CA18105

RIBMINS

Risk-based meat inspection and integrated meat safety assurance

WG 3 - Abattoir level controls and risk categorisation of abattoirs

Nikolaos Dadios | 08. 04. 2022. | RIBMINS conference [Cordoba, Spain]

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the 2020 Framework Programme of the European Union

www.cost.eu

WG3 P11: Beef abattoir interventions in a risk-based meat safety assurance system: A systematic review and meta-analysis of the efficacy of interventions to reduce microbiological contamination of beef carcasses with *Escherichia coli*

Dragan Antic
[Univ. of Liverpool | UK]

John Tulloch
[Univ. of Liverpool | UK]

Catherine McCarthy
[DEFRA | UK]

Kurt Houf
[Univ. Gent | BE]

Bojan Blagojevic
[Univ. of Novi Sad | SRB]

Nikolaos Dadios
[RVC | UK]

WG3 Introduction

- Interventions at abattoir level to control microbiological hazards are an essential part of meat safety assurance systems
- Interventions:
  - GHP-based (pre-requisites at the pre-slaughter stage (e.g. lairage holding time and hide cleanliness assessment) and during slaughter and carcass dressing (e.g. bunging, rodding, hide removal methods, knife trimming, carcass washing, chilling);
  - Hazard-based – established efficacy on cattle hides and carcass meat surface (range of different interventions aimed at microbial removal, immobilisation and/or killing: hot water washing, steam pasteurisation, organic acid washes, other chemical washes)
- Priority hazards for control in beef: *Salmonella* and STEC
- Indicator microorganisms for process hygiene assessment: aerobic colony count (ACC), *Enterobacteriaceae* count (EBC), generic *E. coli* count (ECC)

WG3 specific objectives

- 3.1 Assessment of effectiveness of new tools | methods for detection of carcass contamination
- 3.2 Assessment of the significant intervention strategies and alternative methods for the slaughtering | the carcass dressing

Years 1 & 2

- 3.3 Assessment of the performance of food safety management systems
- 3.4 HEI in risk categorisation of abattoirs

Years 3 & 4

WG3 Task 3.2.1. Systematic review and Meta-analysis **beef** interventions

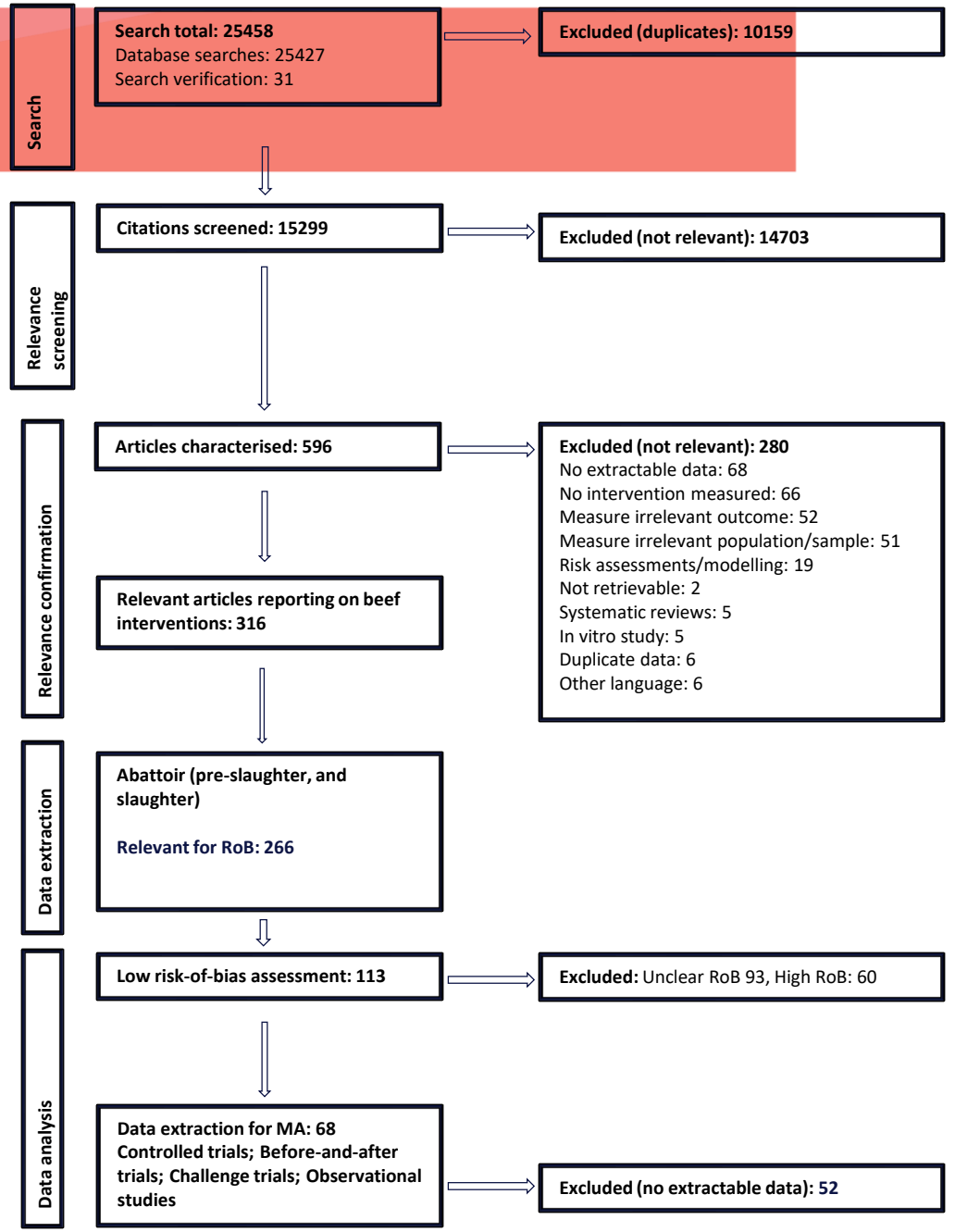
- **The task is finished**
- Literature searched 1996-2020 (25 years)
- Systematic review and meta-analysis performed
- Work spanned 2019-2021

Contributors

John Tulloch [UK]
Catherine McCarthy [UK]
Kurt Houf [BE]
Bojan Blagojevic [RS]
Nikolaos Dadios [UK]
Dragan Antic [UK]

WG3 Methodology

- Systematic review:
  - PICO framework,
  - From lairage to chilled carcasses
  - Scopus, CAB Direct, Agricola and PubMed (1996-2020)
  - All stages, two reviewers, third to resolve discrepancies
  - Risk of bias performed to determine which studies are suitable for meta-analysis
- Meta-analysis:
  - Data stratified by study design/conditions, intervention (sub)category, outcomes and measures (prevalence, concentration: mean log CFU)
  - Meta-analysis performed when an intervention group had three or more trials with a low risk of bias
  - A mixed-effects model was used to create pooled summary statistics and then presented as Forest plots.
  - Tests for heterogeneity of study groups were performed.



