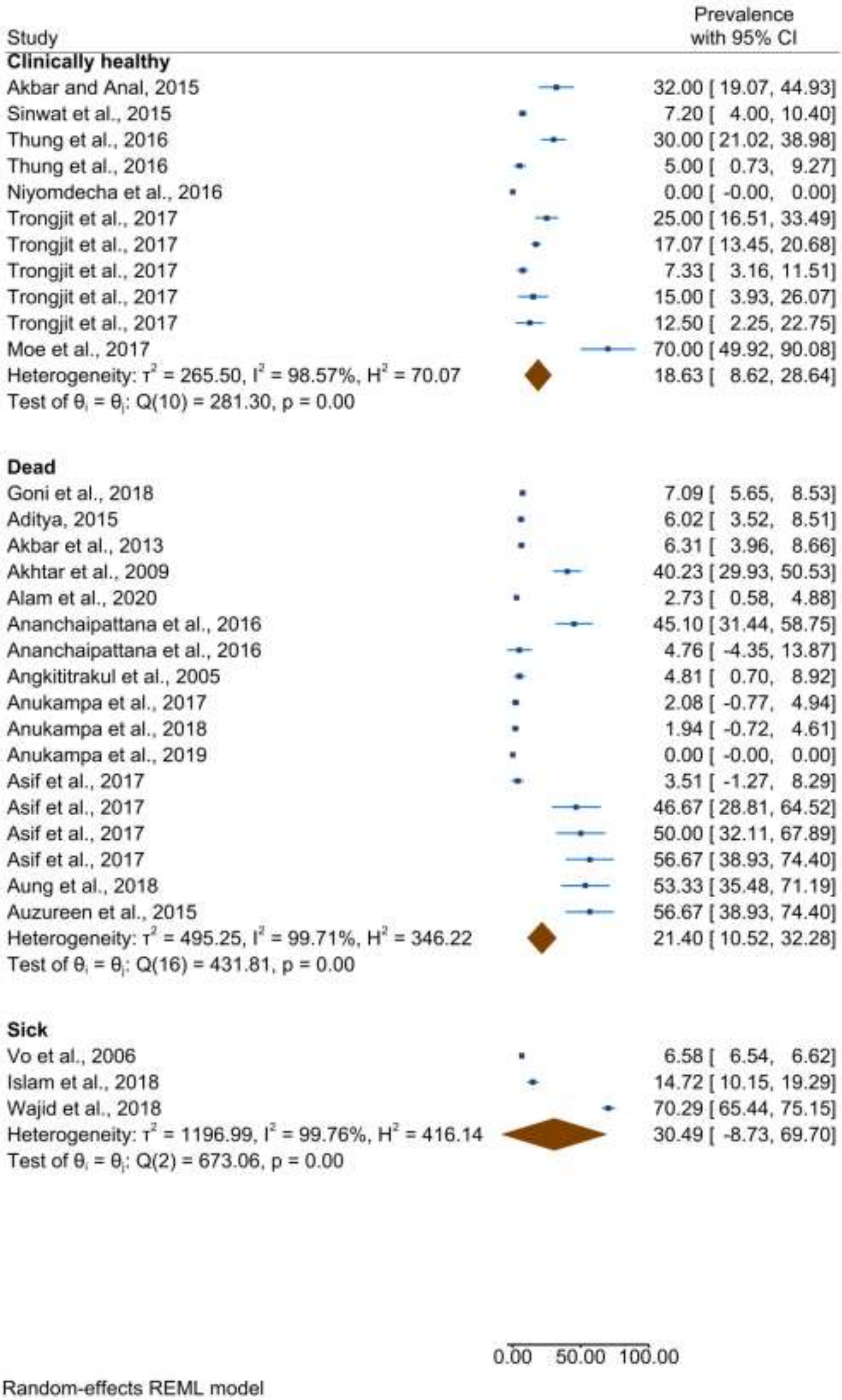

Study
Prevalence with 95% CI
Retail outlet
Patoli et al., 2019 62.50 [47.50, 77.50]
Prasertsee et al., 2019 97.87 [95.49, 100.25]
Prasertsee et al., 2019 75.00 [61.58, 88.42]
Prasertsee et al., 2019 13.33 [1.17, 25.50]
Reddy et al., 2019 20.00 [5.69, 34.31]
Reddy et al., 2019 26.67 [10.84, 42.49]
Reddy et al., 2019 28.33 [16.93, 39.74]
Ruban and Fairoze, 2011 67.14 [60.79, 73.50]
Sajid et al., 2015 60.00 [35.21, 84.79]
Sajid et al., 2015 92.50 [84.34, 100.66]
Sajid et al., 2015 13.00 [9.70, 16.30]
Sajid et al., 2015 1.00 [-0.95, 2.95]
Sajid et al., 2015 23.68 [18.17, 29.20]
Sajid et al., 2015 88.16 [83.02, 93.29]
Saha et al., 2016 14.55 [5.23, 23.86]
Saharan et al., 2020 42.50 [27.18, 57.82]
Saikia and Joshi, 2010 13.33 [1.17, 25.50]
Samad et al., 2018 15.92 [12.93, 18.90]
Samad et al., 2018 48.15 [29.30, 66.99]
Samad et al., 2018 3.50 [0.95, 6.05]
Samanta et al., 2019 43.90 [35.13, 52.67]
Saravanan et al., 2015 62.50 [47.50, 77.50]
Saravanan et al., 2015 10.26 [3.52, 16.99]
Saravanan et al., 2015 28.00 [15.55, 40.45]
Saravanan et al., 2015 16.67 [3.33, 30.00]
Saravanan et al., 2015 40.83 [32.04, 49.63]
Saravanan et al., 2015 4.00 [0.86, 7.14]
Saravanan et al., 2015 72.50 [62.72, 82.28]
Saud et al., 2019 20.00 [12.52, 27.48]
Selvaraj et al., 2010 24.00 [15.63, 32.37]
Selvaraj et al., 2010 28.00 [19.20, 36.80]
Selvaraj et al., 2010 33.00 [26.48, 39.52]
Shafini et al., 2017 8.57 [2.01, 15.13]
Shafini et al., 2017 5.26 [-1.84, 12.36]
Shafini et al., 2017 5.00 [-0.51, 10.51]
Sharma et al., 2019 8.00 [-2.63, 18.63]
Singh et al., 2013 14.89 [9.80, 19.98]
Soomro et al., 2010 38.00 [28.49, 47.51]
Srinivasan et al., 2014 5.14 [2.18, 8.10]
Srinivasan et al., 2014 1.40 [-0.17, 2.98]
Srinivasan et al., 2014 6.90 [3.41, 10.38]
Srinivasan et al., 2014 5.05 [2.00, 8.10]
Srinivasan et al., 2014 4.04 [1.30, 6.78]
Srinivasan et al., 2014 3.74 [1.20, 6.28]
Sripaurya et al., 2019 25.23 [19.41, 31.05]
Suresh et al., 2011 42.57 [34.60, 50.53]
Suresh et al., 2011 21.00 [15.36, 26.64]
Suresh et al., 2011 5.33 [0.25, 10.42]
Suresh et al., 2011 2.90 [-1.06, 6.86]
Suresh et al., 2011 0.00 [-0.00, 0.00]
Suresh et al., 2011 0.00 [-0.00, 0.00]
Suryani et al., 2017 2.67 [-0.98, 6.31]
Ta et al., 2014 40.00 [26.42, 53.58]
Ta et al., 2014 67.50 [52.99, 82.01]
Thai and Yamaguchi, 2012 13.73 [4.28, 23.17]
Tran et al., 2005 4.17 [-1.49, 9.82]
Trongjit et al., 2014 18.07 [9.79, 26.35]
Heterogeneity: τ² = 657.62, I² = 100.00%, H² = 1.17e+07 26.62 [19.85, 33.38]
Test of θᵢ = θⱼ: Q(56) = 10359.87, p = 0.00
0.00 50.00 100.00
Random-effects REML model

