Systematic-review and meta-analysis on effect of decontamination interventions on prevalence and concentration of *Campylobacter* spp. during primary processing of broiler chickens

Section A: PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist

Section and topic Item No		Checklist item	Remark
Administrative Information			
Title: Identification	1a	Identify the report as a protocol of a systematic review	Systematic-review and meta-analysis on effect of decontamination interventions on prevalence and concentration of *Campylobacter* spp. during primary processing of broiler chickens
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	Protocol for a new systematic review
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	Protocol not registered as the systematic review does not directly refer to publications on human health
Authors Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	[1,2]Josphat N. Gichure*, [3]Patrick Murigu Kamau Njage, [4]Joseph M. Wambui, [1]Gary A. Dykes, [5]Elna M. Buys, [1]Ranil Coorey [1]School of Molecular and Life Sciences, Faculty of Science and Engineering, Curtin University, GPO Box U1987, Perth, Western Australia, 6845, Australia [2]Department of Food Science, Nutrition and Technology, South Eastern Kenya University, P.O. Box 170-90200, Kitui, Kenya [3]Division for Epidemiology and Microbial

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Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	Conceptualization: JG, EB, PKN, GD, RC; Methodology: JG, EB, PKN, GD, RC; Investigation: JG, PKN, JW; Resources: JG, EB, PKN, GD, RC; Data curation: JG, PKN, JW; Writing—original draft preparation: JG; Writing—review and editing: JG, EB, PKN, GD, JW, RC.
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	In case the protocol needs to be amended, the description of the amendment shall be dated and submitted with the rationale.
Support: Sources	5a	Indicate sources of financial or other support for the review	Australia Awards Africa postdoctoral scholarship
Sponsor	5b	Provide name for the review funder and/or sponsor	Australia Awards Africa postdoctoral scholarship
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	The funder had no other role in developing the protocol

INTRODUCTION			
Rationale	6	Describe the rationale for the review in the context of what is already known	Review title: Systematic-review and meta-analysis on effect of decontamination interventions on prevalence and concentration of *Campylobacter* spp. during primary processing of broiler chickens Recent scientific advances offer numerous interventions to reduce and eliminate *Campylobacter* spp. However, there lacks an overall picture of what happens across different points from scalding to post-chill. Systematic review followed by meta-analysis and meta-regression were therefore conducted on concentration and prevalence of *Campylobacter* spp. along the slaughter process to provide more evidence on efficacy of interventions, which has not been performed prevously.
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	The aim of this study is to collate data from different studies using systematic-review meta-analysis followed by meta-regression
METHODS			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	Screening and inclusion based on PICO guidelines as per the following criteria. Study designs: for inclusion, randomized controlled (non-randomized) experimental trials, challenge trials, and before-after-trials. Participants: studies on broiler chicken (to identify broilers, the screening checklist will be used). Spent layers and other fowls were excluded. Interventions: microbial decontamination interventions examining the effect on

			Campylobacter spp. concentration and prevalence Comparators: Since there were several interventions investigated, several comparisons were included. Interventions were grouped based on prevalence or concentration studies. For each sub-group, physical and chemical decontamination techniques were investigated Outcomes: the decrease/increase in concentration or prevalence before and after an intervention Timing: only samples collected from the same lot were evaluated. In case the samples are to be taken post-chill, after several days of storage, care was taken to ensure no other factors would have affected the outcomes during storage. Setting: no restrictions. Language- English
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	The search was in two electronic databases namely; (i) Web of Science, and (ii) Pubmed Only literature published after 01/01/1998 were included. Handsearching through scanning the reference lists of the included studies and existing reviews was conducted to complement the electronic database search.
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Publications on qualitative and quantitative trials were identified. No restrictions were made on the design, date or language at this point. Google translate was used in case the title is in a non-English language. Due to institutional subscriptions, Web of Science and Pubmed were used. The algorithm used: ((*Campylobacter** AND

			(((Chicken* OR Poultr*) OR broiler*) OR gallus)) AND (slaughter* OR process*))
Study records: Data management	11 a	Describe the mechanism(s) that will be used to manage records and data throughout the review	Literature search results was exported to EndNote for deduplication, and then shared with the other two reviewers for abstracts screening. Pre-tested checklists were used along the screening process. Data extraction was done using MS Access, then exported to MS Excel. Data analysis was done using Metafor package (Version 2.0-0) in R-programme (version 3.6.0).
Selection process	11 b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	Two independent reviewers screened the titles and articles after deduplication using the checklist provided. The reviewers then screened the reports to confirm that the inclusion criteria had been adhered to. Disagreement was solved through discussions and/ or arbitration by a third reviewer. Since EndNote was used, it was impractical to blind to journal titles, authors, or study institutions.
Data collection process	11 c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	Data extraction was done in duplicate, that is, the two reviewers extracted data independently from each eligible study using standardized MS Access forms. As with the selection process, disagreement will be solved through discussions and/ or arbitration by a third reviewer.
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	The extracted data comprised of; Article identification, Sampling point, Intervention details, Type of control used, Exposure details to intervention, Sampling, Microbial culture, Microbial confirmation, Trial size, and Publication status.
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with	The main intended outcome was the reduction or increase in concentration and prevalence of *Campylobacter* spp. when a given decontamination interventions had been tested during broiler primary processing. Concentration reduction was the difference

		rationale	between control and treatment groups, while relative risks was used in prevalence trials. In terms of data set for the outcomes, categorical data was obtained for prevalence trials while continuous data was collected for concentration trials.
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	The Cochrane Collaboration tool was adopted (with modifications) to assess risk of bias within studies. The specific areas assessed include study design adequacy and set-up, sampling, sequence generation, allocation concealment, blinding, selective outcome reporting and statistical appropriateness. For each, a brief description of the activity was recorded and evaluated based on possible risk of bias as 'high risk', 'unclear risk' or 'low risk'. Disagreements were cleared through discussions or the third reviewer acting as the arbitrator.
Data synthesis	15 a	Describe criteria under which study data will be quantitatively synthesised	The meta-analysis was run using a random-effects model for heterogenous data set while fixed effect model will be used for homogenous data set.
	15 b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I2, Kendall's τ)	Measures of treatment effect • For categorical outcomes (prevalence), effect was evaluated using risk ratio (RR) with 95% confidence interval (CI). • For continuous outcomes (concentration), raw mean differences was used to evaluate the odds ratio (OR) with 95% CI Dealing with missing data: it was envisaged that the corresponding authors would be contacted. Metagear (Version 0.4) in R-package was used to extract data from images (graphs and charts). The following scale was used to rate heterogeneity: I^2 statistic (0% to 40%

			assumed to be unimportant; 50% to 60% to represent moderate heterogeneity; and above 60%, heterogeneity will be considered substantial. Q-test will used to indicate heterogeneity, and τ^2 will indicate variability. Data synthesis Once extracted, data was run using R-packages. The Mantel-Haenszel method adopted for the fixed effect model, while DerSimonian and Laird) method used for the random effect model. The random effect model was used only where heterogeneity was significant (I^2 <50% or P <0.1)
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	Subgroup analysis to explore likely causes of heterogeneity, based on the following: sampling point, intervention (physical vs chemical), technique (spray vs immersion vs cloaca treatment), publication year, and sample size Meta-regression used to evaluate which study characteristics account for heterogeneity and adjust for probable confounders across the studies
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	Descriptive characteristics was provided using systematic narrative synthesis with data presented using text and tables. The narrative synthesis was used to bring out the relationship and findings within-studies and between-studies. This was based on modification of Centre for Reviews and Dissemination guidelines
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	The fixed effect estimates will be compared against the random effects model, and for each, forest and funnel plots developed to assess the possible presence of small sample effect on the bias. Mixed-effect meta-regression model used to explain bias across

			studies.
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	Evidence was evaluated based on the Grading of Recommendations Assessment, Development and Evaluation. On this, quality encompassed risk of bias, publication bias, reliability, directness, and accuracy. The strength was rated as (i) high, (ii) moderate, (iii) low or (iv) very low

***The PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.**

Adopted from (Moher et al., 2015)

Section B: Search strategy used for a systematic review-meta-analysis investigating the change in prevalence and concentration of *Campylobacter* spp. in broiler chickens during primary processing

Algorithm

((*Campylobacter** AND (((Chicken* OR Poultry*) OR broiler*) OR gallus)) AND (slaughter* OR process*))

Timespan: 01/01/1998- 29/10/2018 (Data of completion of database search)

Databases and captured citations prior to de-dublication

1. Web of Science
    a. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.
    b. 1326 hits
2. PubMed- 731 hits
3. Web-searching-
    a. Databases searched: Google, Google Scholar, Scopus and CAB Abstracts
    b. 12 hits

Section C: Screening tool for abstracts for the systematic-review meta-analysis investigating the change in prevalence and concentration of *Campylobacter* spp. in broiler chickens during primary processing.

RefID: _____

Reviewer: _____

Question 1 - Does this abstract pertain to primary research and results written in English?

1. From the title abstract, is it evident that the authors collected and analyzed their own data?

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

   Take note of review articles

2. Can you retrieve an English version of this article?

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

Note that primary research in the screening process refers to Scalding, Defeathering, Evisceration, Inside-Outside Carcass wash, Chilling or Post-chill storage

Broiler chickens exclude spent hens and other fowl for human consumption. At this point, assume 'poultry' or 'chicken' refers to broilers.

3. Does the study investigate the effects of a decontamination intervention on the prevalence or concentration outcome, on broiler chickens, during primary processing of broiler chickens?

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

4. Are the results from samples collected at specific points during primary processing of broiler chickens?

   [ ] Yes

[ ] No

[ ] Can't tell at this point

5. Does the study investigate the effects of a decontamination intervention on broiler chickens, and **NOT** the processing environment (surfaces, air, process water)?

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

6. Does the sample refer to typical broiler breeds slaughtered at 5-7 weeks of age?

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

Section D: Relevance screening tool for full articles for the systematic-review meta-analysis investigating the change in prevalence and concentration of *Campylobacter* spp. in broiler chickens during primary processing.

RefID: _____

Reviewer: _____

Relevance criteria

1. Have the authors used an appropriate study design in this study? Have the researcher adequately measured the outcome of interest before a treatment and after a treatment.