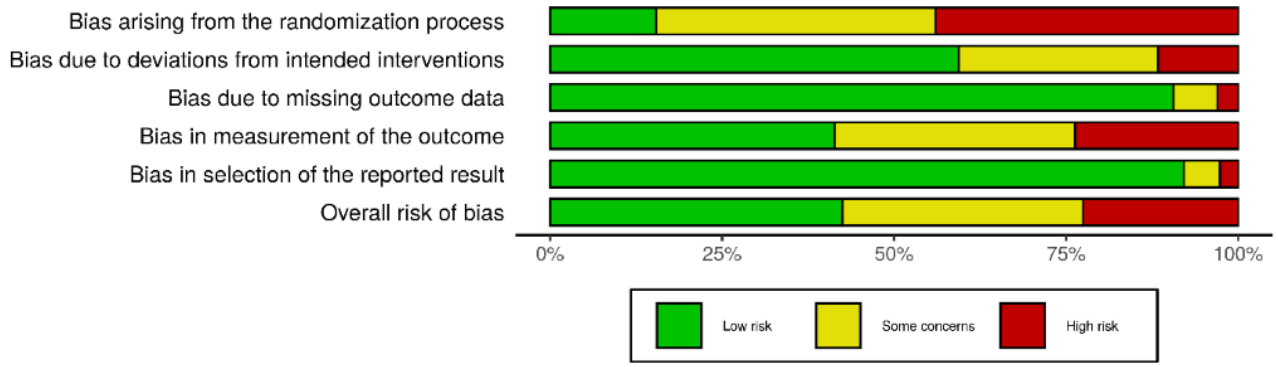
WG3 Results – systematic review

- **266** relevant studies on beef interventions at pre-slaughter and slaughter stage
- Low RoB 113
- Only **68** with extractable data useful for meta-analysis

Article characteristic	No of articles out of 266 (%)
Study design	
Challenge trial	143 (54%)
Before-and-after trial	87 (33%)
Controlled trial	36 (13%)
Observational study	18 (7%)
Study conditions	
Laboratory conditions	124 (47%)
Commercial abattoir conditions	115 (43%)
Research/pilot plant	39 (15%)
Intervention category/subcategory	
Lairage interventions and hide cleanliness	24 (9%)
Cattle hide interventions	34 (13%)
Standard processing procedures/GHP	23 (9%)
Carcass pre-chill interventions	92 (35%)
Chilling and spray chilling	38 (14%)
Multiple interventions	20 (8%)
Outcomes investigated	
Aerobic colony count	138 (52%)
Enterobacteriaceae	47 (%)
Generic *E. coli*	99 (37%)
Pathogenic *E. coli*	143 (54%)
Salmonella	111 (42%)

Results – Risk of Bias

- **113** (43%) papers low risk of bias; 93 (35%) unclear, 60 (22%) high RoB
- Three or more trials – forest plots (FP) generated:
  - **102** with meta-analysis summary effects; 36 no summary effects (e.g. <3 trials)
  - pooled summary effects ('the diamond') represents the point estimate and confidence intervals of all the studies combined using the random effects model.
  - These were either pooled risk ratios (RR), for prevalence outcomes, or pooled log mean difference, for concentration outcomes
- Test for heterogeneity:
  - homogenous (p>0.05 on the test for heterogeneity): **33 FP**
  - moderately (p<0.05, I^2<=60%), and highly heterogeneous (p<0.05, I^2>60%): **69 FP**
- Meta-analysis grade:
  - Significant positive effect
  - No effect
  - Significantly homogenous studies



WG3 Results: Interventions (progressed to meta-analysis)

- **Lairage interventions**
- Lairage cleaning
- Cattle handling in lairage
- Hide cleanliness assessment
- Pre-slaughter cattle hide interventions (washing, clipping, bacteriophage spray)

- **Cattle hide interventions**
- Water wash
- Chemical wash (organic acids, chlorine, sanitiser)
- Chemical dehairing, thermal
- Shellac hide coating

RIBMINS

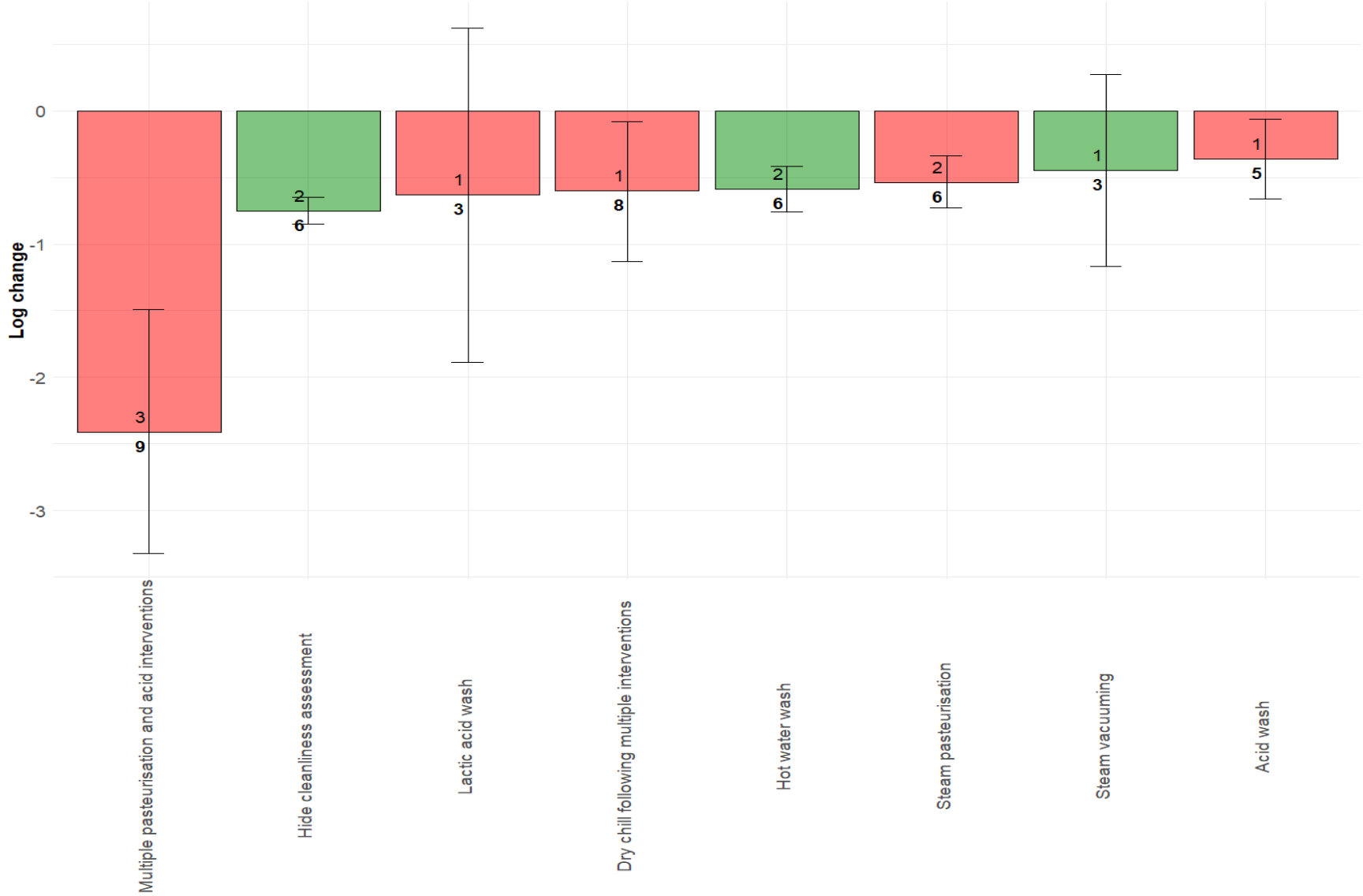
- **Beef carcass interventions**
- SPP & GHP:
  - knives sanitation; hide removal; bung bagging
- Pre-chill carcass treatments:
  - Water wash
  - Knife trimming
  - Hot water wash
  - Steam pasteurisation
  - Steam vacuuming
  - Lactic acid wash
  - Other organic acids wash
  - Other chemicals
- Chilling
  - Dry chilling
  - Dry aging
  - Water spray chilling
  - Spray chilling with chemicals
- Multiple interventions
  - Pasteurisation and acid washes