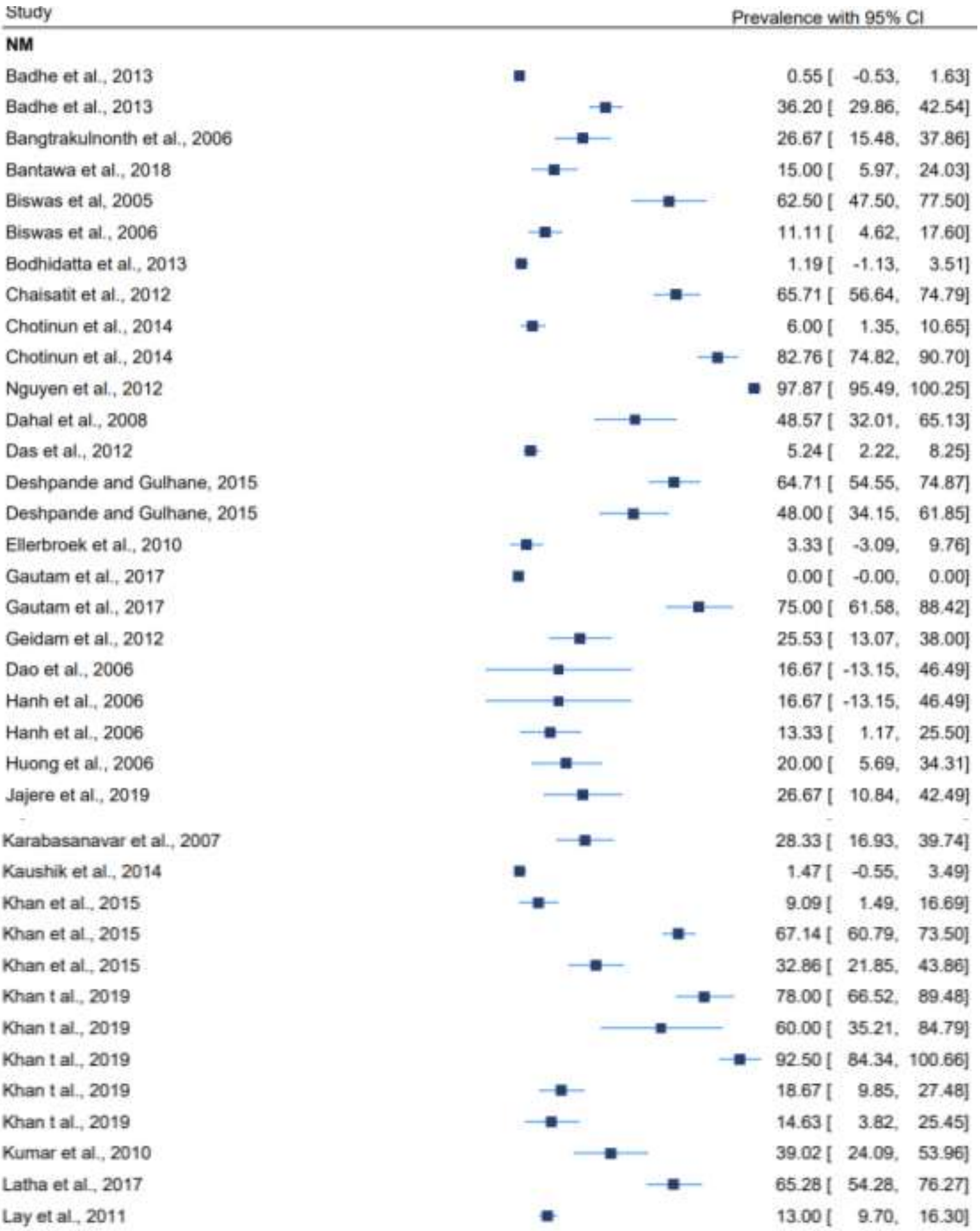

Study
Prevalence with 95% CI
NM
Mir et al., 2015 64.71 [54.55, 74.87]
Mridha et al., 2020 34.00 [20.87, 47.13]
Murugkar et al., 2005 50.00 [36.14, 63.86]
Heterogeneity: τ^2 = 204.24, I^2 = 83.84%, H^2 = 6.19 49.95 [32.26, 67.64]
Test of $\theta_i = \theta_j$: Q(2) = 13.30, p = 0.00
Mixed sites
Lay et al., 2011 78.00 [66.52, 89.48]
Maharjan et al., 2006 6.28 [2.98, 9.59]
Mahato, 2019 6.82 [2.52, 11.12]
Mahmud et al., 2011 13.17 [8.54, 17.80]
Mahmud et al., 2011 5.06 [1.64, 8.48]
Mallhi et al., 2019 4.72 [1.03, 8.41]
Manguiat et al., 2013 9.58 [5.86, 13.31]
Maripandi et al., 2010 72.22 [61.88, 82.57]
Mathew et al., 2009 23.33 [8.20, 38.47]
Menghistu et al., 2011 5.56 [-0.55, 11.67]
Minami et al., 2010 96.43 [92.46, 100.40]
Minami et al., 2010 53.33 [35.48, 71.19]
Mir et al., 2010 62.00 [48.55, 75.45]
Heterogeneity: τ^2 = 1122.91, I^2 = 99.42%, H^2 = 172.39 33.29 [14.90, 51.68]
Test of $\theta_i = \theta_j$: Q(12) = 1972.37, p = 0.00
0.00
50.00
100.00
Random-effects REML model

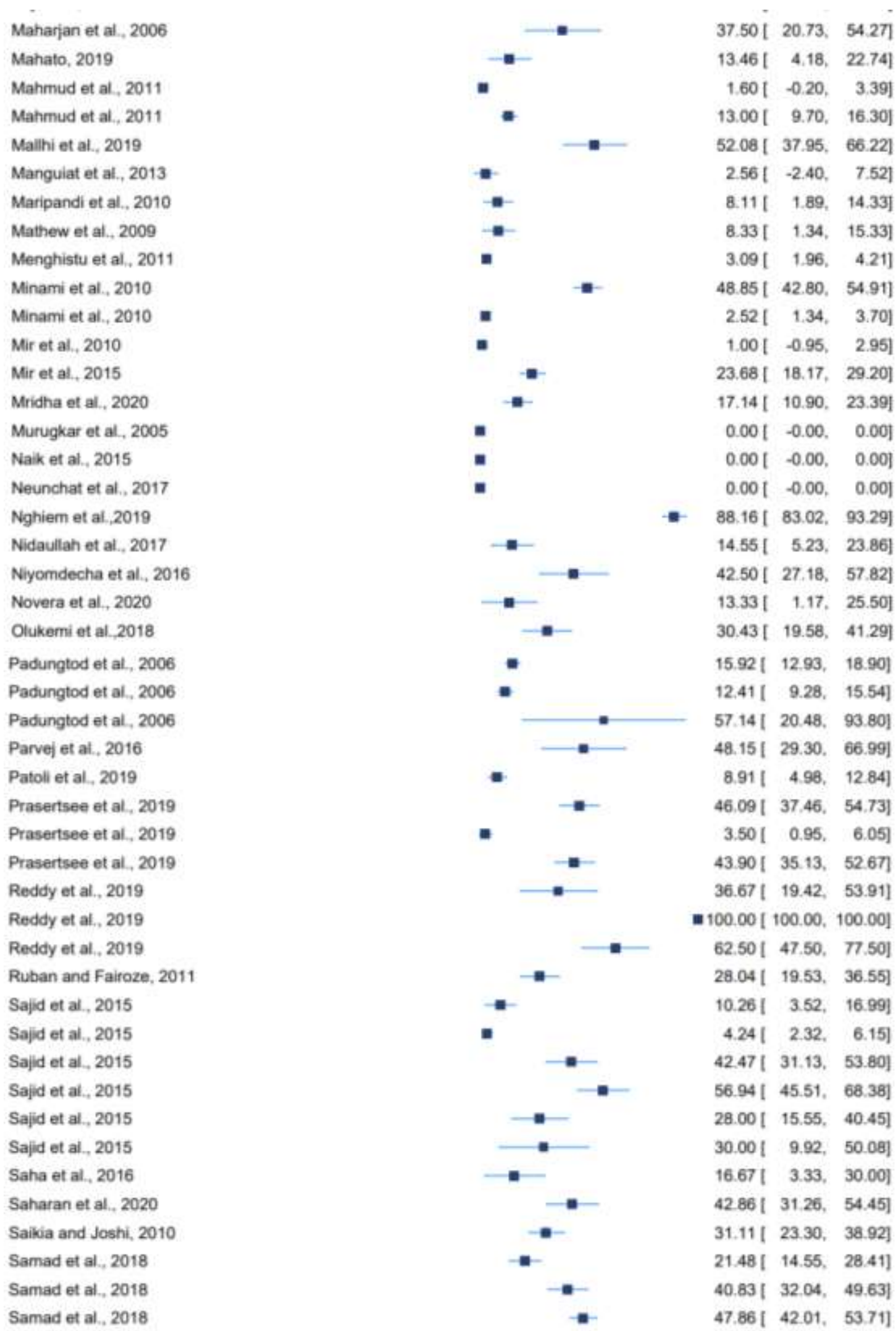
Appendix R. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in egg in different study sites in south and southeast Asia