   [ ] Yes

   [ ] No

   [ ] Can't tell at this point

The samples can either be inoculated or naturally contaminated and the extent of an outcome may be from an earlier point during the primary processing. The designs to accept include Randomized control trials, challenge trials, Before-after-trials. Reject full articles if it's a cohort study, cross-sectional, surveillance reports, modelling and risk analysis publications based on secondary literature. Articles and trials were also accepted if sampling was done to evaluate the effects over a series of different sampling points. Trials refers to treatment-to-control comparisons made within a study. An effect is evaluated by changes in prevalence (frequency or presence/absence) or concentration (colony forming units (CFU) or most probable number (MPN) per unit measured) within a study.

2. Have the methods/ methodology/ procedures been adequately described and presented?

   [ ] Yes

   [ ] No

3. Have the results being adequately presented?

   [ ] Yes

   [ ] No

4. Can specific details of each trial together with its results (control and treatment) be properly extracted?

   [ ] Yes

[ ] No

[ ] Data can be adequately extracted from images using available R-packages

Section E: Risk of Bias Assessment Checklists used for the systematic-review meta-analysis investigating the change in prevalence and concentration of *Campylobacter* spp. in broiler chickens during primary processing.

The checklist was based on GRADE (Grading of Recommendations Assessment, Development, and Evaluation) as recommended (Schünemann et al., 2011).

Quality item	Coding (Please circle the applicable one)	Description
Study design adequacy	Yes	The design is clearly stated including sample size, intervention details, outcomes and controls that will be measured.
	No	One or more of the components are missing.
Sample size justification	Yes	Used formulas, based on desired power or precision and estimate of expected variability to detect differences.
	No	No details in the text, convenient or judgemental sampling done.
Allocation sequence adequately generated	Yes	Allocation sequence is described in enough detail
	No	Sample picked with no formal process for randomization, that is, sampling was judgmental, convenient, & purposive
Allocation concealment or blinding adequate	Yes	Concealment or blinding described
	Not described	No enough details on allocation concealment/ blinding
Adequate description of	Yes	Clearly stated procedures (time,

procedure		temperature, process environment, process capacity
	No	Description not clearly stated
Study set-up	Actual factory set up	Intervention implemented in a typical broiler processing facility and used commercial equipment
	Pilot plant set up	Intervention implemented in a pilot plant
	Lab design	Simulated processing done in the lab
Appropriateness of control group used	Yes	Yes
	No	No
Use of standard methods to culture & confirmation *Campylobacter* spp.	Yes	Standard methods were used and have been adequately described.
	No	Not clear
Report all intended outcomes with no evidence of exclusion of some samples from the results	Yes	The results address all intended outcomes
	No	Evidence some outcomes have been excluded from the results
Appropriateness of statistical analysis, including presentation of measures of variability	Yes	The results fit the study design, outcomes (parameter estimates & measures of variability) adequately presented.
	No	Statistical analysis and measures of variability not properly presented or carried out.
Presence of a dose-response gradient	Yes	The authors present a clear dose-response effect in the study
	No	Not presented
Presence of any other any	Yes	Kindly state in brief

concerns that may contribute to bias	No	None detected during screening or inclusion
Based on GRADE, how **would GRADE** the risk of bias in this study (GRADE 1-10, new)	Low Risk of Bias	Minimal biases indicated, acceptable bias is unlikely across the study
	Unclear Risk of Bias	Elements of acceptable bias detected in the study, that creates uncertainty in the results
	High Risk of Bias	Unacceptable bias identified across the study that consequently affects the overall results

Adopted from (Centre for Reviews and Dissemination, 2009)

Section F: Findings on Risk of Bias Assessment

Allocation concealment and blinding was not reported by any study, and none of the studies justified the sample size used. Allocation sequence was inadequately generated in most studies.

Table 1: Descriptive characteristics of the trials (studies) for inclusion in the systematic review

Criterion	Description	*Campylobacter* spp. conc *n* trials (studies)	*Campylobacter* spp. prevalence *n* trials (studies)
Sample size justification	Clear justification	0(0)	0(0)
	Not described	198(37)	30(15)
Allocation sequence adequately generated	Yes	5(3)	5(3)
	No	193(34)	25(12)
Adequate allocation concealment or blinding	Yes	0(0)	0(0)
	No	198(37)	30(15)
Adequate description of procedure	Yes	169(32)	28(13)
	No	29(5)	2(2)
Appropriateness of control group used	Yes	198(37)	30(15)
	No	0(0)	0(0)
Use of standard methods to analyze *Campylobacter* spp.	Yes	198(37)	30(15)
	No	0(0)	0(0)
All intended outcomes reported/no exclusion of some results	Yes	193(36)	30(15)
	No	5(1)	0(0)
Presentation of measures of variability & statistical analysis	Appropriate	195(36)	27(14)
	Not appropriate	3(1)	3(1)
Presence of a dose-response gradient	Yes	115(8)	5(2)
	No	83(29)	25(13)
Presence of any other any concerns that may contribute to bias	Artificial contamination	31(6)	3(2)
	Multiple sampling factories	3(2)	8(3)
	Activity of prior intervention	2(1)	2(1)
	Others	10(2)	0(0)
	None	152(26)	17(9)
Overall Risk of Bias (RoB) rating based on GRADE	Unclear RoB	49(12)	16(7)
	Low RoB	149(25)	14(8)

Section G: Data extraction tool for a systematic-review meta-analysis investigating the change in prevalence and concentration of *Campylobacter* spp. in broiler chickens during primary processing

Variable	Description	Entry
Article ID	Brief description of article	Author, year, country
Sampling point	Point where samples were collected	Sampling point
Intervention type	Decontamination intervention done	Intervention type
Intervention details	Detailed description of the decontamination intervention	Technique, inoculum, exposure time, exposed part
Microbial sampling	Samples collection	Type of analysed sample
Microbial analysis	Description of steps done for microbial analysis	Non-selective enrichment, selective enrichment, isolation media, purification media, confirmation
Counts/ prevalence	Findings of the trial	Initial concentration (log counts)/ prevalence, variability (Standard deviation/ standard error)

Section H: Extracted data for the systematic review meta-analysis on the effectiveness of processing interventions along broilers abattoirs on *Campylobacter* spp.,

ID	Sampling point	Intervention type	Technique	Exposed part	Type of analysed sample	Conc / prev	*Campylobacter* spp.
A21	Pre-Scalding	Physical decontamination	Additional washers- pre-scald brush washer (conventional)	WC	WCR	Conc	(0.46)
A45	Pre-Scalding	Washing→ squeezing	mechanical compression to induce defecation of carcasses	WC	WCR	Conc	0.30
A45	Pre-Scalding	Squeezing **plus** washing	mechanical compression to induce defecation of carcasses plus washing with tap water (6.8 L/min at 276 kPa, 0.5 liter per carcass)	WC	WCR	Conc	0.30
A3	Scalding	No treatment→ Sterile water	cloaca treatment during defeathering	Cloaca vent	Breast swabs	Conc	(0.20)
A3	Scalding	No treatment→ distilled white vinegar	cloaca treatment during defeathering	Cloaca vent	Breast swabs	Conc	(1.90)
A5	Scalding	Control pH(6.88) →high pH (9.89)	↑pH using lime slurry (calcium hydroxide)	WC	WCR	Conc	(0.71)
A5	Scalding	Control pH(6.88) →high pH (9.89)	↑pH using lime slurry (calcium hydroxide)	WC	WCR	Prev	(44.44)
A17	Defeathering	Increase temperature of scald water	↑ scald water temperature: 53 C → 53.9 ± 0.1 C (for 3 min in a counter current scalder)	WC	WCR	Conc	(2.80)
A2	Defeathering	Chlorine dioxide spray	portable water→50 ppm of ClO2	WC	WC	Conc	(1.04)
A34	Defeathering	Prepick evisceration	evisceration by hand	WC	breast swab	Conc	(2.21)
A34	Defeathering	vent plug	vent plug using commercial canned expanding foam	cloaca	breast swab	Conc	(0.21)
A34	Defeathering	Upside-Down Hang	rehung carcass on the shackle by the neck and wings, head facing up and vent facing down	WC	breast swab	Conc	(0.28)
A43	Defeathering	Acetic acid	control water→1 M acetic acid, 12 ml	cloaca	breast skin swab	Conc	(2.03)
A43	Defeathering	Lactic acid	control water→1 M lactic acid, 12 ml	cloaca	breast skin swab	Conc	(1.23)

A43	Defeathering	Propionic acid	control water→1 M propionic acid, 12 ml	cloaca	breast skin swab	Conc	(1.51)
A48	Defeathering	plugged and sutured cloaca	Control→ plugged and sutured cloaca	cloaca	Breast swab	Conc	(1.70)
A48	Defeathering	plugged and sutured cloaca	Control→ plugged and sutured cloaca	cloaca	Breast swab	Prev	(88.20)
A5	Defeathering	High chlorine dip	High chlorine dip (83.3 mg/kg), high pH scalding (mean pH 9.89)→High chlorine dip (83.3 mg/kg), normal pH scalding (mean pH 6.04)	WC	WC	Conc	(0.66)
A15	Post-Defeathering	Hot water post-plucking dip	delayed (30 min after defeathering) immersion rescald treatment of 28 s at 60 ± 1 C	WC	WCR	Conc	(0.50)
A15	Post-Defeathering	Hot water post-plucking Spray	delayed (30 min after defeathering) spray rescald treatment of 20 s at 73 ± 1 C	WC	WCR	Conc	(0.10)
A15	Post-Defeathering	Hot water post-plucking dip	immediate immersion rescald treatment of 28 s at 60 ± 1 C	WC	WCR	Conc	0.00
A15	Post-Defeathering	Hot water post-plucking Spray	immediate spray rescald treatment of 20 s at 70 ± 2 C	WC	WCR	Conc	(0.40)
A17	Post-Defeathering	Additional spray wash	additional outside spray (3 secs) after defeathering (100 kPa, 400 l per hour)	WC	WCR	Conc	2.30
A21	Post-Defeathering	Additional washers	post-defeathering spray washer	WC	WCR	Conc	(0.12)
A39	Post-Defeathering	trisodium phosphate- pre pluck	distilled water control → 5% w/v TSP	cloaca	swab	Conc	0.13
A39	Post-Defeathering	trisodium phosphate- pre pluck	distilled water control → 10% w/v TSP	cloaca	swab	Conc	(0.06)
A39	Post-Defeathering	trisodium phosphate- pre pluck	distilled water control → 20% w/v TSP	cloaca	swab	Conc	(0.18)
A39	Post-Defeathering	citric acid- pre pluck	distilled water control → 1% w/v citric acid	cloaca	swab	Conc	0.03
A39	Post-Defeathering	citric acid- pre pluck	distilled water control → 5% w/v citric acid	cloaca	swab	Conc	(0.37)