WG3 Results: Interventions (progressed to meta-analysis)

- This presentation will cover only meta-analysis results for **beef carcass** interventions effects on:
  - Generic *E. coli* counts and prevalence (predominantly from commercial abattoir (controlled and before-and after) trials; and
  - Pathogenic *E. coli* (STEC O157 and non-O157 serotypes), predominantly from laboratory (challenge) trials
- 58 papers on *E. coli* for meta-analysis:
  - 27 studies under commercial abattoir conditions; 11 research pilot plants; 21 laboratory conditions
  - 3 controlled trials; 27 before-and-after trials; 32 challenge trials
  - 39 studies on pre-chill carcass interventions; 19 carcass chilling; 5 multiple interventions

RIBMINS

WG3 Results – overall carcass interventions for **generic** *E. coli*

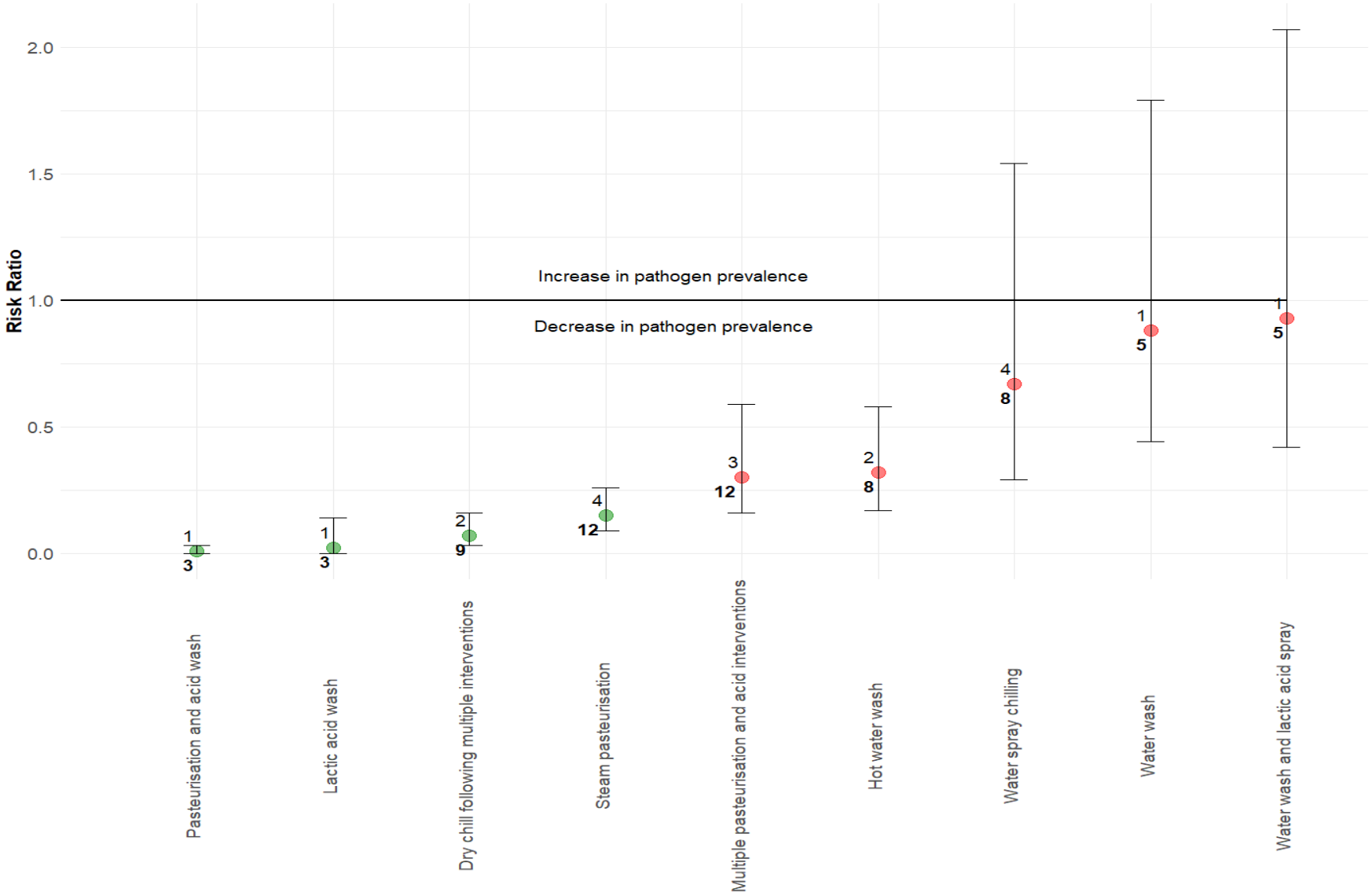


A comparison of meta-analyses of cattle hide and beef carcass processing interventions on **generic *E.coli* counts** (pooled **log** change) on beef carcasses under **commercial abattoir** conditions

Green: Homogenous trials
Red: Heterogeneous trials

Numbers in bar chart:
Top number = Number of studies,
Bottom number = Number of trials