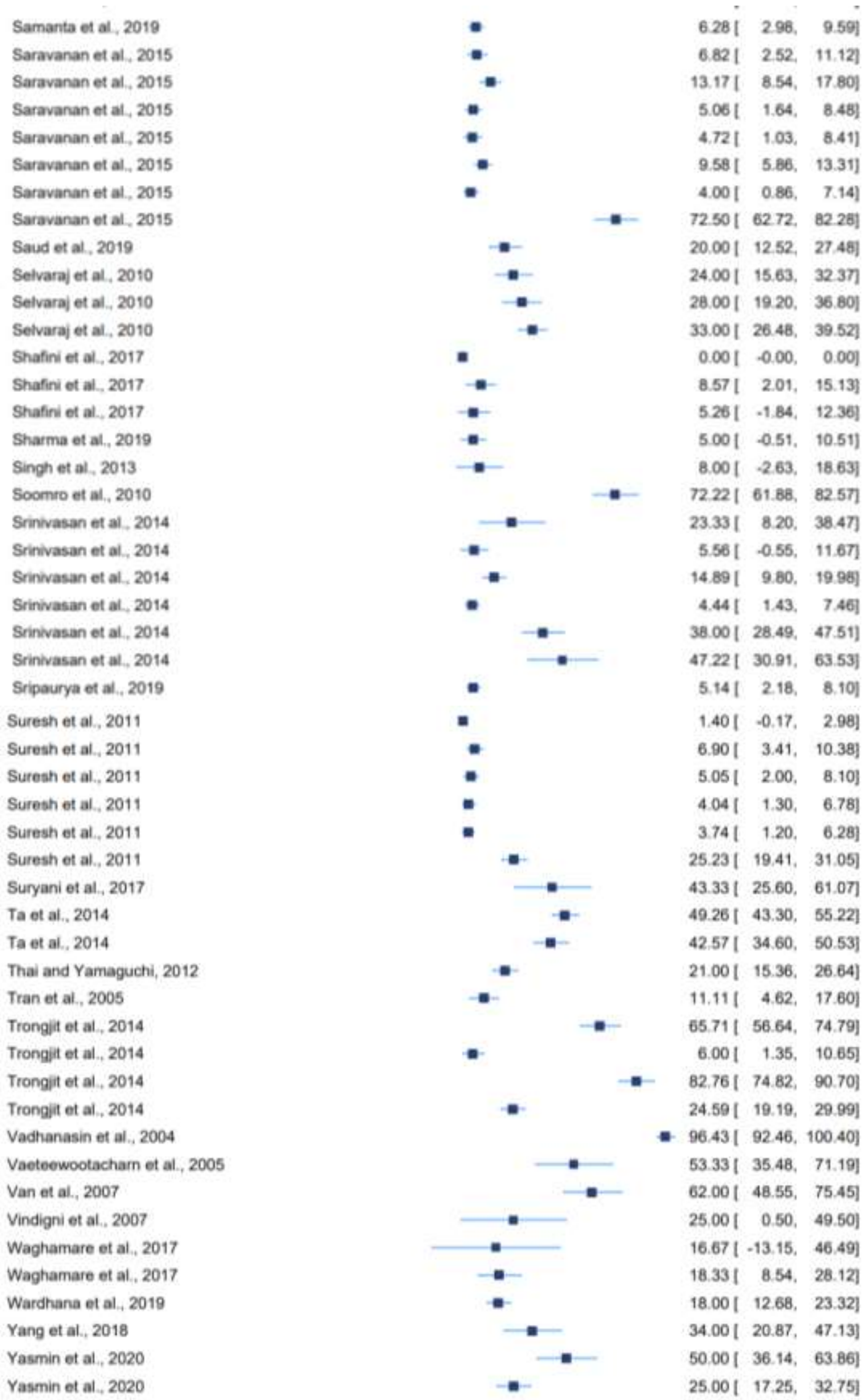


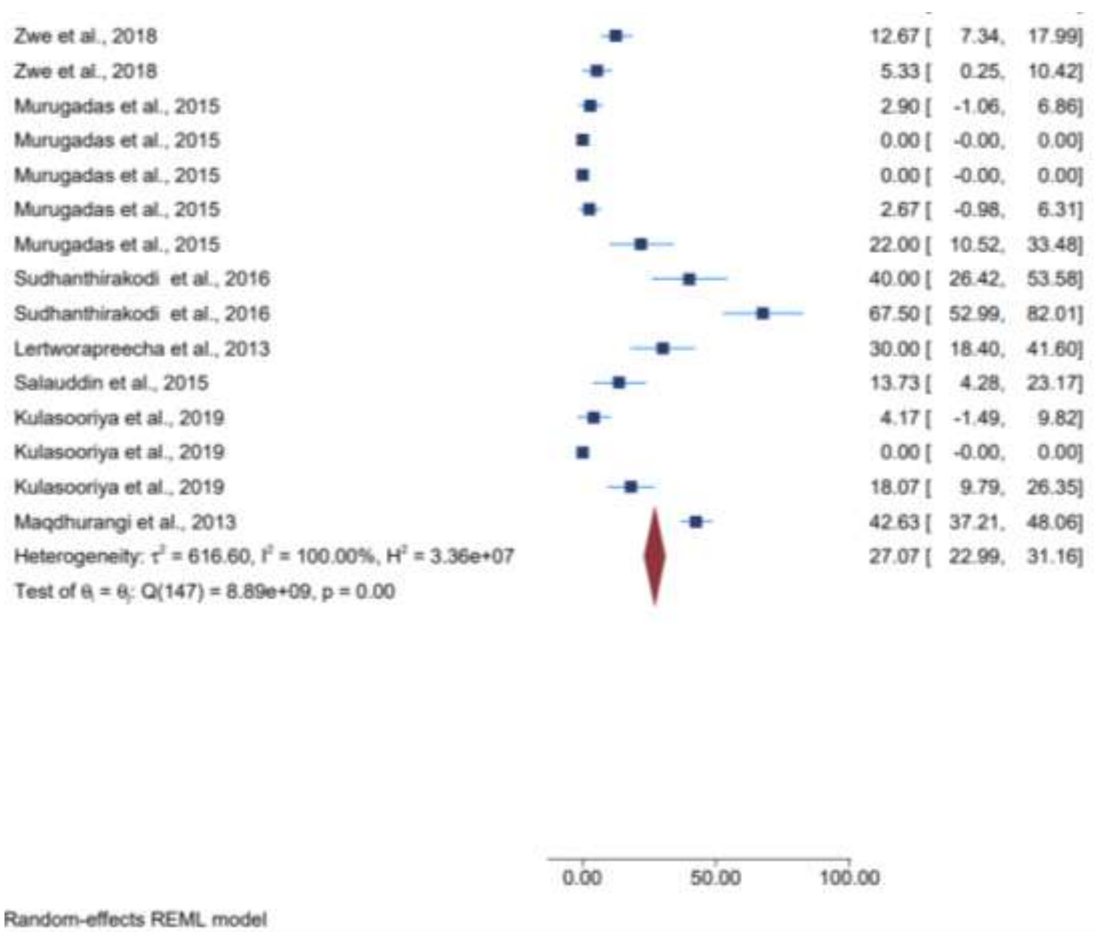
Appendix S. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* according to health status of chickens in south and southeast Asia