A39	Post-Defeathering	citric acid- pre pluck	distilled water control → 10% w/v citric acid	cloaca	swab	Conc	(0.55)
A39	Post-Defeathering	lactic acid- pre pluck	distilled water control → 1% w/v lactic acid	cloaca	swab	Conc	0.00
A39	Post-Defeathering	lactic acid- pre pluck	distilled water control → 5% w/v lactic acid	cloaca	swab	Conc	(0.33)
A39	Post-Defeathering	lactic acid- pre pluck	distilled water control → 10% w/v lactic acid	cloaca	swab	Conc	(0.53)
A5	Post-Defeathering	High chlorine dip + high pH scald	High chlorine dip (83.3 mg/kg) after normal pH scalding (mean pH 6.04) →High chlorine dip (83.3 mg/kg) after high pH scald (mean pH 9.89)	WC	WC	Prev	(32.22)
A12	Evisceration	External or internal visible fecal contamination	External→Internal contamination, followed by similar IOCW	medial surface of the sternum	WCR	Conc	(1.00)
A12	Evisceration	External or internal visible fecal contamination	1.0 g cecal content on breast skin, then left for 10 mins at room temperature, then washed off at IOBW	Breast skin	WCR	Prev	8.33
A12	Evisceration	External or internal visible fecal contamination	1.0 g cecal content on medial surface of the sternum, then left for 10 mins at room temperature, then washed off at IOBW	medial surface of the sternum	WCR	Prev	(25.00)
A17	Evisceration	Additional spray wash	additional outside spray (3 secs) after defeathering (100 kPa, 400 l per hour)	WC	WCR	Conc	0.90
A17	Evisceration	Increase temperature of scald water	53 C → 53.9 ± 0.1 C (for 3 min in a counter current scalder)	WC	WCR	Conc	(0.30)
A34	Evisceration	Pre-scald evisceration	hand evisceration after bleeding befoore scalding	WC	breast swab	Conc	(2.45)
A46	Evisceration	Pre-evisceration skin removal	Skin on→skin off (skin removal prior to evisceration using sterile scapel, then eviscerated and inside-outside wash done using spray wash)	surface skin	WCR	Conc	(1.60)

A46	Evisceration	Pre-evisceration skin removal	Skin on→skin off (skin removal prior to evisceration using sterile scapel, then eviscerated and inside-outside wash done using spray wash)	surface skin	inside carcass swab	Conc	(0.10)
A46	Evisceration	Pre-evisceration skin removal	Skin on→skin off (skin removal prior to evisceration using sterile scapel, then eviscerated and inside-outside wash done using spray wash)	surface skin	outside carcass swabs	Conc	(0.40)
A46	Evisceration	Pre-evisceration skin removal	skin removal prior to evisceration using sterile scapel, then eviscerated and inside-outside wash done using spray wash	surface skin	inside carcass swab	Prev	0.00
A46	Evisceration	Pre-evisceration skin removal	skin removal prior to evisceration using sterile scapel, then eviscerated and inside-outside wash done using spray wash	surface skin	outside carcass swabs	Prev	(53.33)
A6	Evisceration	Steam and ultrasound treatment	Steam (90–94 °C) and ultrasound at 30–40 kHz for 15-20 mins after evisceration	WC	Breast skin	Conc	(0.86)
A6	Evisceration	Steam and ultrasound treatment	Steam (90–94 °C) and ultrasound at 30–40 kHz for 15-20 mins after evisceration then 80 mins air chill	WC	Breast skin	Conc	(1.11)
A6	Evisceration	Steam and ultrasound treatment	Steam (90–94 °C) and ultrasound at 30–40 kHz for 15-20 mins after evisceration	WC	Breast skin	Conc	(0.78)
A6	Evisceration	Steam and ultrasound treatment	Steam (90–94 °C) and ultrasound at 30–40 kHz for 15-20 mins after evisceration then 80 mins air chill	WC	Breast skin	Conc	(0.56)
A26	Post-Evisceration	Steam + ultrasound	Steam + ultrasound	WC	WCR	Conc	2.51
A35	Post-Evisceration	steam pasteurization-12 secs	Steam temperature: 90 C in three stage: water removal, steam application and cold water spraying	WC	Breast skin swab	Conc	(0.46)
A35	Post-Eviscera	steam pasteurization-	Steam temperature: 90 C in three stage: water	WC	Breast skin swab	Conc	(1.30)

	tion	24 secs	removal, steam application and cold water spraying				
A35	Post-Evisceration	steam pasteurization-12 seconds	Steam temperature: 90 C in three stage: water removal, steam application and cold water spraying	WC	Breast skin swab	Prev	0.00
A35	Post-Evisceration	steam pasteurization-24 seconds	Steam temperature: 90 C in three stage: water removal, steam application and cold water spraying	WC	Breast skin swab	Prev	(30.00)
A35	Post-Evisceration	steam pasteurization-12 seconds	Steam temperature: 90 C in three stage: water removal, steam application and cold water spraying	WC	visceral cavity swab	Prev	(10.00)
A35	Post-Evisceration	steam pasteurization-24 seconds	Steam temperature: 90 C in three stage: water removal, steam application and cold water spraying	WC	visceral cavity swab	Prev	(30.00)
A39	Post-Evisceration	trisodium phosphate- pre pluck	distilled water control →5% w/v TSP	cloaca	swab	Conc	(0.51)
A39	Post-Evisceration	trisodium phosphate- pre pluck	distilled water control →10% w/v TSP	cloaca	swab	Conc	(0.54)
A39	Post-Evisceration	trisodium phosphate- pre pluck	distilled water control →20% w/v TSP	cloaca	swab	Conc	(0.72)
A39	Post-Evisceration	citric acid- pre pluck	distilled water control →1% w/v citric acid	cloaca	swab	Conc	(0.11)
A39	Post-Evisceration	citric acid- pre pluck	distilled water control →5% w/v citric acid	cloaca	swab	Conc	(0.82)
A39	Post-Evisceration	citric acid- pre pluck	distilled water control →10% w/v citric acid	cloaca	swab	Conc	(0.74)
A39	Post-Evisceration	lactic acid- pre pluck	distilled water control →1% w/v lactic acid	cloaca	swab	Conc	(0.63)
A39	Post-Evisceration	lactic acid- pre pluck	distilled water control →5% w/v lactic acid	cloaca	swab	Conc	(0.90)
A39	Post-Evisceration	lactic acid- pre pluck	distilled water control →10% w/v lactic acid	cloaca	swab	Conc	(0.66)

A16	Inside-Outside wash	Trimming using a knife→ High pressure spray (HPS)	Carcass with visible gastrointestinal contamination. HPS- 1.5 L of potable water per carcass (0.5 to 2.0 ppm of chlorine) with 10 kgf/cm2 of pressure	external and/or internal surfaces	WCR	Prev	(11.69)
A16	Inside-Outside wash	High pressure spray (HPS)	Carcass with NO visible gastrointestinal contamination: HPS- 1.5 L of potable water per carcass (0.5 to 2.0 ppm of chlorine) with 10 kgf/cm2 of pressure	external and/or internal surfaces	WCR	Prev	(6.88)
A21	Inside-Outside wash	Additional washers	pre IOBW spray washer	WC	WCR	Conc	(0.66)
A21	Inside-Outside wash	Additional washers	post IOBW brush washer	WC	WCR	Conc	(0.06)
A25	Inside-Outside wash	electrolyzed oxidizing water spray	EO (electrolyzed oxidising water) pH 2.4, oxidation reduction potential of 1,180 mV containing 50 mg/L of total chlorine	WC	WCR	Conc	(1.90)
A25	Inside-Outside wash	sodium hypochlorite spray	50 mg/L of HOCl solution (pH 8.0)	WC	WCR	Conc	(1.60)
A54	Inside-Outside wash	Chlorine Conc and Water Temperature (spray washers)	0 ppm→50 ppm Chlorine, water temperature 21.1°C	WC	WCR	Conc	0.30
A54	Inside-Outside wash	Chlorine Conc and Water Temperature (spray washers)	0 ppm→50 ppm Chlorine, water temperature 43.3°C	WC	WCR	Conc	(0.40)
A54	Inside-Outside wash	Chlorine Conc and Water Temperature (spray washers)	0 ppm→50 ppm Chlorine, water temperature 54.4°C	WC	WCR	Conc	(0.20)
A7	Inside-Outside wash	acidified sodium chlorite Spray- 30 seconds	Portable water → ASC (1,000 ppm at a pH range 2.39 and 2.67)	WC	breast skin	Conc	(1.09)
A7	Inside-Outside wash	chlorine dioxide Spray- 30 seconds	Portable water → ClO2 (tank conc of 9.03 ppm (SD=3.78). Spray nozzles conc of 6.48 ppm (SD=1.45).	WC	Breast skin	Conc	0.06