WG3 Results – overall carcass interventions for **generic** *E. coli*

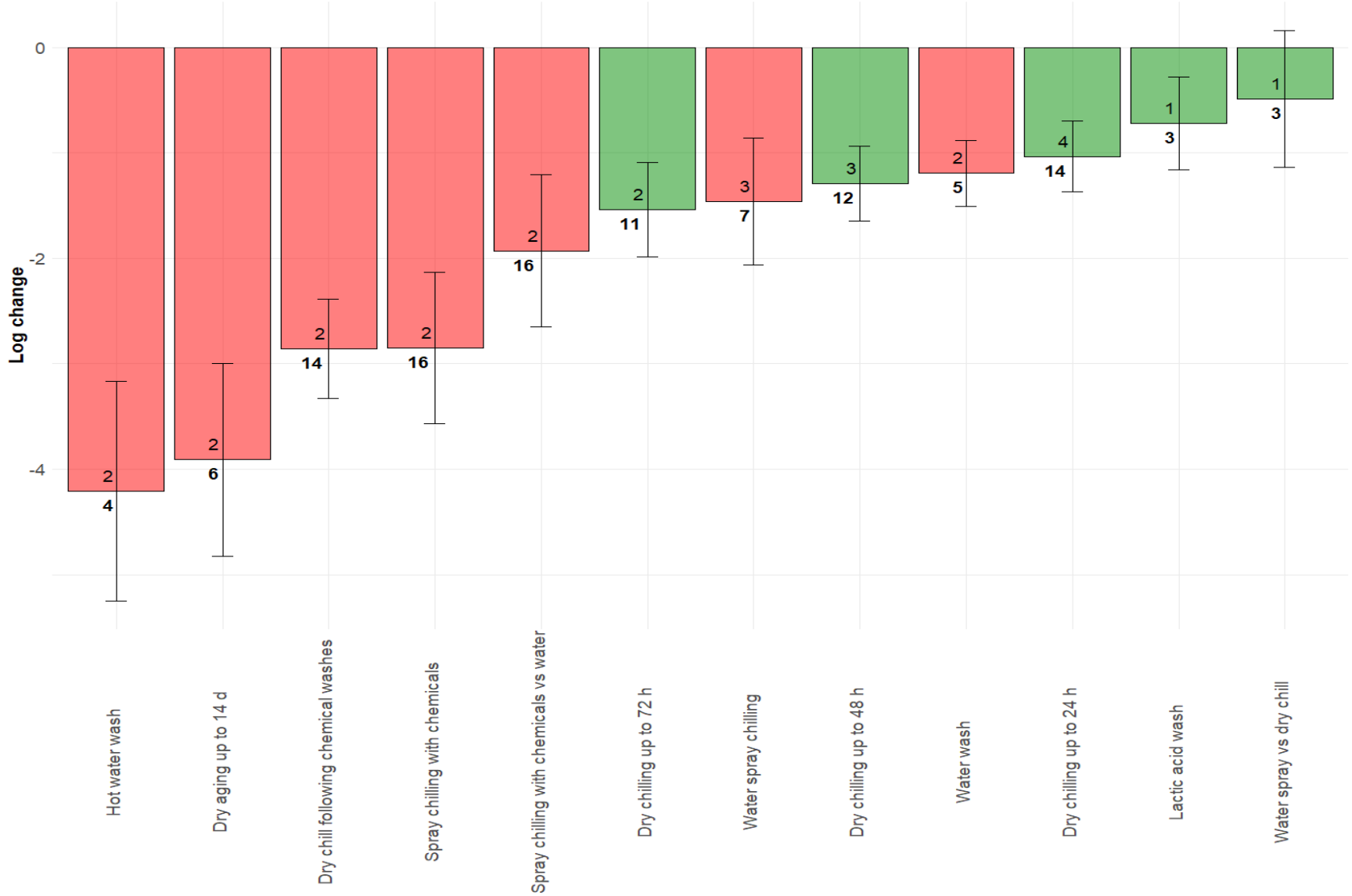


A comparison of meta-analyses of beef carcass processing interventions on **generic *E.coli* prevalence** (pooled **risk ratios**) on beef carcasses under **commercial abattoir** conditions

Green: Homogenous trials
Red: Heterogeneous trials

Numbers in bar chart:
Top number = Number of studies,
Bottom number = Number of trials

WG3 Results – overall carcass interventions for **pathogenic** *E. coli*



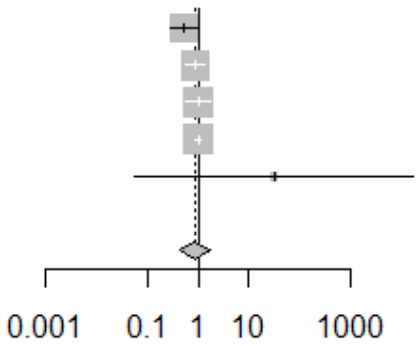
A comparison of meta-analyses of beef carcass processing interventions on **pathogenic *E. coli* counts** (pooled **log** change) on beef meat under **laboratory** conditions

Green: Homogenous trials
Red: Heterogeneous trials

Numbers in bar chart:
Top number = Number of studies,
Bottom number = Number of trials

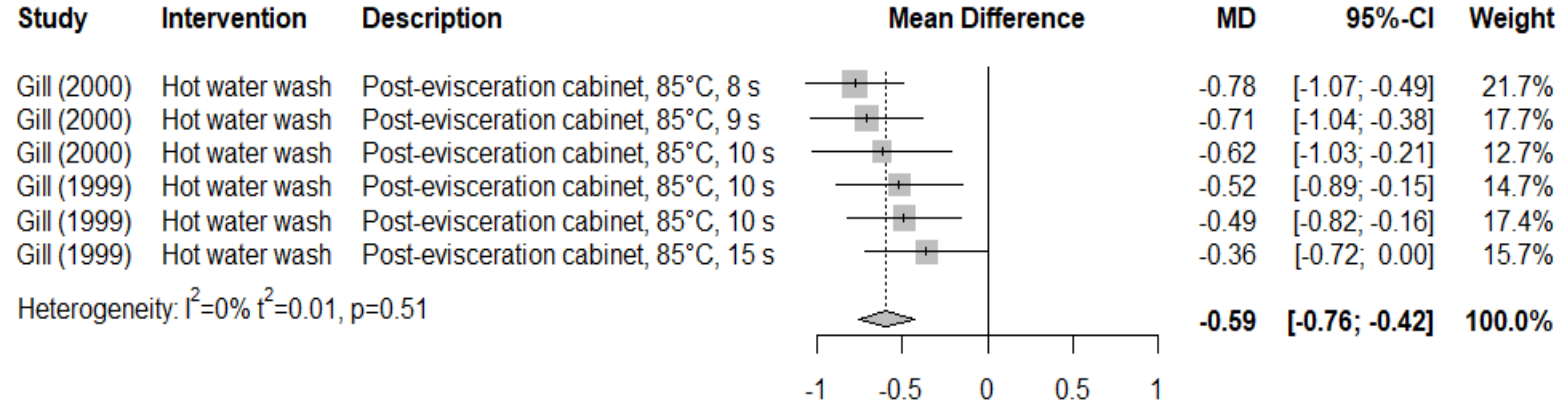
WG3 Results – pre-chill carcass interventions: **water wash**

Study	Intervention	Description	RR	95%-CI	Weight
Gill & Landers (2003b)	Water wash	Post-evisceration cabinet, 40°C, 280 psi, 25 s	0.53	[0.28; 1.03]	22.8%
Gill & Landers (2003b)	Water wash	Post-evisceration cabinet, 40°C, 280 psi, 25 s	0.88	[0.58; 1.34]	25.1%
Gill & Landers (2003b)	Water wash	Post-evisceration cabinet, 40°C, 280 psi, 12 s	1.00	[0.59; 1.70]	24.0%
Gill & Landers (2003b)	Water wash	Post-evisceration cabinet, 40°C, 280 psi, 25 s	1.00	[0.85; 1.18]	26.6%
Gill & Landers (2003b)	Water wash	Cold water at 2°C, 140 psi	31.00	[0.06; 16428.28]	1.5%
Heterogeneity: I^2=14.7% t^2=0.61, p=0.32			**0.88**	**[0.44; 1.79]**	**100.0%**

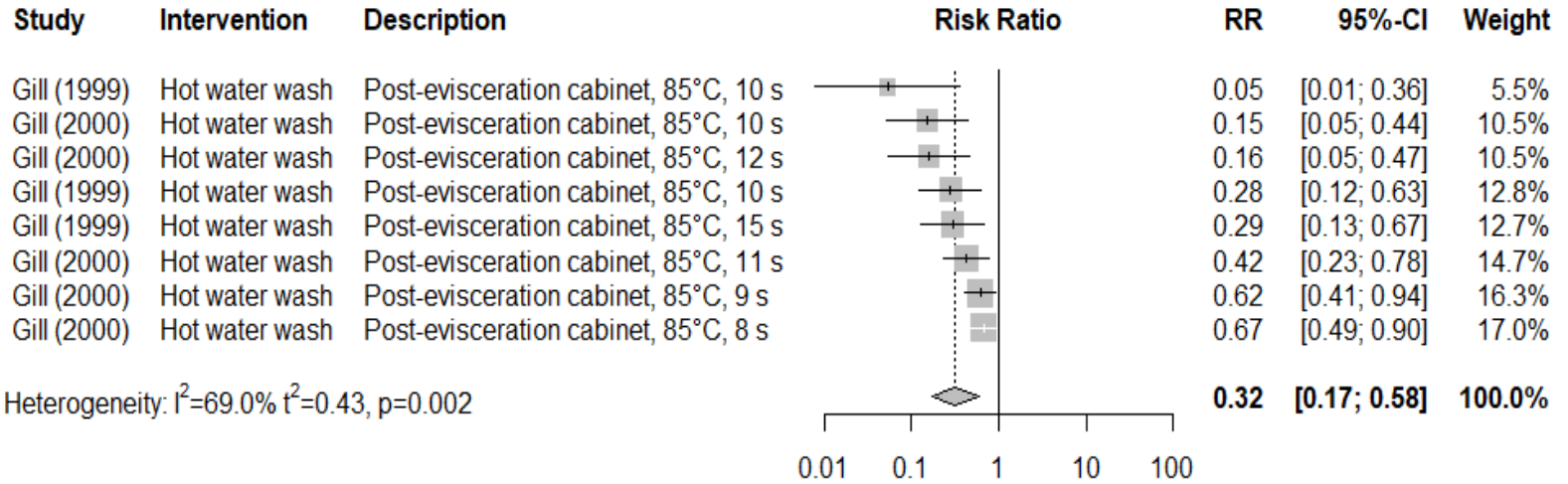


Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of water wash in reducing **generic *E. coli* prevalence** on beef carcasses (low heterogeneity, no effect)