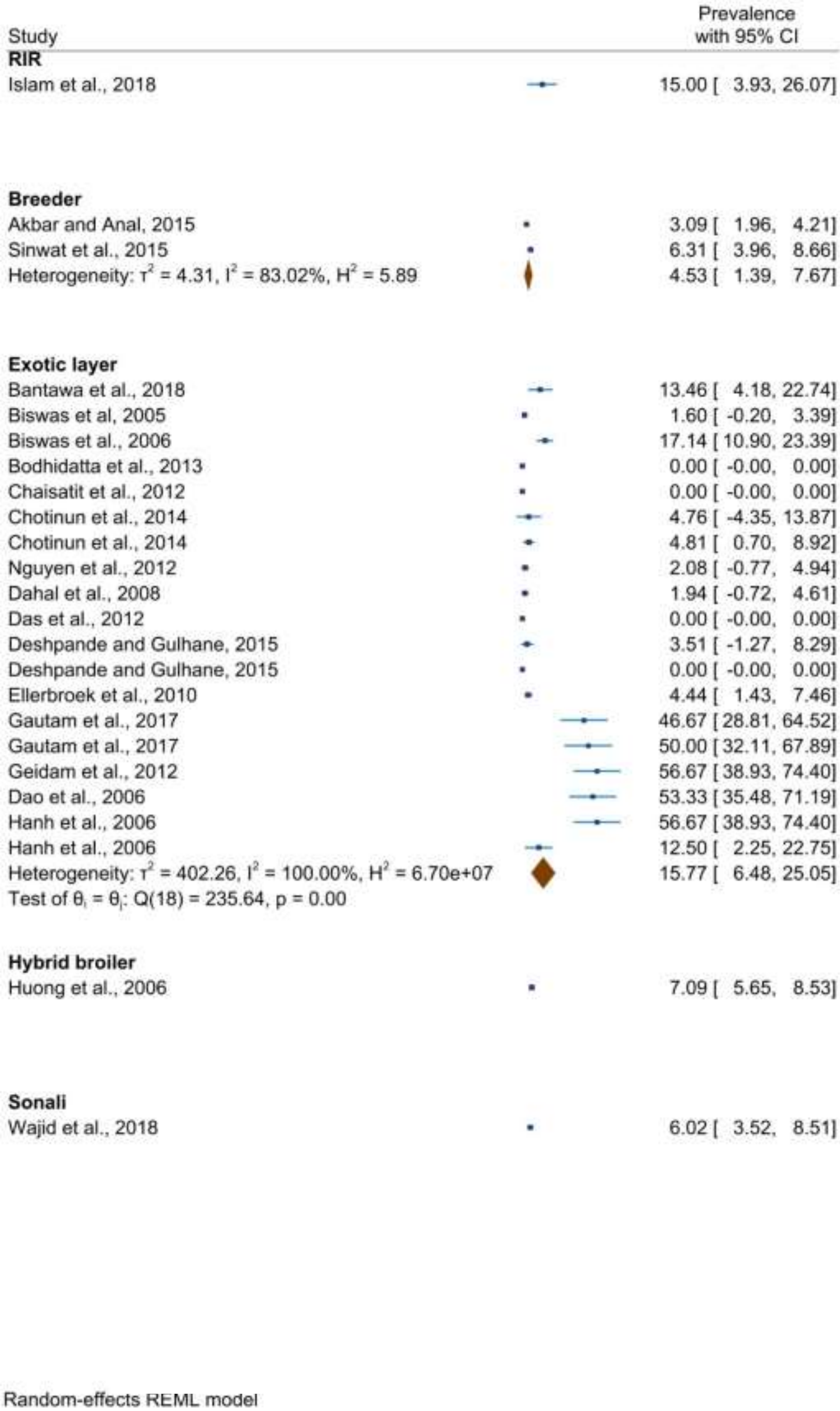

Study
Prevalence with 95% CI
NM
Badhe et al., 2013 0.55 [-0.53, 1.63]
Badhe et al., 2013 36.20 [29.86, 42.54]
Bangtrakulnonth et al., 2006 26.67 [15.48, 37.86]
Bantawa et al., 2018 15.00 [5.97, 24.03]
Biswas et al, 2005 62.50 [47.50, 77.50]
Biswas et al., 2006 11.11 [4.62, 17.60]
Bodhidatta et al., 2013 1.19 [-1.13, 3.51]
Chaisatit et al., 2012 65.71 [56.64, 74.79]
Chotinun et al., 2014 6.00 [1.35, 10.65]
Chotinun et al., 2014 82.76 [74.82, 90.70]
Nguyen et al., 2012 97.87 [95.49, 100.25]
Dahal et al., 2008 48.57 [32.01, 65.13]
Das et al., 2012 5.24 [2.22, 8.25]
Deshpande and Gulhane, 2015 64.71 [54.55, 74.87]
Deshpande and Gulhane, 2015 48.00 [34.15, 61.85]
Ellerbroek et al., 2010 3.33 [-3.09, 9.76]
Gautam et al., 2017 0.00 [-0.00, 0.00]
Gautam et al., 2017 75.00 [61.58, 88.42]
Geidam et al., 2012 25.53 [13.07, 38.00]
Dao et al., 2006 16.67 [-13.15, 46.49]
Hanh et al., 2006 16.67 [-13.15, 46.49]
Hanh et al., 2006 13.33 [1.17, 25.50]
Huong et al., 2006 20.00 [5.69, 34.31]
Jajere et al., 2019 26.67 [10.84, 42.49]
Karabasanavar et al., 2007 28.33 [16.93, 39.74]
Kaushik et al., 2014 1.47 [-0.55, 3.49]
Khan et al., 2015 9.09 [1.49, 16.69]
Khan et al., 2015 67.14 [60.79, 73.50]
Khan et al., 2015 32.86 [21.85, 43.86]
Khan t al., 2019 78.00 [66.52, 89.48]
Khan t al., 2019 60.00 [35.21, 84.79]
Khan t al., 2019 92.50 [84.34, 100.66]
Khan t al., 2019 18.67 [9.85, 27.48]
Khan t al., 2019 14.63 [3.82, 25.45]
Kumar et al., 2010 39.02 [24.09, 53.96]
Latha et al., 2017 65.28 [54.28, 76.27]
Lay et al., 2011 13.00 [9.70, 16.30]