A7	Inside-Outside wash	peroxyacetic acid Spray - 30 seconds	Portable water → PAA (400 ppm of peracetic acid, 1,600 ppm of hydrogen peroxide and 800 ppm of acetic acid.)	WC	Breast skin	Conc	(0.96)
A7	Inside-Outside wash	trisodium phosphate Spray - 30 seconds	Portable water → TSP (High pH 12.4)	WC	Breast skin	Conc	(1.18)
A7	Inside-Outside wash	acidified sodium chlorite Spray - 30 seconds	Portable water → 1,000 ppm ASC (pH range 2.39 and 2.67	WC	Neck skin	Conc	(1.20)
A7	Inside-Outside wash	chlorine dioxide Spray - 30 seconds	Portable water → Chlorine dioxide (tank conc 9.03 ppm, Spray nozzles conc 6.48 ppm	WC	Neck skin	Conc	0.55
A7	Inside-Outside wash	peroxyacetic acid Spray - 30 seconds	Portable water → 400 ppm of PAA, 1,600 ppm of hydrogen peroxide and 800 ppm of acetic acid.	WC	Neck skin	Conc	(0.57)
A7	Inside-Outside wash	trisodium phosphate Spray - 30 seconds	Portable water → TSP (pH 12.4)	WC	Neck skin	Conc	(2.01)
A7	Inside-Outside wash	acidified sodium chlorite spray – 15 seconds	Portable water → ASC 1,000 ppm at a pH range 2.39 and 2.67	WC	Breast skin	Conc	(0.82)
A7	Inside-Outside wash	peroxyacetic acid spray – 15 seconds s	Portable water → 400 ppm PAA (1,600 ppm of hydrogen peroxide and 800 ppm of acetic acid.	WC	Breast skin	Conc	(0.78)
A7	Inside-Outside wash	trisodium phosphate spray – 15 seconds	Portable water → TSP (pH 12.4)	WC	Breast skin	Conc	(0.55)
A7	Inside-Outside wash	acidified sodium chlorite spray – 15 seconds	Portable water → ASC 1,000 ppm at a pH range 2.39 and 2.67	WC	Neck skin	Conc	(1.22)
A7	Inside-Outside wash	peroxyacetic acid spray – 15 seconds	Portable water → 400 ppm of PAA, 1,600 ppm of hydrogen peroxide and 800 ppm of acetic acid.	WC	Neck skin	Conc	(0.73)
A7	Inside-Outside wash	trisodium phosphate spray – 15 seconds	Portable water → TSP (pH 12.4)	WC	Neck skin	Conc	(1.13)
A24	Post-Inside-Outside wash	Trisodium phosphate immersion – 15 seconds	portable water→10% (wt/vol) TSP	WC	neck skin	Conc	(1.16)

A40	Post-Inside-Outside wash	acidified sodium chlorite	offline reprocessing→ online continuous spray wash of visibly contaminated carcasses with visble fecal and ingesta	WC	WCR	Conc	(1.75)
A40	Post-Inside-Outside wash	acidified sodium chlorite	offline reprocessing→ online continuous spray wash of visibly contaminated carcasses with visble fecal and ingesta	WC	WCR	Prev	(24.10)
A44	Post-Inside-Outside Wash	lactic acid - spray tunnel	1.9% lactic acid, pH 3.9, flow rate 10400 g per min, time 7 sec	WC	breast skin swab	Conc	0.20
A44	Post-Inside-Outside Wash	lactic acid - spray tunnel	1.9% lactic acid, pH 3.9, flow rate 10400 g per min, time 7 sec	WC	breast skin swab	Conc	0.12
A44	Post-Inside-Outside Wash	lactic acid - spray tunnel	4.0 % lactic acid, pH 4.0, flow rate 29700 g per min, time 7 sec	WC	breast skin swab	Conc	0.05
A44	Post-Inside-Outside Wash	lactic acid- Hand held Electrostatic sprayer (ESS) quick	4.0 % lactic acid, pH 4.0, flow rate 184 g per min, time 21 sec	WC	breast skin swab	Conc	(0.12)
A44	Post-Inside-Outside Wash	lactic acid- Hand held Electrostatic sprayer (ESS) quick	4.0 % lactic acid, pH 4.0, flow rate 184 g per min, time 5 sec	WC	breast skin swab	Conc	0.48
A44	Post-Inside-Outside Wash	lactic acid- Hand held Electrostatic sprayer (ESS) slow	4.0 % lactic acid, pH 4.0, flow rate 184 g per min, time 21 sec	WC	breast skin swab	Conc	(0.22)
A44	Post-Inside-Outside Wash	lactic acid- Tunnel spray	4.0 % lactic acid, pH 3.9, flow rate 12500 g per min, time 7 sec	WC	breast skin swab	Conc	(0.43)
A44	Post-Inside-Outside Wash	lactic acid- Hozelock spray	8.0 % lactic acid, pH 3.9, flow rate 790 g per min, time 21 sec	WC	breast skin swab	Conc	(1.94)
A20	Pre-Chilling	cationic disinfectant spray	cetylpyridinium chloride	WC	WCR	Conc	(1.56)

A20	Pre-Chilling	cationic disinfectant spray	cetylpyridinium chloride	WC	WCR	Prev	(87.59)
A21	Pre-Chilling	Additional washers	Pre-chill spray washer	WC	WCR	Conc	(0.06)
A10	Chilling	Immersion vs air chilling	ice and potable water mixture (approximately 0.6 C), 2 rpm, 50-min → continuous flow of air with velocity 3.5 m/s, air less than 0 C, for 150 mins	WC	WCR	Conc	(0.40)
A11	Chilling	Electrolyzed NaCl + overnight post-chill refrigeration	Plan water (0.1ppm free Cl, pH 7.5, redox 436mV→electrolyzed NaCl (1.2ppm free Cl, redox=574-697mV) ***Spray (during chilling)***	WC	Breast swab	Conc	(0.35)
A11	Chilling	Electrolyzed water + overnight post-chill refrigeration	Plain water→electrolysed sodium chloride,2 pipes each with flow rate 786 g/min for 1 min, free cholorine= 0.2, pH=8.5, redox=790mV ***Spray-(Post Inside Outside wash)***	WC	Breast swab	Conc	0.29
A11	Chilling	Electrolyzed water + overnight post-chill refrigeration	Plain water→electrolysed sodium carbonate, 2 pipes each with flow rate 786 g/min for 1 min, free cholorine= 0.2, pH=11.3, redox=15mV ***Spray- (Post Inside Outside wash)***	WC	Breast swab	Conc	(0.20)
A11	Chilling	Electrolyzed NaCl + overnight post-chill refrigeration	2 electrolyzed NaCl sprays; first post-pluck (16.7ppm Cl, pH 7.3, redox 792mV) then second pre-chill (18.4ppm Cl, pH 7.3, redox 825mV). 0.5 ppm ClO2 spray. ***Spray-(Post-Pluck and Post-Inside Outside Wash)***	WC	Breast swab	Conc	0.01
A17	Chilling	Additional spray wash	additional outside spray after defeathering (100 kPa, 400 l per hour)	WC	WCR	Conc	1.20

A17	Chilling	Increase temperature of scald water	53 C → 53.9 ± 0.1 C (for 3 min in a counter current scalder)	WC	WCR	Conc	(0.20)
A18	Chilling	immersion →air chilling	three-stage countercurrent immersion chiller for a total time of 85 min. 1st stage water at 17.2°C, second stage water at 5.6 to 6.7°C, and third stage water at -1.1 to 0°C. Chlorine in chiller approximately 40 ppm.→120 min in an air-chilling room in two stages, with temperatures of -7.7 to -5.5°C and -4.4 to -1.1°C, respectively.	WC	WCR	Prev	(9.40)
A20	Chilling	Air → immersion	150 mins at 1.0 m/s cold (1.0 +/- 0.2 C) after disinfection with cetylpyridinium chloride → 50 mins; Total chlorine conc in the chilling water (50- 90 ppm), free chlorine (0.4-0.8 ppm), water temperature 0.5 +/- 0.4 C	WC	WCR	Conc	(0.40)
A20	Chilling	Air → immersion	150 mins at 1.0 m/s cold (1.0 +/- 0.2 C) after disinfection with cetylpyridinium chloride→50 mins; Total chlorine conc in the chilling water (50-90 ppm), free chlorine (0.4- 0.8 ppm), water temperature 0.5 +/- 0.4 C	WC	WCR	Prev	(16.13)
A23	Chilling	Air → immersion	air velocity 3.6 m/min, temperature of 0°C and RH of 72%, chilling time 120 min →0.5 to 1.1°C water with 5 mg/kg of free chlorine with birds exposed to air agitation during the first 25 min. total immersion	WC	WCR	Conc	(2.01)

			time 80 min				
A23	Chilling	Air → immersion	air velocity 3.6 m/min, temperature of 0°C and RH of 72%, chilling time 120 min →0.5 to 1.1°C water with 5 mg/kg of free chlorine with birds exposed to air agitation during the first 25 min. total immersion time 80 min → Step 1: 4 tanks with temp at 8, 5, 5, and 2°C, respectively. Time 20 s (1st tank), 40 s (2nd tank), 80 s (3rd tank), and 80 s (4th tank). Drain time between tanks 30, 60, and 60 s. Step 2: air chill- velocity 3.6 m/min, 0°C and RH of 72%, for 120 mins	whole chicken	WCR	Conc	(0.55)
A23	Chilling	immersion → Immersion-air combi	0.5 to 1.1°C water with 5 mg/kg of free chlorine with birds exposed to air agitation during the first 25 min. total immersion time 80 min → Step 1: 4 tanks with temp at 8, 5, 5, and 2°C, respectively. Time 20 s (1st tank), 40 s (2nd tank), 80 s (3rd tank), and 80 s (4th tank). Drain time between tanks 30, 60, and 60 s. Step 2: air chill- velocity 3.6 m/min, 0°C and RH of 72%, for 120 mins	WC	WCR	Conc	1.46
A23	Chilling	Air→immersion	0.5 to 1.1°C water with 5 mg/kg of free chlorine with birds exposed to air agitation during the first 25 min. total immersion time 80 min	WC	WCR	Prev	(40.00)
A23	Chilling	Air→Immersion -air combi	air velocity 3.6 m/min, temperature of 0°C and RH of 72%, chilling time 120 min	whole chicken	WCR	Prev	11.53