WG3 Results – hazard-based, pre-chill carcass interventions: **hot water wash**

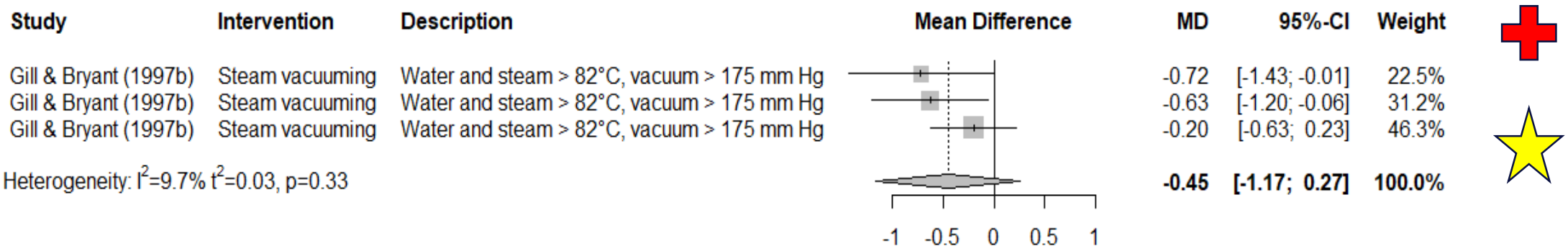


Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of hot water wash in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcasses (low heterogeneity, positive effect)



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of hot water wash in reducing **generic *E. coli* prevalence** on beef carcasses (high heterogeneity, positive effect)

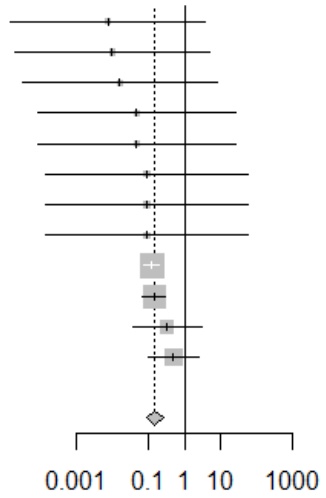
Results – pre-chill carcass interventions: **steam vacuuming**



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of steam vacuuming in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcasses (low heterogeneity, no effect)

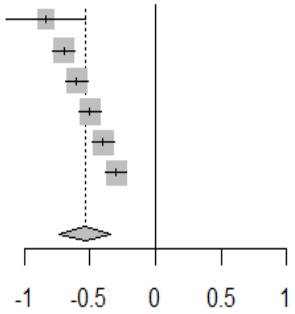
WG3 Results – hazard-based, pre-chill carcass interventions: **steam pasteurisation**

Study	Intervention	Description	RR	95%-CI	Weight
Nutsch (1997)	Steam pasteurisation	82.2°C, pressurised, 8 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	0.01	[0.00; 3.81]	1.6%
Nutsch (1997)	Steam pasteurisation	82.2°C, pressurised, 8 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	0.01	[0.00; 4.98]	1.6%
Retzlaff (2005)	Steam pasteurisation	85.0°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.02	[0.00; 8.22]	1.6%
Nutsch (1997)	Steam pasteurisation	82.2°C, pressurised, 6 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	0.05	[0.00; 25.34]	1.5%
Retzlaff (2005)	Steam pasteurisation	82.2°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.05	[0.00; 26.29]	1.5%
Nutsch (1997)	Steam pasteurisation	82.2°C, pressurised, 6 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	0.09	[0.00; 55.81]	1.5%
Retzlaff (2005)	Steam pasteurisation	76.7°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.09	[0.00; 57.17]	1.5%
Retzlaff (2005)	Steam pasteurisation	87.8°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.09	[0.00; 57.17]	1.5%
Corantin (2005)	Steam pasteurisation	74.5°C, 95 to 100 psi, 5 s	0.13	[0.08; 0.20]	34.1%
Gill & Bryant (1997b)	Steam pasteurisation	105°C, pressurised, 6.5 s	0.14	[0.07; 0.31]	28.7%
Retzlaff (2005)	Steam pasteurisation	73.9°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.33	[0.04; 2.94]	9.9%
Retzlaff (2005)	Steam pasteurisation	79.4°C, pressurised, 11 s; then cold water spray (1°C), 12 s	0.50	[0.10; 2.43]	15.3%
Heterogeneity: I^2=0% t^2=0.42, p=0.90			**0.15**	**[0.09; 0.26]**	**100.0%**



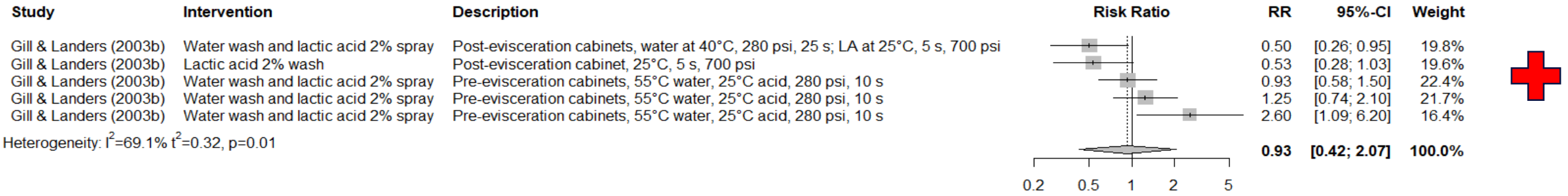
Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of steam pasteurisation in reducing **generic *E. coli* prevalence** on beef carcasses (low heterogeneity, positive effect)

Study	Intervention	Description	MD	95%-CI	Weight
Gill & Bryant (1997b)	Steam pasteurisation	105°C, pressurised, 6.5 s	-0.84	[-1.14; -0.54]	10.7%
Nutsch (1998)	Steam pasteurisation	82.2°C, pressurised, 6.5 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	-0.70	[-0.78; -0.62]	17.9%
Nutsch (1998)	Steam pasteurisation	82.2°C, pressurised, 6.5 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	-0.60	[-0.68; -0.52]	17.9%
Nutsch (1998)	Steam pasteurisation	82.2°C, pressurised, 6.5 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	-0.50	[-0.58; -0.42]	17.9%
Nutsch (1998)	Steam pasteurisation	82.2°C, pressurised, 6.5 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	-0.40	[-0.48; -0.32]	17.9%
Nutsch (1998)	Steam pasteurisation	82.2°C, pressurised, 6.5 s; then cold water spray (4.4°C) at 40 lb/in2, 10 s	-0.30	[-0.38; -0.22]	17.9%
Heterogeneity: I^2=91.7% t^2=0.03, p<0.0001			**-0.54**	**[-0.73; -0.34]**	**100.0%**