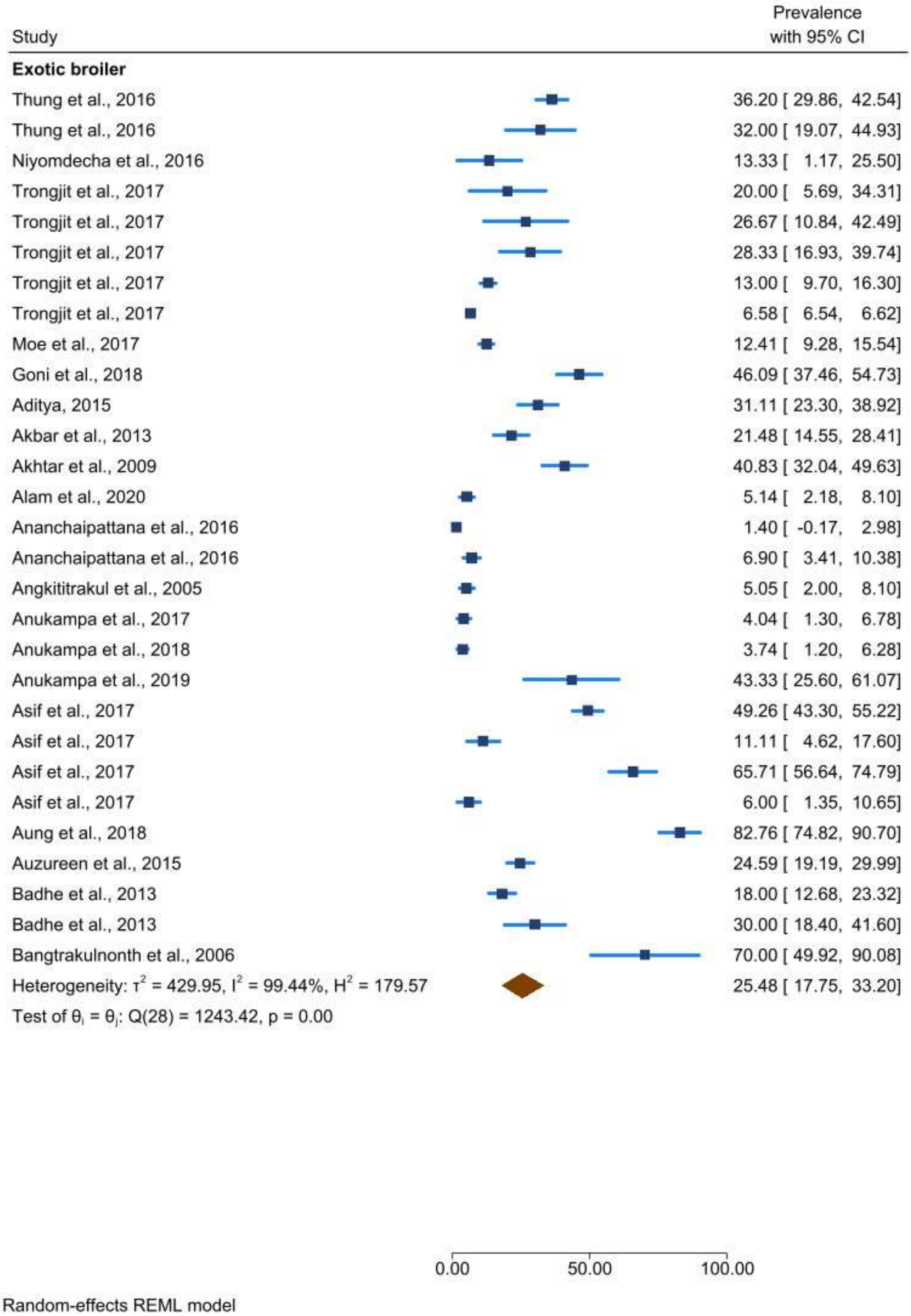

Maharjan et al., 2006 37.50 [20.73, 54.27]
Mahato, 2019 13.46 [4.18, 22.74]
Mahmud et al., 2011 1.60 [-0.20, 3.39]
Mahmud et al., 2011 13.00 [9.70, 16.30]
Mallhi et al., 2019 52.08 [37.95, 66.22]
Manguiat et al., 2013 2.56 [-2.40, 7.52]
Maripandi et al., 2010 8.11 [1.89, 14.33]
Mathew et al., 2009 8.33 [1.34, 15.33]
Menghistu et al., 2011 3.09 [1.96, 4.21]
Minami et al., 2010 48.85 [42.80, 54.91]
Minami et al., 2010 2.52 [1.34, 3.70]
Mir et al., 2010 1.00 [-0.95, 2.95]
Mir et al., 2015 23.68 [18.17, 29.20]
Mridha et al., 2020 17.14 [10.90, 23.39]
Murugkar et al., 2005 0.00 [-0.00, 0.00]
Naik et al., 2015 0.00 [-0.00, 0.00]
Neunchat et al., 2017 0.00 [-0.00, 0.00]
Nghiem et al.,2019 88.16 [83.02, 93.29]
Nidaullah et al., 2017 14.55 [5.23, 23.86]
Niyomdecha et al., 2016 42.50 [27.18, 57.82]
Novera et al., 2020 13.33 [1.17, 25.50]
Olukemi et al.,2018 30.43 [19.58, 41.29]
Padungtod et al., 2006 15.92 [12.93, 18.90]
Padungtod et al., 2006 12.41 [9.28, 15.54]
Padungtod et al., 2006 57.14 [20.48, 93.80]
Parvej et al., 2016 48.15 [29.30, 66.99]
Patoli et al., 2019 8.91 [4.98, 12.84]
Prasertsee et al., 2019 46.09 [37.46, 54.73]
Prasertsee et al., 2019 3.50 [0.95, 6.05]
Prasertsee et al., 2019 43.90 [35.13, 52.67]
Reddy et al., 2019 36.67 [19.42, 53.91]
Reddy et al., 2019 100.00 [100.00, 100.00]
Reddy et al., 2019 62.50 [47.50, 77.50]
Ruban and Fairoze, 2011 28.04 [19.53, 36.55]
Sajid et al., 2015 10.26 [3.52, 16.99]
Sajid et al., 2015 4.24 [2.32, 6.15]
Sajid et al., 2015 42.47 [31.13, 53.80]
Sajid et al., 2015 56.94 [45.51, 68.38]
Sajid et al., 2015 28.00 [15.55, 40.45]
Sajid et al., 2015 30.00 [9.92, 50.08]
Saha et al., 2016 16.67 [3.33, 30.00]
Saharan et al., 2020 42.86 [31.26, 54.45]
Saikia and Joshi, 2010 31.11 [23.30, 38.92]
Samad et al., 2018 21.48 [14.55, 28.41]
Samad et al., 2018 40.83 [32.04, 49.63]
Samad et al., 2018 47.86 [42.01, 53.71]