A23	Chilling	Immersion→Immersion-air combi	Step 1: 4 tanks with temp at 8, 5, 5, and 2°C, respectively. Time 20 s (1st tank), 40 s (2nd tank), 80 s (3rd tank), and 80 s (4th tank). Drain time between tanks 30, 60, and 60 s. Step 2: air chill- velocity 3.6 m/min, 0°C and RH of 72%, for 120 mins	WC	WCR	Prev	51.53
A26	Chilling	Forced air chilling	forced air chiller on a continuous shackle line for 3 h to obtain an outer carcass temperature of approximately 3C.	WC	WCR	Conc	0.44
A28	Chilling	Air → immersion	refrigerated room (1°C) with a series of 3 circulation fans, for 150 min, air velocity 76.2 m/min, Relative humidity between 79.4 to 87.6% RH (ave. RH 81.6%)→ paddle-agitated chill tank filled with 151 L ice and tap water (average total chlorine level of 0.5 mg/L) for 50 min	WC	Half carcass rinse	Conc	(0.59)
A36	Chilling	chlorine stabilizers immersion	chlorine treatment (pH 7.34, 51.9 ppm of free chlorine)	drummette	drummette rinse	Conc	(1.47)
A36	Chilling	chlorine stabilizers immersion	chlorine stabilizer (T-128) based on phosphoric acid–propylene glycol (pH 2.99, 0.00 ppm of free chlorine)	drummette	drummette rinse	Conc	(1.90)
A36	Chilling	chlorine stabilizers immersion	chlorine with chlorine stabilizer (T-128) based on phosphoric acid–propylene glycol (pH 3.59, 50.5 ppm of free chlorine)	drummette	drummette rinse	Conc	(2.05)
A36	Chilling	chlorine stabilizers immersion	chlorine treated with phosphoric acid–propylene glycol chlorine stabilizer (pH 3.55, 50.6 ppm of free chlorine)→Chlorine	drummette	drummette rinse	Conc	1.32

			treated with 0.01% H3PO4 (pH 3.42, 50.5 ppm of free chlorine)				
A4	Chilling	Chlorine drench volume	2.1 L/kg (low) → 16.8 L/kg (high) volume distilled water in bag	Half carcass	Half carcass rinse	Conc	(0.30)
A41	Chilling	rapid surface cooling	immersed pre-chill in liquid nitrogen- 2 seconds	breast skin	breast skin	Conc	(0.28)
A41	Chilling	rapid surface cooling	immersed pre-chill in liquid nitrogen- 10 seconds	breast skin	breast skin	Conc	(0.77)
A41	Chilling	rapid surface cooling	immersed pre-chill in liquid nitrogen- 20 seconds	breast skin	breast skin	Conc	(1.04)
A41	Chilling	rapid surface cooling	immersed pre-inside-outside wash in liquid nitrogen- 20 seconds	breast skin	breast skin	Conc	(1.30)
A41	Chilling	rapid surface cooling	immersed pre-chill in liquid nitrogen- 30 seconds	breast skin	breast skin	Conc	(0.04)
A41	Chilling	rapid surface cooling	fumigation with liquid nitrogen in a cabinet prechill- 120 seconds	WC	breast skin	Conc	0.81
A41	Chilling	rapid surface cooling	spray with liquid nitrogen in a cabinet post-chill- 120 seconds	WC	breast skin	Conc	(0.27)
A41	Chilling	rapid surface cooling	spray with liquid nitrogen in a cabinet pre-chill- 120 seconds	WC	breast skin	Conc	(0.09)
A47	Chilling	chiller water volume immersion	low volume chilling (3.3L per Kg →high volume chilling (6.7 L per Kg), distilled water, temperature 0.6 C, 45 minutes	WC halves	half carcass rinse	Conc	0.20
A50	Chilling	visible ingesta (immersion chiller)	chilled with visible ingesta→ chilled without visible ingesta	WC	WCR	Conc	(0.10)
A57	Chilling	Peracetic acid mixture	30 ppm chlorine→85 ppm of PAHP (peracetic acid and hydrogen peroxide)	WC	WCR	Prev	(26.00)
A60	Chilling	Fecal + cross contamination	fecal contamination→ no fecal contamination during immersion chilling	half carcass	half carcass rinse	Conc	0.10
A60	Chilling	Fecal contamination and cross	no fecal → fecal contamination during immersion chilling	half carcass	half carcass rinse	Prev	25.00

		contamination immersion					
A11	Post-Chilling	Electrolyzed NaCl + 7 day post-chill refrigeration	Plain water (0.1ppm free Cl, pH 7.5, redox 436mV→electrolyzed NaCl (1.2ppm free Cl, redox=574-697mV) ***Spray (during chilling)***	WC	Breast swab	Conc	(0.04)
A11	Post-Chilling	Electrolyzed water + 7 day post-chill refrigeration	Plain water→electrolysed sodium chloride,2 pipes each with flow rate 786 g/min for 1 min, free cholorine= 0.2, pH=8.5, redox=790mV; Refrigerated Storage= 7 days 4°C ***Spray- (Post Inside Outside wash)***	WC	Breast swab	Conc	0.04
A11	Post-Chilling	Electrolyzed water + 7 day post-chill refrigeration	Plain water→electrolysed sodium carbonate, 2 pipes each with flow rate 786 g/min for 1 min, free cholorine= 0.2, pH=11.3, redox=15mV; Refrigerated Storage= 7 days 4°C ***Spray- (Post Inside Outside wash)***	WC	Breast swab	Conc	0.10
A11	Post-Chilling	Electrolyzed NaCl + 7 day post-chill refrigeration	2 electrolyzed NaCl sprays; first post-pluck (16.7ppm Cl, pH 7.3, redox 792mV) then second pre-chill (18.4ppm Cl, pH 7.3, redox 825mV). 0.5 ppm ClO2 spray; Refrigerated = 7 days, 4°C ***Spray- (Post-Pluck and Post-Inside Outside Wash)***	WC	Breast swab	Conc	(0.10)
A26	Post-Chilling	Crust freezing ***Belt freezing***	continuous CO2 belt freezer (low temperature–freezing zone (-55C). Fillets crust frozen individually to an outer surface temperature of approximately -1C	skinless breast fillets	skinless breast rinse	Conc	0.42
A27	Post-Chilling	Chlorine	Portable water → 0.004% (40 ppm)	WC	WCR	Conc	(0.10)

		immersion	Chlorine- 20 seconds				
A27	Post-Chilling	peracetic acid ***immersion***	Portable water →0.04% (400 ppm) peracetic acid (PAA)- 20 seconds	WC	WCR	Conc	(1.30)
A27	Post-Chilling	peracetic acid *immersion*	Portable water →0.1% (1000 ppm) peracetic acid (PAA) - 20 seconds	WC	WCR	Conc	(1.40)
A27	Post-Chilling	Lysozyme *immersion*	Portable water →0.1% (1000 ppm) lysozyme- 20 seconds	WC	WCR	Conc	0.00
A27	Post-Chilling	Lysozyme immersion	Portable water →0.5% (5000 ppm) lysozyme- 20 seconds	WC	WCR	Conc	(0.30)
A41	Post-Chilling	rapid surface cooling	fumigation with liquid nitrogen in a cabinet prechill	WC	breast skin	Conc	0.86
A41	Post-Chilling	rapid surface cooling	spray with liquid nitrogen in a cabinet post-chill	WC	breast skin	Conc	(0.36)
A41	Post-Chilling	rapid surface cooling	spray with liquid nitrogen in a cabinet pre-chill	WC	breast skin	Conc	0.02
A51	Post-Chilling	Traditional versus modern processing	Traditional wet markets→ modern facilities	WC	Necks	Prev	(54.40)
A53	Post-Chilling	acidified sodium chlorite *immersion*	600 and 800 ppm sodium chlorite, pH 2.5 and 2.7, for 15 secs	WC	WCR	Conc	(0.92)
A53	Post-Chilling	acidified sodium chlorite *immersion*	600 and 800 ppm sodium chlorite, pH 2.5 and 2.7, for 15 secs	WC	WCR	Conc	(1.20)
A53	Post-Chilling	acidified sodium chlorite *immersion*	600 and 800 ppm sodium chlorite, pH 2.5 and 2.7, for 15 secs	WC	WCR	Prev	(87.50)
A53	Post-Chilling	acidified sodium chlorite *immersion*	600 and 800 ppm sodium chlorite, pH 2.5 and 2.7, for 15 secs	WC	WCR	Prev	(75.00)
A9	Post-Chilling	acidified sodium chlorite *immersion*	Control- No treatment → 900 mg/kg sodium chlorite, pH 2.5–2.6, acidified using citric acid	WC	WCR	Conc	(3.80)
A9	Post-Chilling	acidified sodium chlorite *immersion*	Control→900 mg/kg sodium chlorite, pH 2.5–2.6, acidified using citric acid	WC	WCR	Prev	(76.67)

ID	Author(s)
A1	(Kemp, Aldrich, & Waldroup, 2000)
A2	(Berrang, Meinersmann, Cox, & Fedorka-Cray, 2011)
A3	(Berrang, Smith, & Hinton, 2006a)
A4	(Northcutt, Cason, Smith, Buhr, & Fletcher, 2006)
A5	(Berrang, Windham, & Meinersmann, 2011)
A6	(Musavian, Krebs, Nonboe, Corry, & Purnell, 2014)
A7	(Purnell, James, James, Howell, & Corry, 2014)
A8	(Cavani, Schocken-Iturrino, Garcia, & Oliveira, 2010)
A9	(Sexton et al., 2007)
A10	(Huezo, Northcutt, Smith, Fletcher, & Ingram, 2007)
A11	(Burfoot, Mulvey, Jewell, Foy, & Howell, 2015)
A12	(Smith et al., 2007)
A13	(Shin et al., 2012)
A14	(Uyarcan & Kayaardı, 2018)
A15	(Berrang, Dickens, & Musgrove, 2000)
A16	(Giombelli et al., 2015)
A17	(Lehner, Reich, & Klein, 2014)
A18	(Sanchez et al., 2002)
A19	(Souza et al., 2012)
A20	(Zhang, Jeong, Janardhanan, Ryser, & Kang, 2011)
A21	(Berrang & Bailey, 2009)
A22	(Pacholewicz, Lipman, Swart, Havelaar, & Heemskerk, 2016)
A23	(Demirok et al., 2013)
A24	(Whyte, Collins, Mcgill, Monahan, & O ’mahony, 2001)
A25	(Northcutt, Smith, Ingram, Hinton, & Musgrove, 2007)
A26	(Boysen & Rosenquist, 2009)
A27	(Nagel, Bauermeister, Bratcher, Singh, & McKee, 2013)
A28	(Berrang, Meinersmann, Smith, & Zhuang, 2008)
A29	(Bartenfeld et al., 2014)
A30	(Singh, Lee, Silva, Chin, & Kang, 2017)
A31	(Cason, Buhr, & Hinton, 2001)
A32	(McKee, Townsend, & Bilgili, 2008)
A33	(Stopforth et al., 2007)
A34	(Berrang, Smith, & Meinersmann, 2011)
A35	(Whyte, McGill, & Collins, 2003)
A36	(Schambach, Berrang, Harrison, & Meinersmann, 2014)
A37	(Trindade, Kushida, Montes-Villanueva, dos Santos-Pereira, & de Oliveira, 2012)
A38	(S. M. Russell, 2008)
A39	(Meredith, McDowell, & Bolton, 2013)
A40	(Kemp, Aldrich, Guerra, & Schneider, 2001)
A41	(Burfoot et al., 2016)
A42	(Scott M. Russell & Axtell, 2005)
A43	(Berrang, Smith, & Hinton, 2006b)