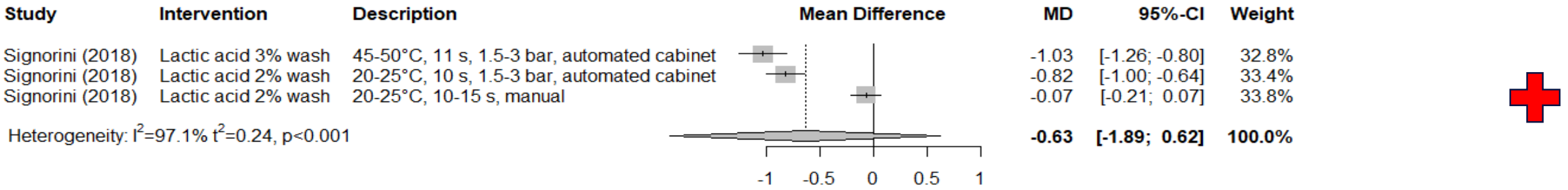


Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of steam pasteurisation in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcasses (high heterogeneity, positive effect)

WG3 Results – hazard-based, pre-chill carcass interventions: **lactic acid wash**



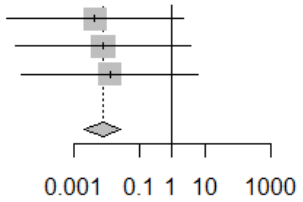
Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of lactic acid spray wash in reducing **generic *E. coli* prevalence** on beef carcasses (high heterogeneity, no effect)



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of lactic acid spray wash in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcasses (high heterogeneity, no effect)

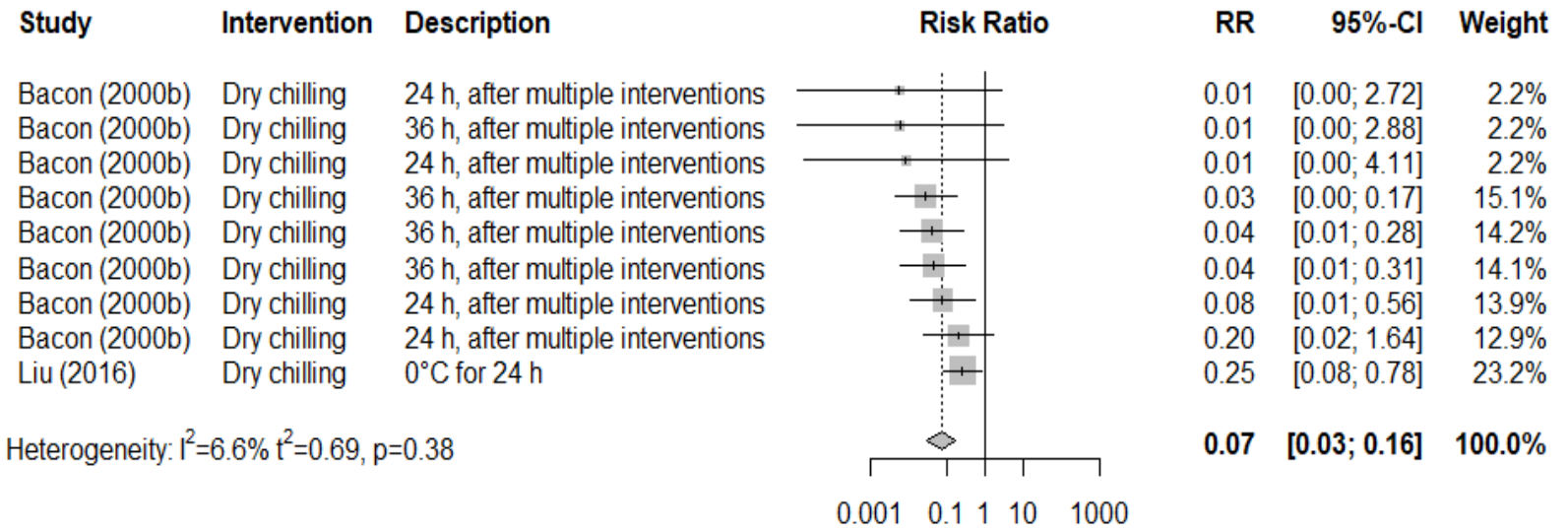
WG3 Results – hazard-based, pre-chill carcass interventions: **pasteurization & acid**

Study	Intervention	Description	RR	95%-CI	Weight
Gill & Landers (2003b)	Steam pasteurisation and lactic acid 2% spray	Post-evisceration cabinets, steam at 88-94°C, 12 s, LA at 700 psi	0.00	[0; 2.10]	33.5%
Gill & Landers (2003b)	Peroxyacetic acid spray and steam pasteurisation	Post-evisceration cabinets, PAA 200 ppm, 700 psi, steam at 88-94°C, 12 s	0.01	[0; 3.75]	33.3%
Gill & Landers (2003b)	Hot water and lactic acid 2% wash	Post-evisceration cabinet, water at 85°C, 10 s, 280 psi; LA at 25°C, 5 s, 700 psi	0.01	[0; 6.15]	33.2%
Heterogeneity: I^2=0% t^2=0.005, p=0.97			**0.01**	**[0; 0.03]**	**100.0%**

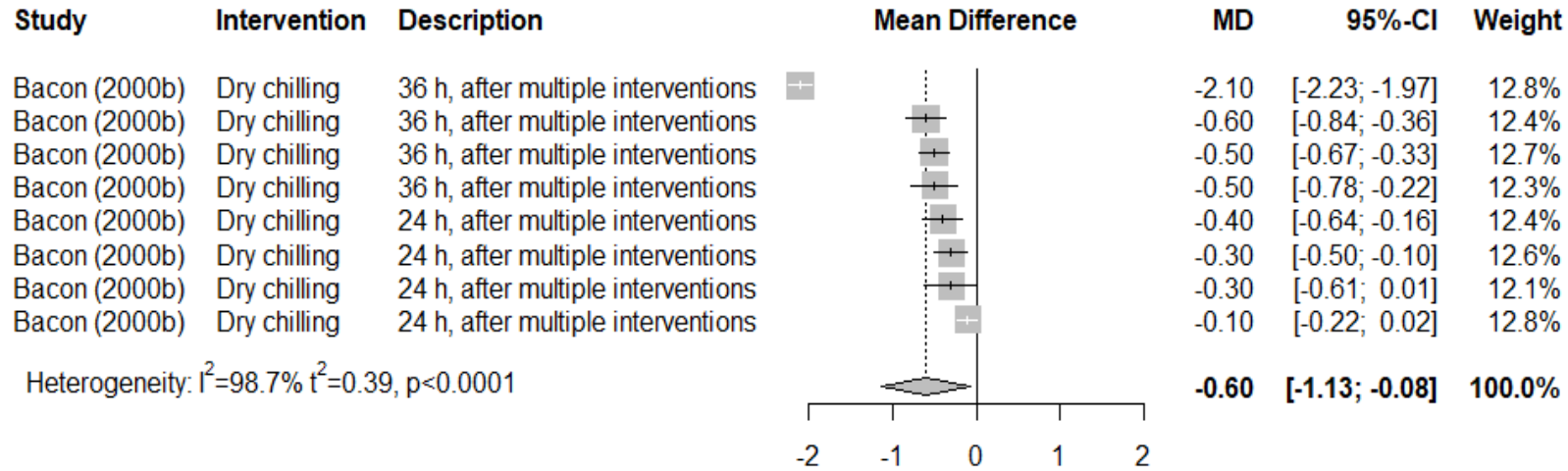


Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of pasteurisation and subsequent acid spray washes in reducing **generic *E. coli* prevalence** on beef carcasses (low heterogeneity, positive effect)