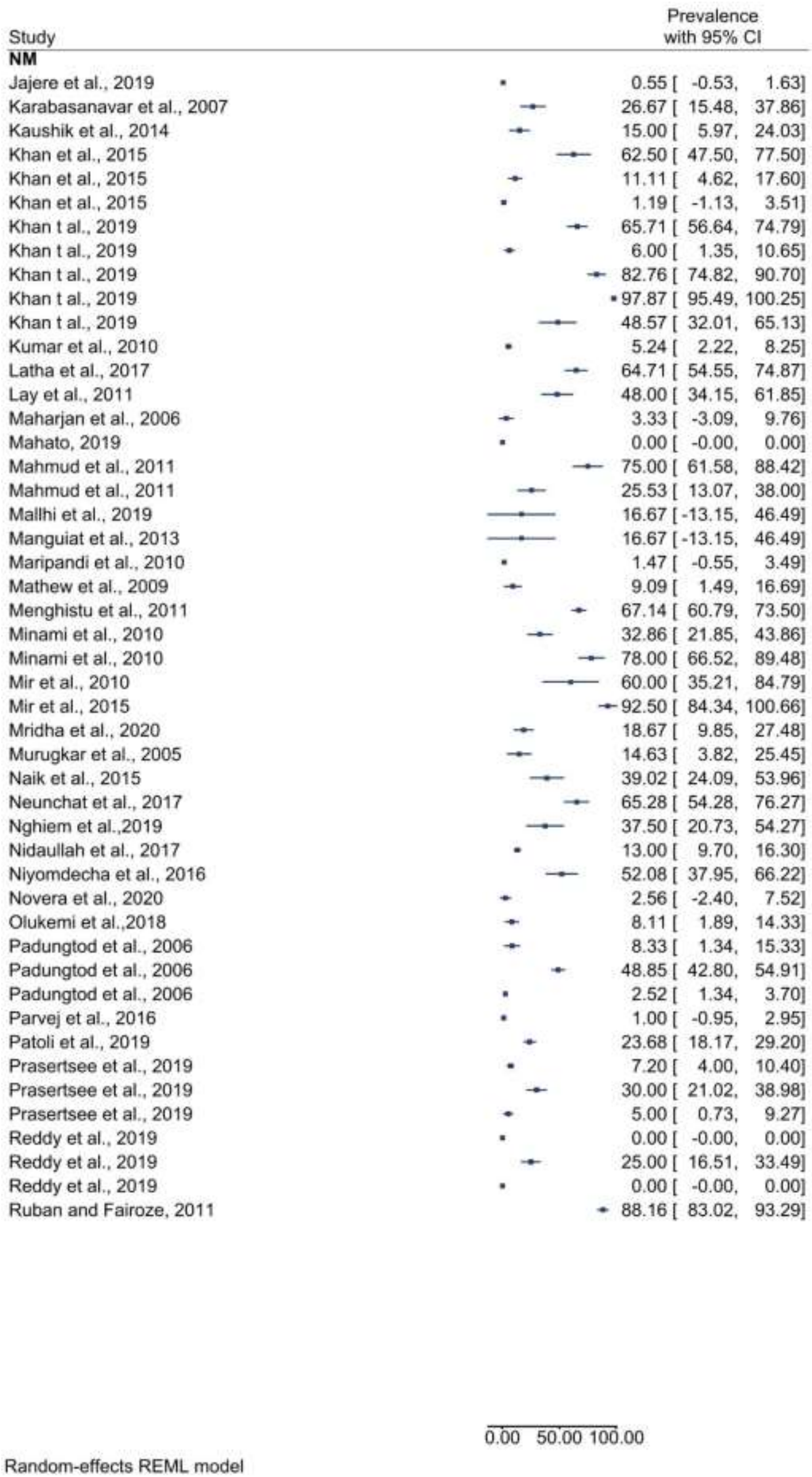

Samanta et al., 2019 6.28 [2.98, 9.59]
Saravanan et al., 2015 6.82 [2.52, 11.12]
Saravanan et al., 2015 13.17 [8.54, 17.80]
Saravanan et al., 2015 5.06 [1.64, 8.48]
Saravanan et al., 2015 4.72 [1.03, 8.41]
Saravanan et al., 2015 9.58 [5.86, 13.31]
Saravanan et al., 2015 4.00 [0.86, 7.14]
Saravanan et al., 2015 72.50 [62.72, 82.28]
Saud et al., 2019 20.00 [12.52, 27.48]
Selvaraj et al., 2010 24.00 [15.63, 32.37]
Selvaraj et al., 2010 28.00 [19.20, 36.80]
Selvaraj et al., 2010 33.00 [26.48, 39.52]
Shafini et al., 2017 0.00 [-0.00, 0.00]
Shafini et al., 2017 8.57 [2.01, 15.13]
Shafini et al., 2017 5.26 [-1.84, 12.36]
Sharma et al., 2019 5.00 [-0.51, 10.51]
Singh et al., 2013 8.00 [-2.63, 18.63]
Soomro et al., 2010 72.22 [61.88, 82.57]
Srinivasan et al., 2014 23.33 [8.20, 38.47]
Srinivasan et al., 2014 5.56 [-0.55, 11.67]
Srinivasan et al., 2014 14.89 [9.80, 19.98]
Srinivasan et al., 2014 4.44 [1.43, 7.46]
Srinivasan et al., 2014 38.00 [28.49, 47.51]
Srinivasan et al., 2014 47.22 [30.91, 63.53]
Sripaurya et al., 2019 5.14 [2.18, 8.10]
Suresh et al., 2011 1.40 [-0.17, 2.98]
Suresh et al., 2011 6.90 [3.41, 10.38]
Suresh et al., 2011 5.05 [2.00, 8.10]
Suresh et al., 2011 4.04 [1.30, 6.78]
Suresh et al., 2011 3.74 [1.20, 6.28]
Suresh et al., 2011 25.23 [19.41, 31.05]
Suryani et al., 2017 43.33 [25.60, 61.07]
Ta et al., 2014 49.26 [43.30, 55.22]
Ta et al., 2014 42.57 [34.60, 50.53]
Thai and Yamaguchi, 2012 21.00 [15.36, 26.64]
Tran et al., 2005 11.11 [4.62, 17.60]
Trongjit et al., 2014 65.71 [56.64, 74.79]
Trongjit et al., 2014 6.00 [1.35, 10.65]
Trongjit et al., 2014 82.76 [74.82, 90.70]
Trongjit et al., 2014 24.59 [19.19, 29.99]
Vadhanasin et al., 2004 96.43 [92.46, 100.40]
Vaeteewootacharn et al., 2005 53.33 [35.48, 71.19]
Van et al., 2007 62.00 [48.55, 75.45]
Vindigni et al., 2007 25.00 [0.50, 49.50]
Waghamare et al., 2017 16.67 [-13.15, 46.49]
Waghamare et al., 2017 18.33 [8.54, 28.12]
Wardhana et al., 2019 18.00 [12.68, 23.32]
Yang et al., 2018 34.00 [20.87, 47.13]
Yasmin et al., 2020 50.00 [36.14, 63.86]
Yasmin et al., 2020 25.00 [17.25, 32.75]


Zwe et al., 2018 12.67 [7.34, 17.99]
Zwe et al., 2018 5.33 [0.25, 10.42]
Murugadas et al., 2015 2.90 [-1.06, 6.86]
Murugadas et al., 2015 0.00 [-0.00, 0.00]
Murugadas et al., 2015 0.00 [-0.00, 0.00]
Murugadas et al., 2015 2.67 [-0.98, 6.31]
Murugadas et al., 2015 22.00 [10.52, 33.48]
Sudhanthirakodi et al., 2016 40.00 [26.42, 53.58]
Sudhanthirakodi et al., 2016 67.50 [52.99, 82.01]
Lertworapreecha et al., 2013 30.00 [18.40, 41.60]
Salauddin et al., 2015 13.73 [4.28, 23.17]
Kulasooriya et al., 2019 4.17 [-1.49, 9.82]
Kulasooriya et al., 2019 0.00 [-0.00, 0.00]
Kulasooriya et al., 2019 18.07 [9.79, 26.35]
Maqdhurangi et al., 2013 42.63 [37.21, 48.06]
Heterogeneity: τ^2 = 616.60, I^2 = 100.00%, H^2 = 3.36e+07 27.07 [22.99, 31.16]
Test of $\theta_i = \theta_j$: Q(147) = 8.89e+09, p = 0.00
0.00
50.00
100.00
Random-effects REML model

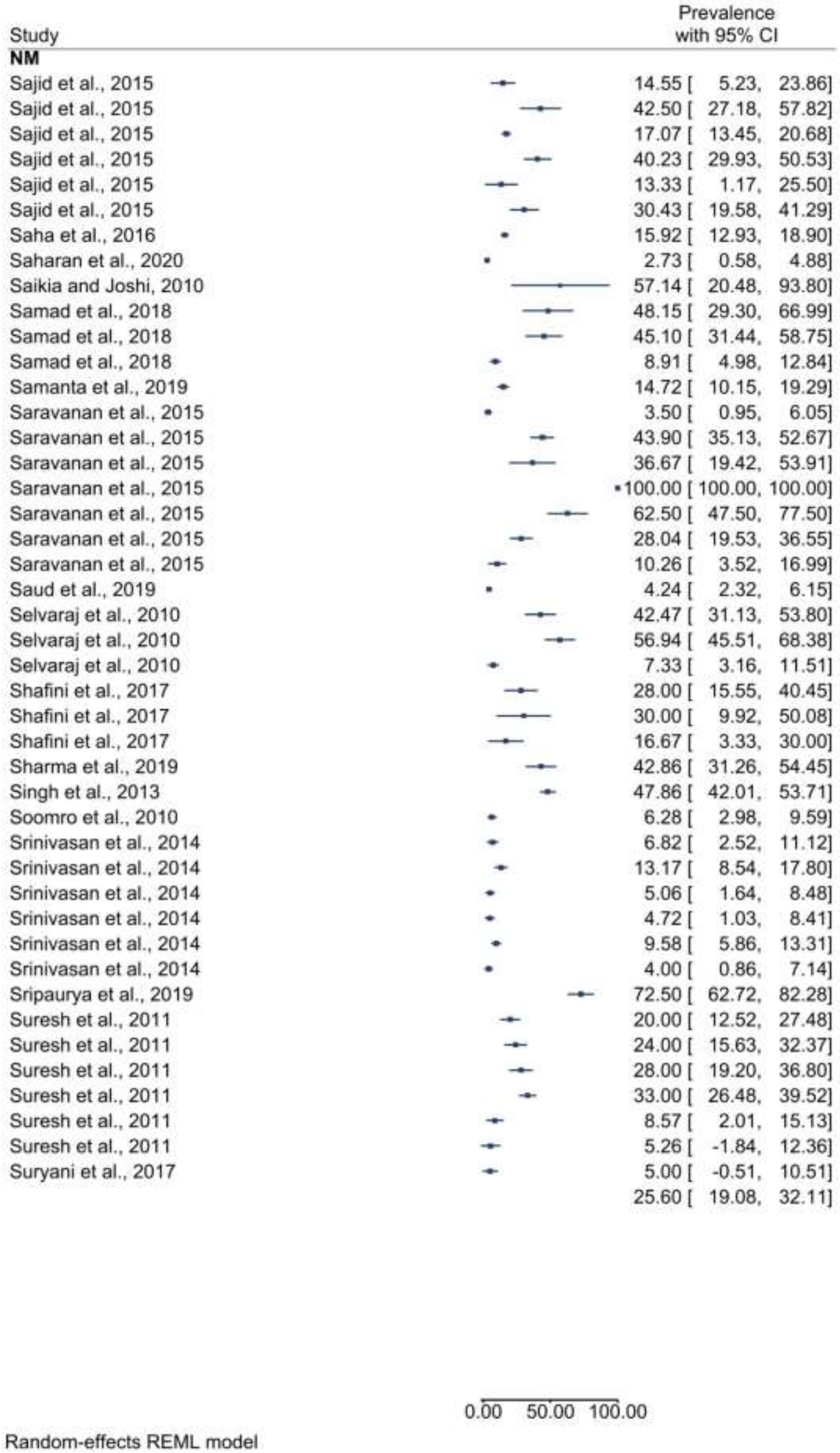
Appendix T. Forest plot for pooled prevalence (sample unit) of non-typhoidal *Salmonella* in chickens in different production type in south and southeast Asia