A44	(Burfoot, Allen, et al., 2015)
A45	(Northcutt, McNeal, Ingram, Buhr, & Fletcher, 2008)
A46	(Berrang, Buhr, Cason, & Dickens, 2002)
A47	(Northcutt, Cason, et al., 2008)
A48	(Berrang, Buhr, Cason, & Dickens, 2001)
A49	(L. J. Bauermeister, Bowers, Townsend, & McKee, 2008)
A50	(Bilgili, Waldroup, Zelenka, & Marion, 2002)
A51	(Rejab, Zessin, Fries, & Patchanee, 2012)
A52	(Fabrizio, Sharma, Demirci, & Cutter, 2002)
A53	(Oyarzabal, Hawk, Bilgili, Warf, & Kemp, 2004)
A54	(Northcutt, Smith, Musgrove, Ingram, & Hinton, 2005)
A55	(Bourassa, Fletcher, Buhr, Cason, & Berrang, 2005)
A56	(Yang, Li, & Slavik, 1998)
A57	(Laura J. Bauermeister, Bowers, Townsend, & McKee, 2008)
A58	(Higgins et al., 2005)
A59	(Özdemir & Pamuk, 2006)
A60	(Smith, Cason, & Berrang, 2005)

Section I: Detailed results for each meta-analysis of the effects of decontamination interventions on *Campylobacter* spp. during primary processing of broiler

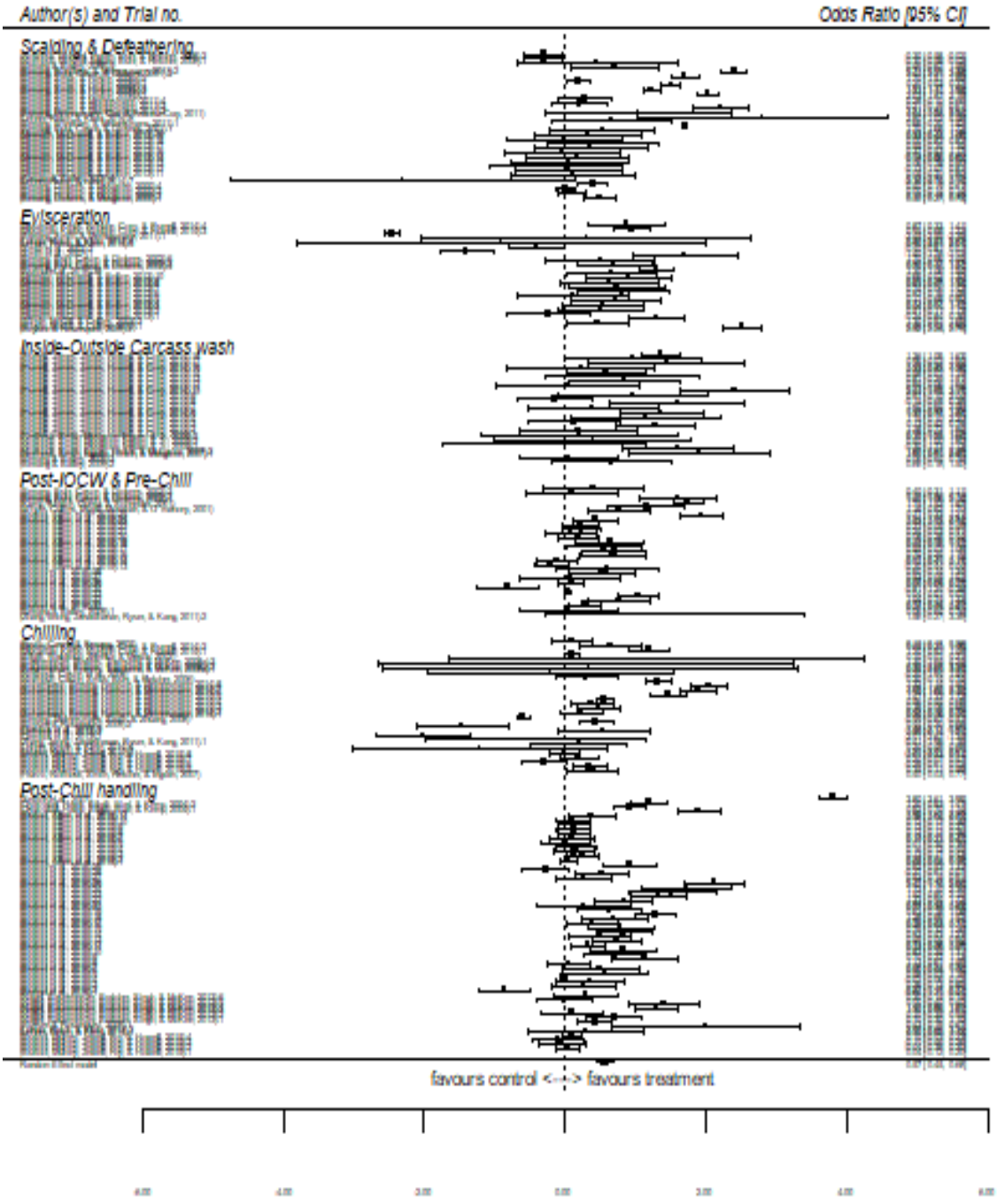


Figure 1: Illustrative Forest plots to represent the odds of *Campylobacter* spp. concentration reduction at different points along broiler chicken primary processing

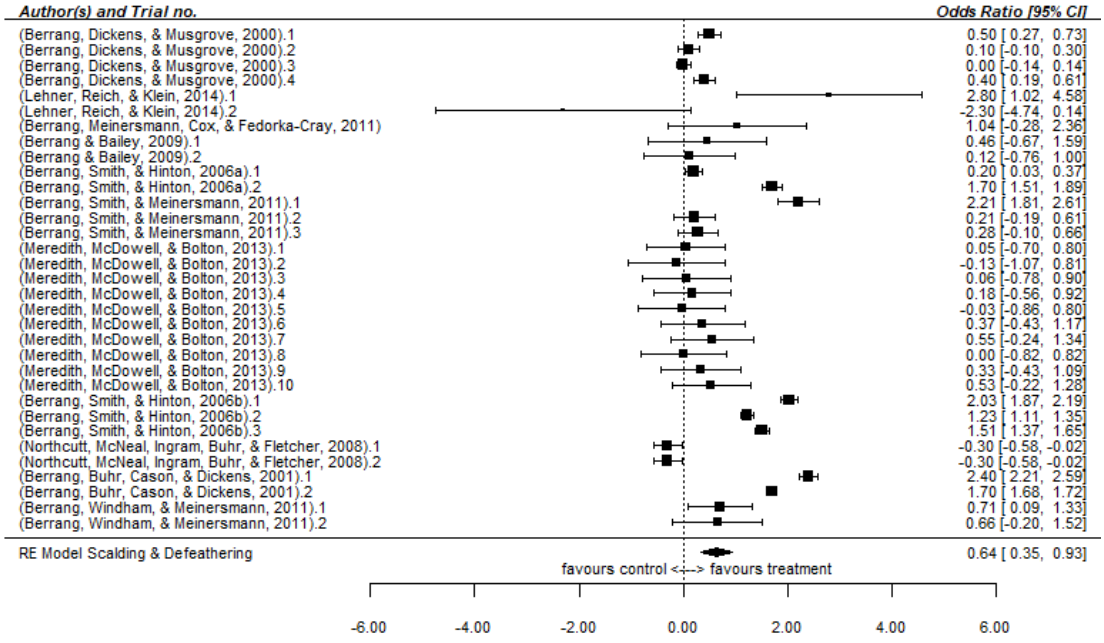


Figure 2a: Illustrative forest plot to represent the odds of Campylobacter spp. concentration reduction during scalding and defeathering

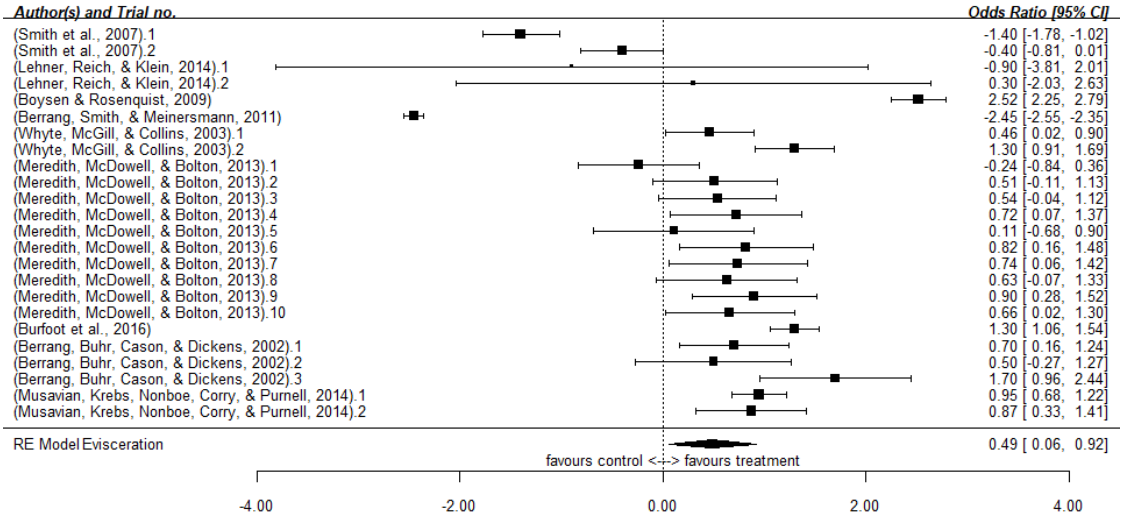


Figure 2b: Illustrative forest plot to represent the odds of Campylobacter spp. concentration reduction during evisceration