WG3 Results – chilling: **dry chilling after multiple interventions**

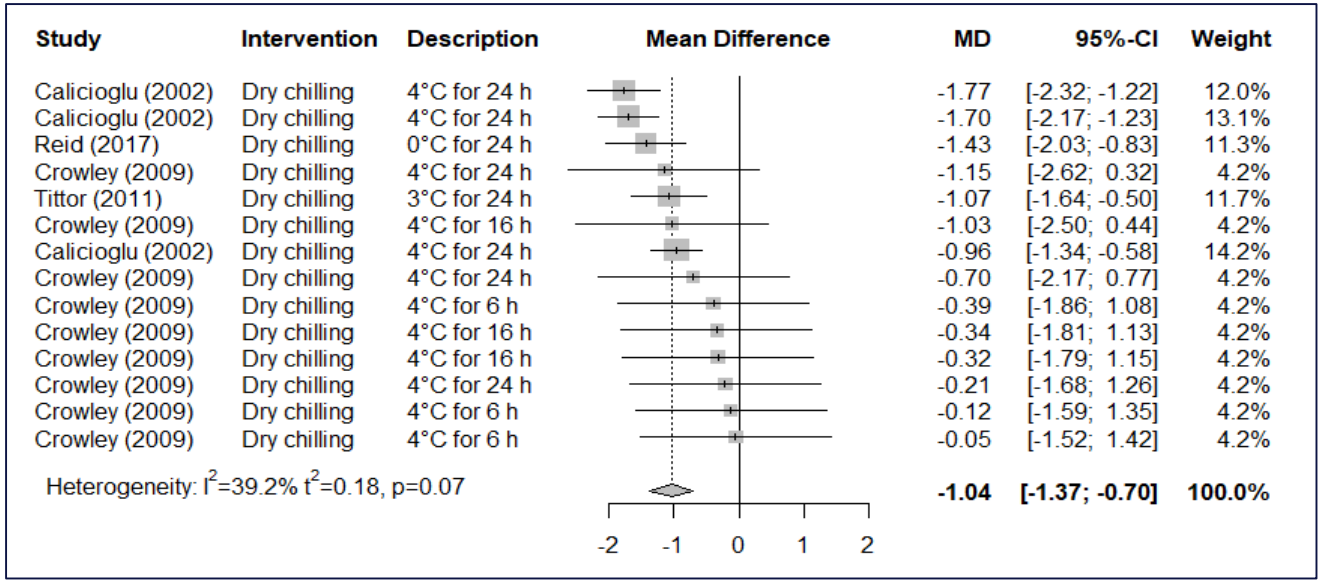


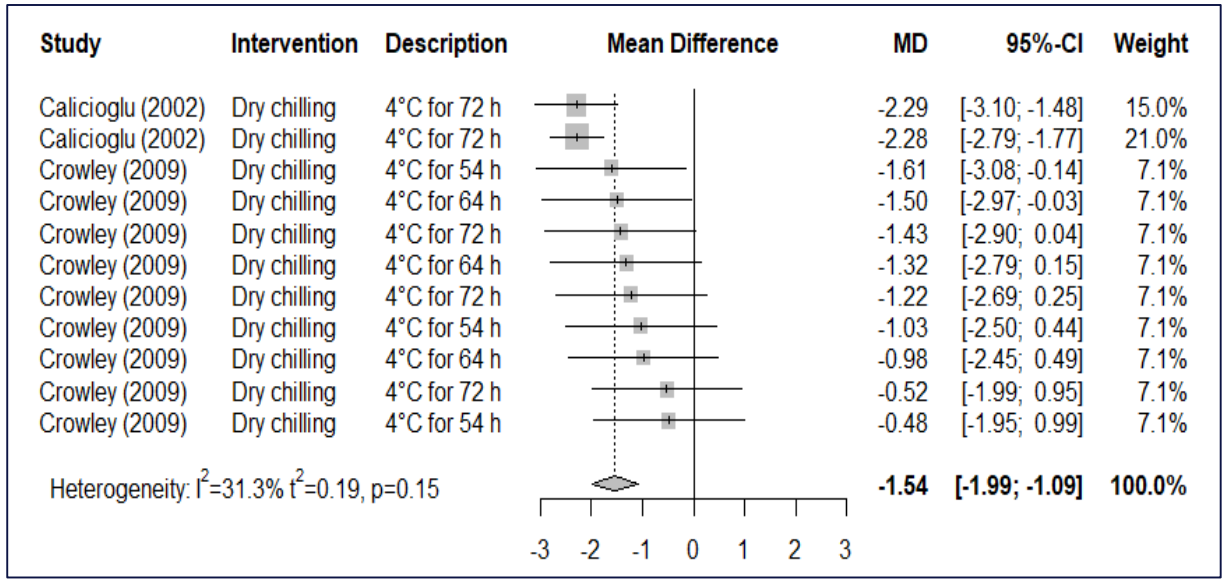
Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of dry chilling following multiple slaughter line interventions in reducing **generic *E. coli* prevalence** on beef carcasses (low heterogeneity, positive effect)

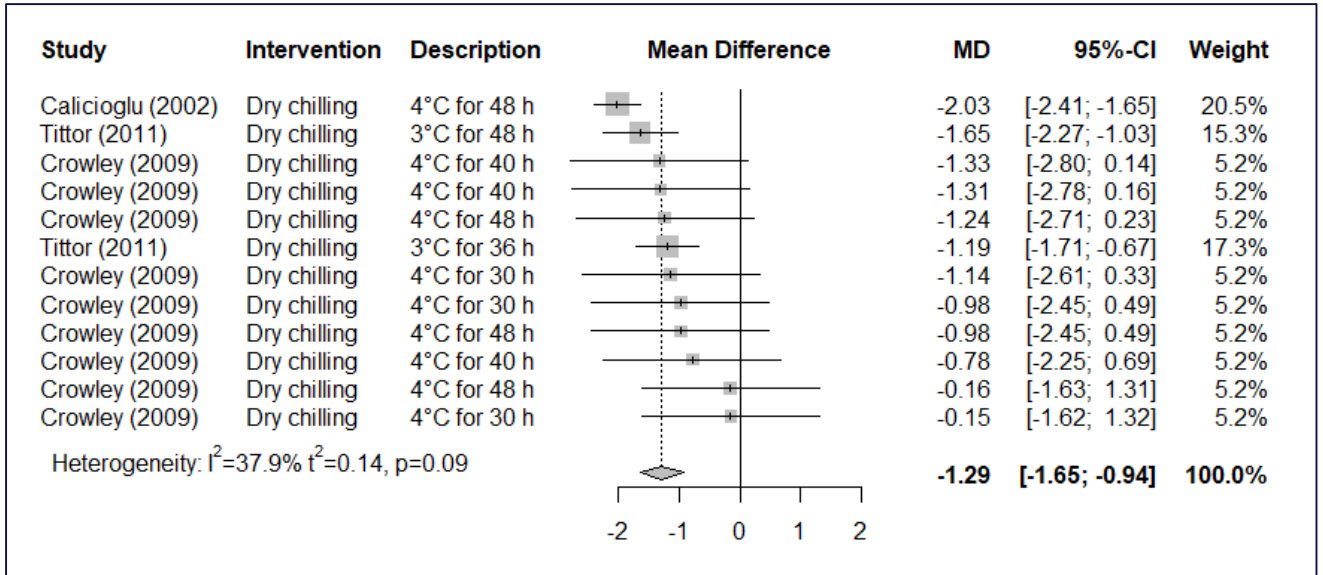


Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of dry chilling following multiple slaughter line interventions in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcass sides (high heterogeneity, positive effect)