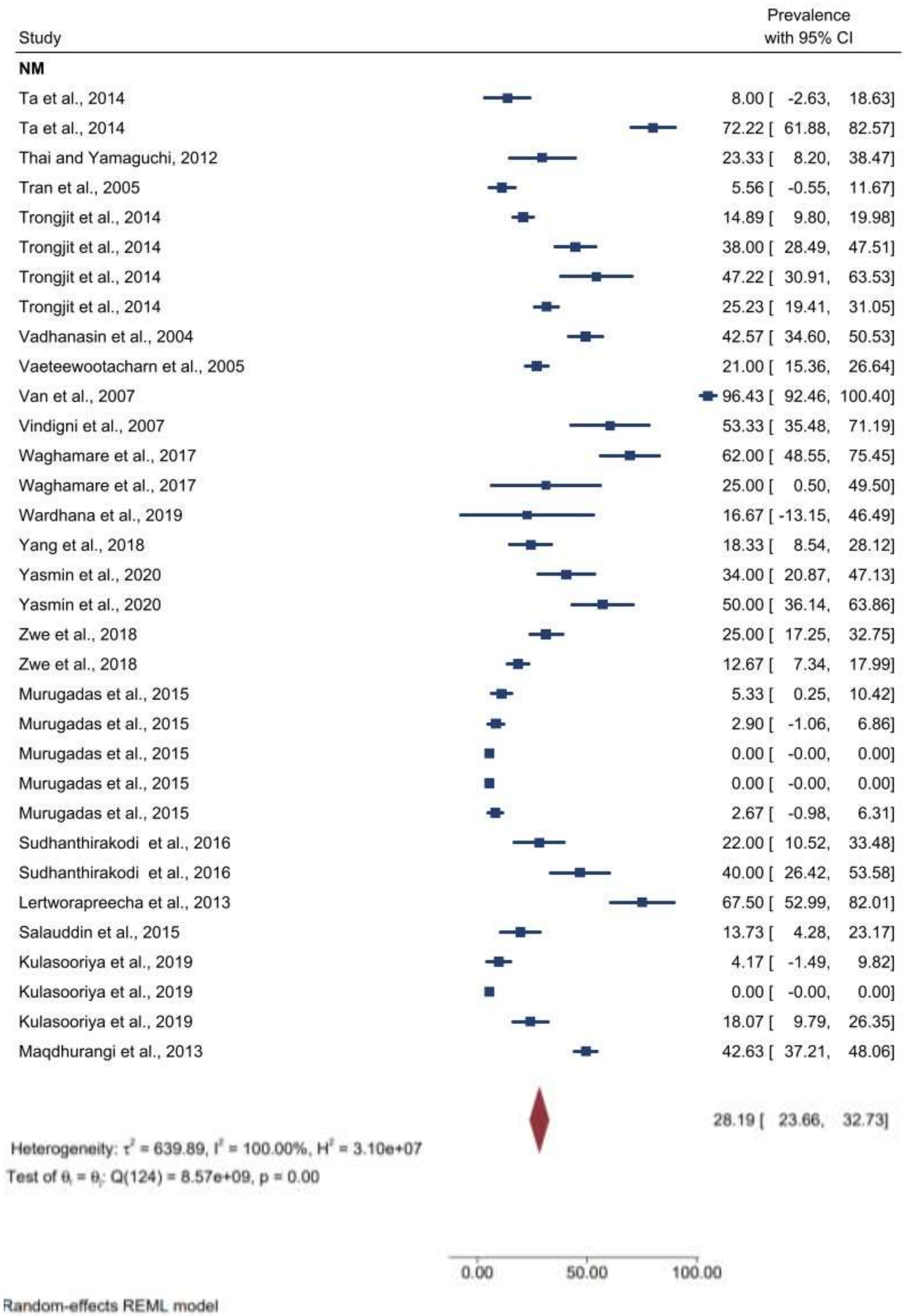



Study
Prevalence with 95% CI
Exotic broiler
Thung et al., 2016 36.20 [29.86, 42.54]
Thung et al., 2016 32.00 [19.07, 44.93]
Niyomdecha et al., 2016 13.33 [1.17, 25.50]
Trongjit et al., 2017 20.00 [5.69, 34.31]
Trongjit et al., 2017 26.67 [10.84, 42.49]
Trongjit et al., 2017 28.33 [16.93, 39.74]
Trongjit et al., 2017 13.00 [9.70, 16.30]
Trongjit et al., 2017 6.58 [6.54, 6.62]
Moe et al., 2017 12.41 [9.28, 15.54]
Goni et al., 2018 46.09 [37.46, 54.73]
Aditya, 2015 31.11 [23.30, 38.92]
Akbar et al., 2013 21.48 [14.55, 28.41]
Akhtar et al., 2009 40.83 [32.04, 49.63]
Alam et al., 2020 5.14 [2.18, 8.10]
Ananchaipattana et al., 2016 1.40 [-0.17, 2.98]
Ananchaipattana et al., 2016 6.90 [3.41, 10.38]
Angkititrakul et al., 2005 5.05 [2.00, 8.10]
Anukampa et al., 2017 4.04 [1.30, 6.78]
Anukampa et al., 2018 3.74 [1.20, 6.28]
Anukampa et al., 2019 43.33 [25.60, 61.07]
Asif et al., 2017 49.26 [43.30, 55.22]
Asif et al., 2017 11.11 [4.62, 17.60]
Asif et al., 2017 65.71 [56.64, 74.79]
Asif et al., 2017 6.00 [1.35, 10.65]
Aung et al., 2018 82.76 [74.82, 90.70]
Auzureen et al., 2015 24.59 [19.19, 29.99]
Badhe et al., 2013 18.00 [12.68, 23.32]
Badhe et al., 2013 30.00 [18.40, 41.60]
Bangtrakulnonth et al., 2006 70.00 [49.92, 90.08]
Heterogeneity: τ^2 = 429.95, I^2 = 99.44%, H^2 = 179.57 25.48 [17.75, 33.20]
Test of $\theta_i = \theta_j$: Q(28) = 1243.42, p = 0.00
0.00
50.00
100.00
Random-effects REML model



Study
Prevalence with 95% CI
NM
Jajere et al., 2019 0.55 [-0.53, 1.63]
Karabasanavar et al., 2007 26.67 [15.48, 37.86]
Kaushik et al., 2014 15.00 [5.97, 24.03]
Khan et al., 2015 62.50 [47.50, 77.50]
Khan et al., 2015 11.11 [4.62, 17.60]
Khan et al., 2015 1.19 [-1.13, 3.51]
Khan t al., 2019 65.71 [56.64, 74.79]
Khan t al., 2019 6.00 [1.35, 10.65]
Khan t al., 2019 82.76 [74.82, 90.70]
Khan t al., 2019 97.87 [95.49, 100.25]
Khan t al., 2019 48.57 [32.01, 65.13]
Kumar et al., 2010 5.24 [2.22, 8.25]
Latha et al., 2017 64.71 [54.55, 74.87]
Lay et al., 2011 48.00 [34.15, 61.85]
Maharjan et al., 2006 3.33 [-3.09, 9.76]
Mahato, 2019 0.00 [-0.00, 0.00]
Mahmud et al., 2011 75.00 [61.58, 88.42]
Mahmud et al., 2011 25.53 [13.07, 38.00]
Mallhi et al., 2019 16.67 [-13.15, 46.49]
Manguiat et al., 2013 16.67 [-13.15, 46.49]
Maripandi et al., 2010 1.47 [-0.55, 3.49]
Mathew et al., 2009 9.09 [1.49, 16.69]
Menghistu et al., 2011 67.14 [60.79, 73.50]
Minami et al., 2010 32.86 [21.85, 43.86]
Minami et al., 2010 78.00 [66.52, 89.48]
Mir et al., 2010 60.00 [35.21, 84.79]
Mir et al., 2015 92.50 [84.34, 100.66]
Mridha et al., 2020 18.67 [9.85, 27.48]
Murugkar et al., 2005 14.63 [3.82, 25.45]
Naik et al., 2015 39.02 [24.09, 53.96]
Neunchat et al., 2017 65.28 [54.28, 76.27]
Nghiem et al.,2019 37.50 [20.73, 54.27]
Nidaullah et al., 2017 13.00 [9.70, 16.30]
Niyomdecha et al., 2016 52.08 [37.95, 66.22]
Novera et al., 2020 2.56 [-2.40, 7.52]
Olukemi et al.,2018 8.11 [1.89, 14.33]
Padungtod et al., 2006 8.33 [1.34, 15.33]
Padungtod et al., 2006 48.85 [42.80, 54.91]
Padungtod et al., 2006 2.52 [1.34, 3.70]
Parvej et al., 2016 1.00 [-0.95, 2.95]
Patoli et al., 2019 23.68 [18.17, 29.20]
Prasertsee et al., 2019 7.20 [4.00, 10.40]
Prasertsee et al., 2019 30.00 [21.02, 38.98]
Prasertsee et al., 2019 5.00 [0.73, 9.27]
Reddy et al., 2019 0.00 [-0.00, 0.00]
Reddy et al., 2019 25.00 [16.51, 33.49]
Reddy et al., 2019 0.00 [-0.00, 0.00]
Ruban and Fairoze, 2011 88.16 [83.02, 93.29]
0.00 50.00 100.00
Random-effects REML model