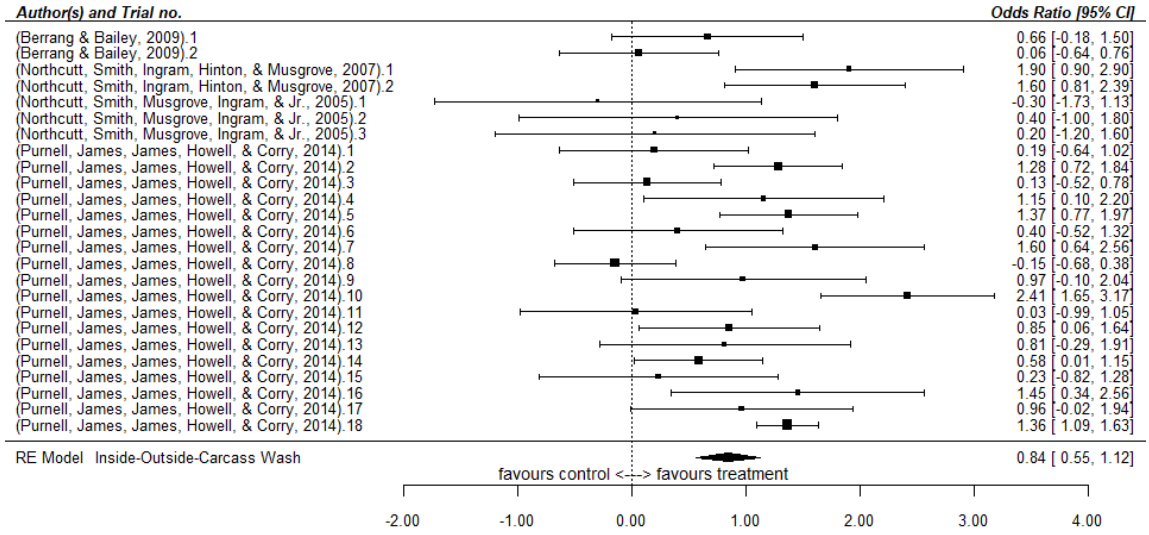


Figure 2c: Illustrative forest plot to represent the odds of Campylobacter spp. concentration reduction during inside-outside carcass wash

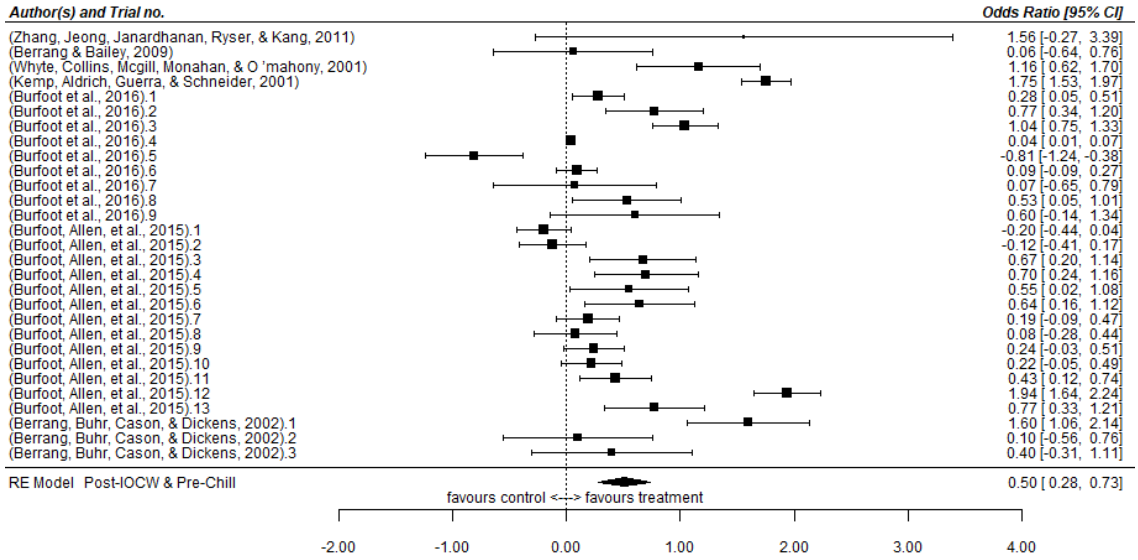


Figure 2d: Illustrative forest plots to represent the odds of Campylobacter spp. concentration reduction at post-Inside-Outside-Carcass-wash and Pre-chill

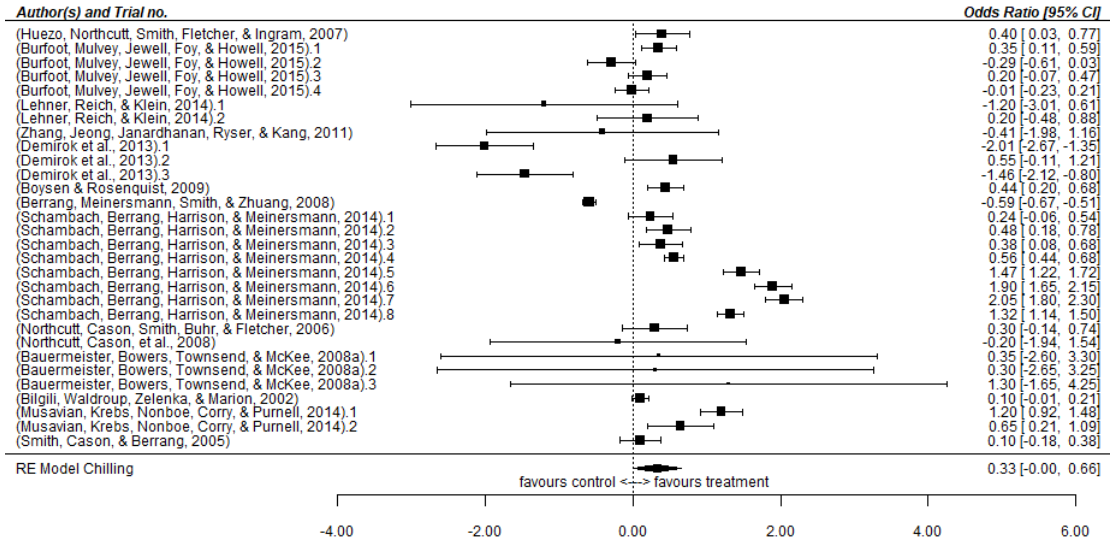


Figure 2e: Illustrative forest plots to represent the odds of Campylobacter spp. concentration reduction during chilling

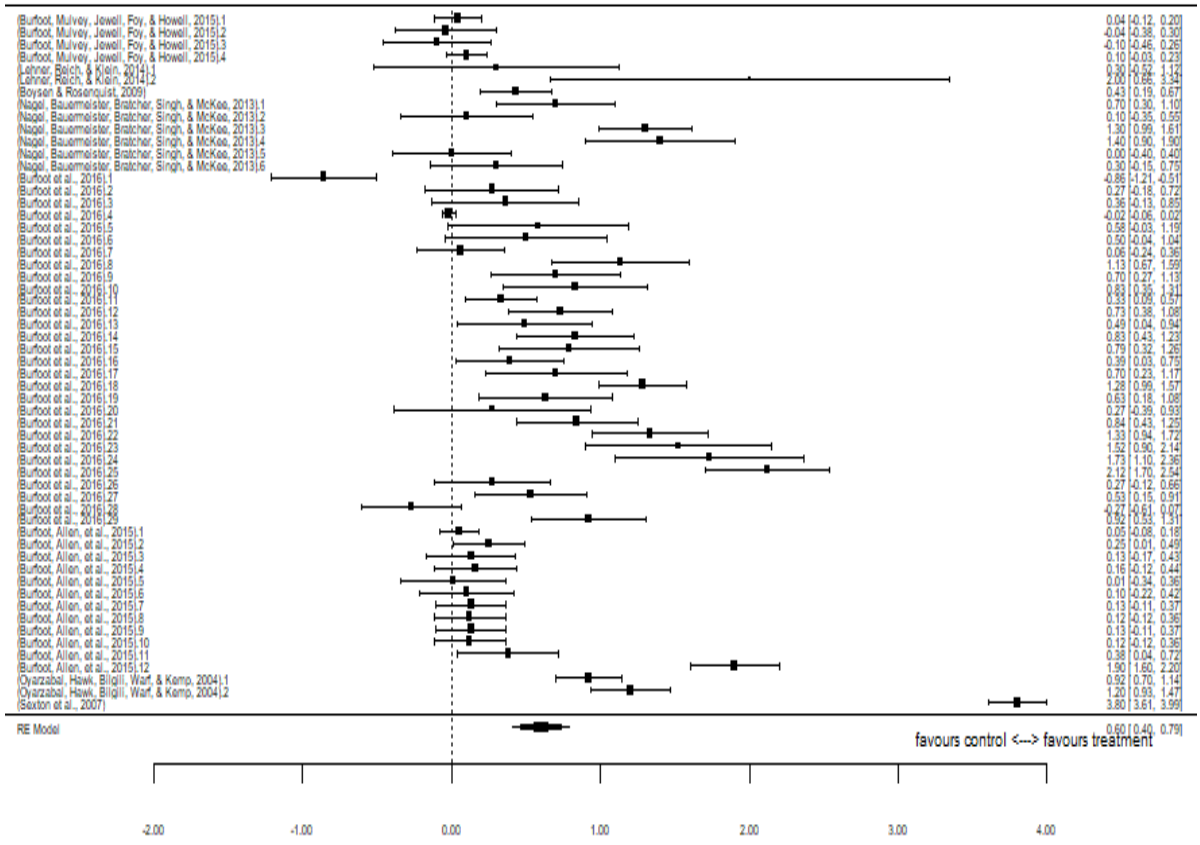
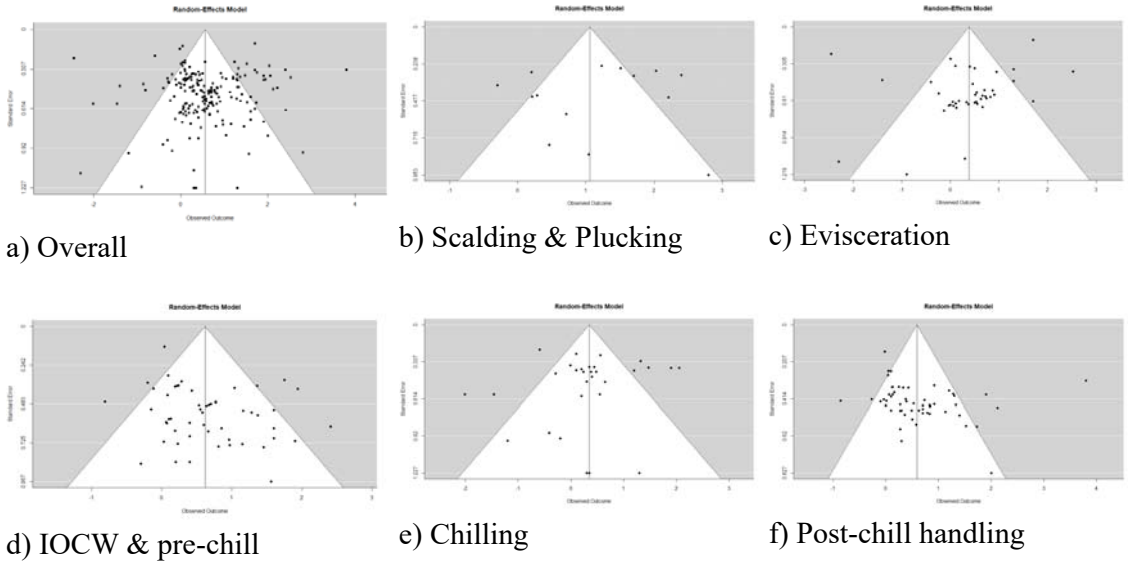