Study
Prevalence with 95% CI
NM
Sajid et al., 2015 14.55 [5.23, 23.86]
Sajid et al., 2015 42.50 [27.18, 57.82]
Sajid et al., 2015 17.07 [13.45, 20.68]
Sajid et al., 2015 40.23 [29.93, 50.53]
Sajid et al., 2015 13.33 [1.17, 25.50]
Sajid et al., 2015 30.43 [19.58, 41.29]
Saha et al., 2016 15.92 [12.93, 18.90]
Saharan et al., 2020 2.73 [0.58, 4.88]
Saikia and Joshi, 2010 57.14 [20.48, 93.80]
Samad et al., 2018 48.15 [29.30, 66.99]
Samad et al., 2018 45.10 [31.44, 58.75]
Samad et al., 2018 8.91 [4.98, 12.84]
Samanta et al., 2019 14.72 [10.15, 19.29]
Saravanan et al., 2015 3.50 [0.95, 6.05]
Saravanan et al., 2015 43.90 [35.13, 52.67]
Saravanan et al., 2015 36.67 [19.42, 53.91]
Saravanan et al., 2015 100.00 [100.00, 100.00]
Saravanan et al., 2015 62.50 [47.50, 77.50]
Saravanan et al., 2015 28.04 [19.53, 36.55]
Saravanan et al., 2015 10.26 [3.52, 16.99]
Saud et al., 2019 4.24 [2.32, 6.15]
Selvaraj et al., 2010 42.47 [31.13, 53.80]
Selvaraj et al., 2010 56.94 [45.51, 68.38]
Selvaraj et al., 2010 7.33 [3.16, 11.51]
Shafini et al., 2017 28.00 [15.55, 40.45]
Shafini et al., 2017 30.00 [9.92, 50.08]
Shafini et al., 2017 16.67 [3.33, 30.00]
Sharma et al., 2019 42.86 [31.26, 54.45]
Singh et al., 2013 47.86 [42.01, 53.71]
Soomro et al., 2010 6.28 [2.98, 9.59]
Srinivasan et al., 2014 6.82 [2.52, 11.12]
Srinivasan et al., 2014 13.17 [8.54, 17.80]
Srinivasan et al., 2014 5.06 [1.64, 8.48]
Srinivasan et al., 2014 4.72 [1.03, 8.41]
Srinivasan et al., 2014 9.58 [5.86, 13.31]
Srinivasan et al., 2014 4.00 [0.86, 7.14]
Sripaurya et al., 2019 72.50 [62.72, 82.28]
Suresh et al., 2011 20.00 [12.52, 27.48]
Suresh et al., 2011 24.00 [15.63, 32.37]
Suresh et al., 2011 28.00 [19.20, 36.80]
Suresh et al., 2011 33.00 [26.48, 39.52]
Suresh et al., 2011 8.57 [2.01, 15.13]
Suresh et al., 2011 5.26 [-1.84, 12.36]
Suryani et al., 2017 5.00 [-0.51, 10.51]
25.60 [19.08, 32.11]
0.00 50.00 100.00
Random-effects REML model


Study
Prevalence with 95% CI
NM
Ta et al., 2014 8.00 [-2.63, 18.63]
Ta et al., 2014 72.22 [61.88, 82.57]
Thai and Yamaguchi, 2012 23.33 [8.20, 38.47]
Tran et al., 2005 5.56 [-0.55, 11.67]
Trongjit et al., 2014 14.89 [9.80, 19.98]
Trongjit et al., 2014 38.00 [28.49, 47.51]
Trongjit et al., 2014 47.22 [30.91, 63.53]
Trongjit et al., 2014 25.23 [19.41, 31.05]
Vadhanasin et al., 2004 42.57 [34.60, 50.53]
Vaeteewootacharn et al., 2005 21.00 [15.36, 26.64]
Van et al., 2007 96.43 [92.46, 100.40]
Vindigni et al., 2007 53.33 [35.48, 71.19]
Waghamare et al., 2017 62.00 [48.55, 75.45]
Waghamare et al., 2017 25.00 [0.50, 49.50]
Wardhana et al., 2019 16.67 [-13.15, 46.49]
Yang et al., 2018 18.33 [8.54, 28.12]
Yasmin et al., 2020 34.00 [20.87, 47.13]
Yasmin et al., 2020 50.00 [36.14, 63.86]
Zwe et al., 2018 25.00 [17.25, 32.75]
Zwe et al., 2018 12.67 [7.34, 17.99]
Murugadas et al., 2015 5.33 [0.25, 10.42]
Murugadas et al., 2015 2.90 [-1.06, 6.86]
Murugadas et al., 2015 0.00 [-0.00, 0.00]
Murugadas et al., 2015 0.00 [-0.00, 0.00]
Murugadas et al., 2015 2.67 [-0.98, 6.31]
Sudhanthirakodi et al., 2016 22.00 [10.52, 33.48]
Sudhanthirakodi et al., 2016 40.00 [26.42, 53.58]
Lertworapreecha et al., 2013 67.50 [52.99, 82.01]
Salauddin et al., 2015 13.73 [4.28, 23.17]
Kulasooriya et al., 2019 4.17 [-1.49, 9.82]
Kulasooriya et al., 2019 0.00 [-0.00, 0.00]
Kulasooriya et al., 2019 18.07 [9.79, 26.35]
Maqdhurangi et al., 2013 42.63 [37.21, 48.06]
28.19 [23.66, 32.73]
Heterogeneity: τ² = 639.89, I² = 100.00%, H² = 3.10e+07
Test of θi = θj: Q(124) = 8.57e+09, p = 0.00
0.00
50.00
100.00
Random-effects REML model

Appendix U. STATA-17 commands

```
meta set ppercent sepercent, studylabel(author)
meta forestplot, random(reml)
meta forestplot, random(reml) subgroup(country)
meta forestplot, random(reml) subgroup(sample_type)
meta forestplot, random(reml) subgroup(study_site)
meta forestplot, random(reml) subgroup(health_status)
meta forestplot, random(reml) subgroup(production_type)
gen logppercent=log10(ppercent)
gen logciu=log10(ci_u)
gen logcil=log10(ci_l)
gen logsepercent=log(sepercent)
meta funnelplot
meta bias, egger random(reml)
meta regress i.country, random(reml)
meta regress i.sample_type, random(reml)
meta regress i.production_type, random(reml)
meta regress i.study_site, random(reml)
meta regress i.health_status, random(reml)
```

Biography

Nurun Nahar Chisty passed the Secondary School Certificate Examination, SSC, in 2010 obtaining GPA 4.83 (A) and then Higher Secondary Certificate Examination, HSC, in 2012 obtaining GPA 5.00 (A+). Nurun Nahar Chisty obtained her Doctor of Veterinary Medicine Degree in 2019 from Chattogram Veterinary and Animal Sciences University, CVASU, Bangladesh. Now, she is a candidate for the degree of Master of Science in Epidemiology under the Department of Medicine and Surgery, Faculty of Veterinary Medicine, Chattogram Veterinary and Animal Sciences University. She has immense interest working on zoonotic food-borne pathogens and educational research.