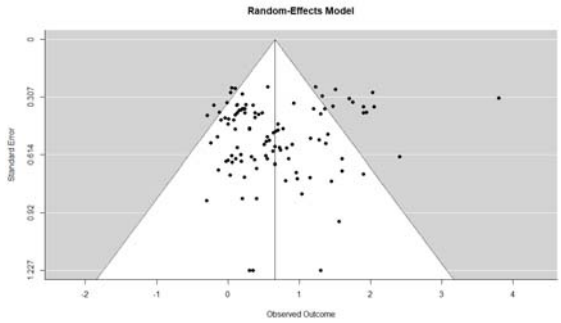
Figure 2f: Illustrative Forest plots to represent the odds of Campylobacter spp. concentration reduction post-chilling



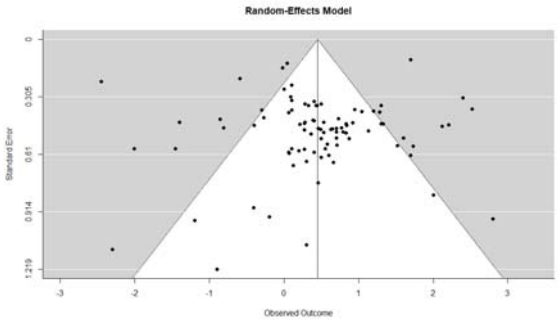
a) Overall b) Scalding & Plucking c) Evisceration

d) IOCW & pre-chill e) Chilling f) Post-chill handling

Figure 3 (a-f) Funnel plot to highlight publications bias on the effect of decontamination techniques on *Campylobacter* spp. concentration during broiler chicken primary processing

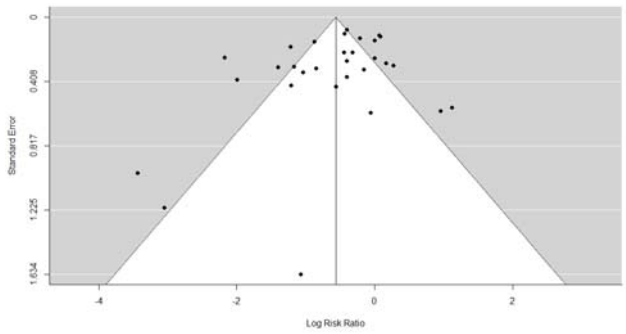


4a) Chemical decontamination techniques

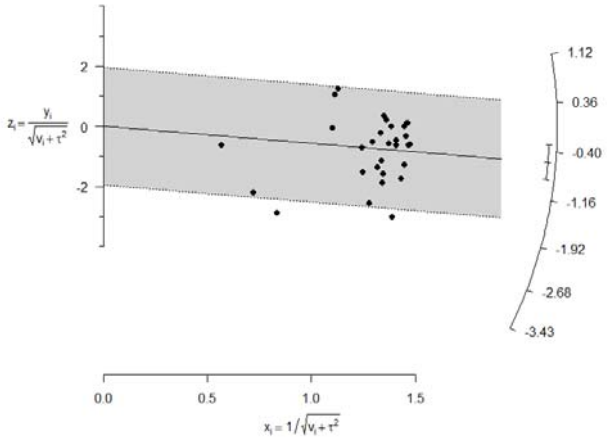


4b) Physical decontamination techniques

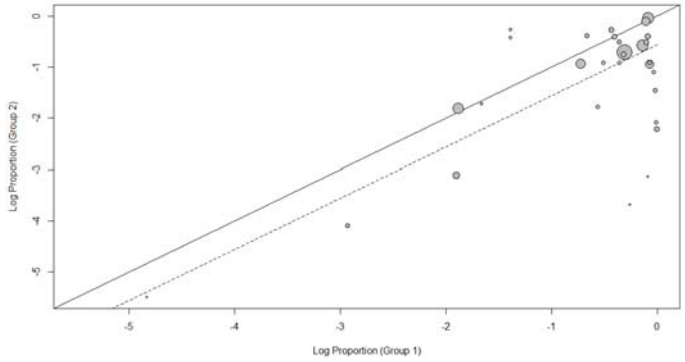
Figure 4(a-b): Funnel plot to compare publication bias between chemical and physical decontamination trials on *Campylobacter* spp. concentration during broiler chicken primary processing



5a) Funnel plot



5b) Radial plot



5c) L'Abbe plot

Figure 5(a-c): Funnel, radial and L'Abbe plots to bring out heterogeneity and publication bias within the *Campylobacter* spp. prevalence studies

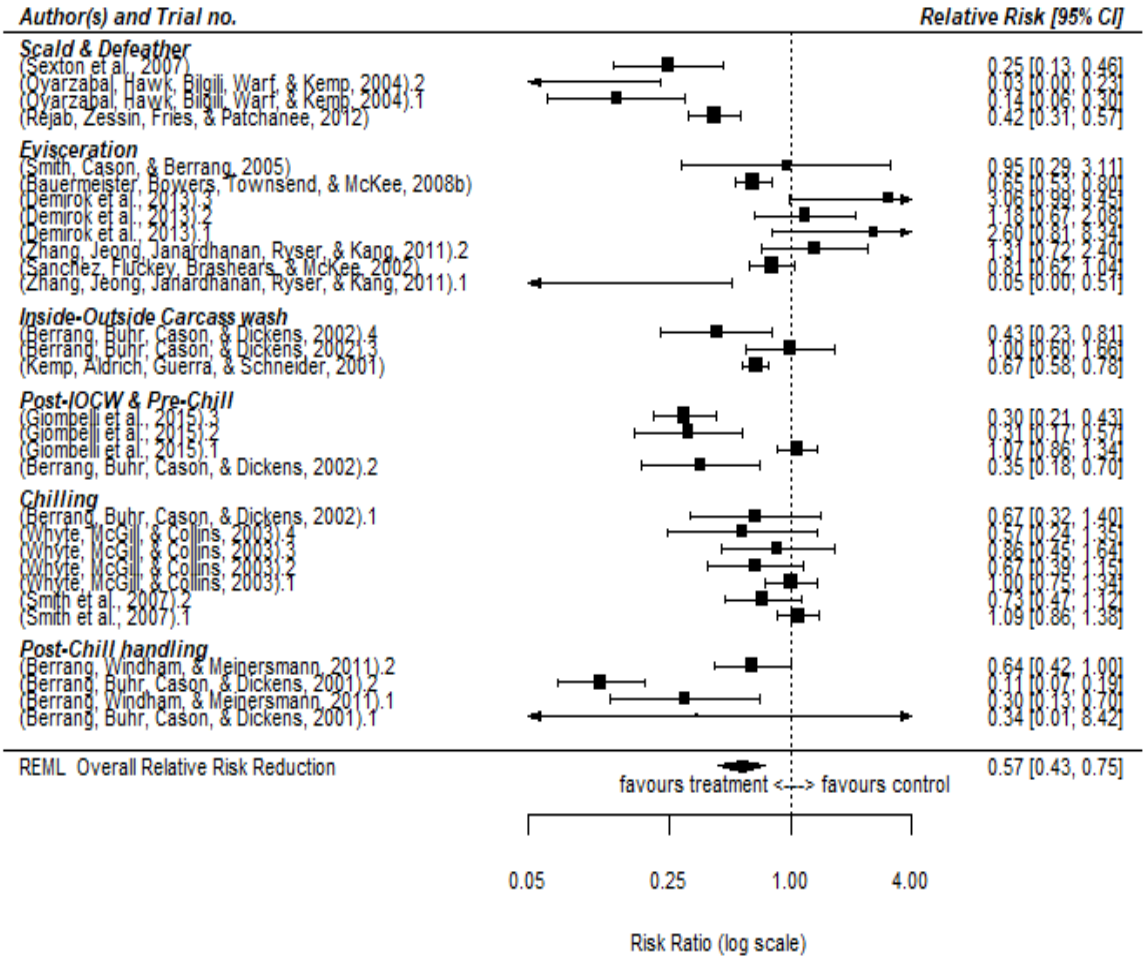


Figure 6: Forest plot to represent the relative risk of *Campylobacter* spp. prevalence reduction during broiler chicken primary processing

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