WG3 Results – chilling: **conventional dry chilling (lab trials)**



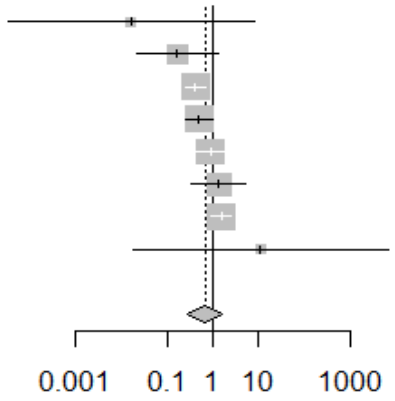




Forest plots of the results of **challenge** trials performed under **laboratory** conditions to investigate the efficacy of dry chilling up to 24h, 48h and 72h in reducing ***E. coli* O157:H7 numbers** (log_{10} CFU) on beef (low heterogeneity, positive effect)

WG3 Results – chilling: **water spray chilling**

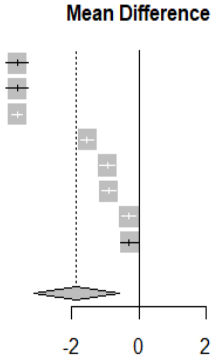
Study	Intervention	Description	RR	95%-CI	Weight
Gill & Bryant (1997b)	Water spray chilling	Intermittent (4°C water, 2°C air for 8 h), then dry air, -5°C, 22 h	0.02	[0.00; 8.38]	2.0%
Gill & Landers (2003a)	Water spray chilling	Intermittent for 8 h at 0°C, then dry air at 0°C, 24 h in total	0.17	[0.02; 1.29]	10.0%
Gill & Bryant (1997a)	Water spray chilling	Intermittent (4°C water, 2°C air for 8 h), then dry air, -5°C, 22 h	0.42	[0.26; 0.68]	18.7%
Gill & Bryant (1997a)	Water spray chilling	Intermittent (4°C water, 2°C air for 8 h), then dry air, -5°C, 22 h	0.50	[0.24; 1.03]	17.6%
Corantin (2005)	Water spray chilling	24 h, after steam pasteurisation	0.89	[0.46; 1.73]	17.8%
Gill & Landers (2003a)	Water spray chilling	Intermittent for 8 h at 2°C, then dry air at 2°C, 24 h in total	1.33	[0.33; 5.36]	13.6%
Gill & Landers (2003a)	Water spray chilling	Intermittent for 10 h at -2°C, then dry air at -1°C, 24 h in total	1.55	[0.92; 2.59]	18.5%
Gill & Landers (2003a)	Water spray chilling	Intermittent for 8 h at 2°C, then dry air at -2°C, 36 h in total	11.00	[0.02; 6958.77]	1.9%
Heterogeneity: I^2=63.9% t^2=1.12, p=0.007			**0.67**	**[0.29; 1.54]**	**100.0%**



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of water spray chilling in reducing **generic *E. coli* prevalence** on beef carcasses (high heterogeneity, no effect)

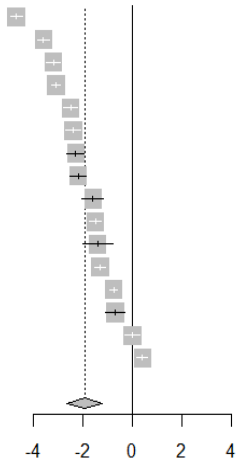
WG3 Results – chilling: **spray chilling with chemicals (lab trials)**

Study	Intervention	Description	MD	95%-CI	Weight
Kocharunchitt (2020)	Chlorine dioxide spray chilling	Intermittent (50 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 72 h	-3.63	[-3.96; -3.30]	12.4%
Kocharunchitt (2020)	Peroxyacetic acid spray chilling	Intermittent (200 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 72 h	-3.63	[-3.96; -3.30]	12.4%
Kocharunchitt (2020)	Chlorine dioxide spray chilling	Intermittent (50 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 24 h	-3.62	[-3.78; -3.46]	12.6%
Kocharunchitt (2020)	Peroxyacetic acid spray chilling	Intermittent (200 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 24 h	-1.54	[-1.73; -1.35]	12.5%
Kocharunchitt (2020)	Chlorine dioxide spray chilling	Intermittent (50 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 24 h	-0.94	[-1.16; -0.72]	12.5%
Kocharunchitt (2020)	Chlorine dioxide spray chilling	Intermittent (50 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 72 h	-0.90	[-1.10; -0.70]	12.5%
Kocharunchitt (2020)	Peroxyacetic acid spray chilling	Intermittent (200 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 72 h	-0.30	[-0.52; -0.08]	12.5%
Kocharunchitt (2020)	Peroxyacetic acid spray chilling	Intermittent (200 ppm, 4 s every 15 min for 9 h), then air at 7°C, in total 24 h	-0.28	[-0.55; -0.01]	12.5%
Heterogeneity: I^2=99.4% t^2=2.23, p=0			**-1.85**	**[-3.12; -0.58]**	**100.0%**



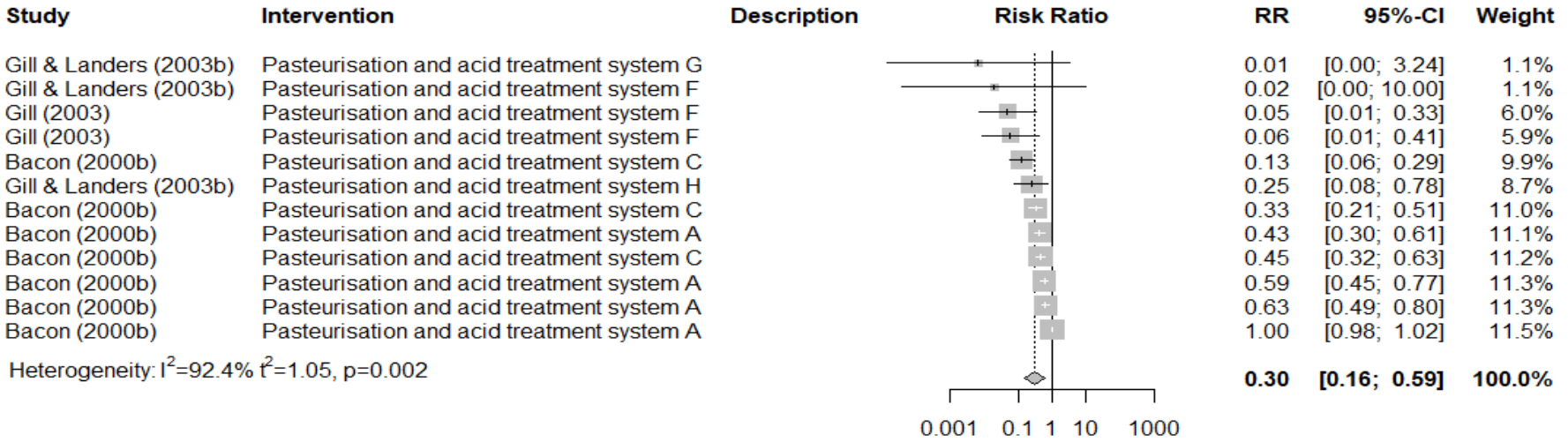
Forest plot of the results of **challenge trials** performed under **laboratory** conditions to investigate the efficacy of spray chilling with chemicals vs. water spray chilling in reducing **generic *E. coli* counts** (log_{10} CFU) on beef (high heterogeneity, positive effect)

Study	Intervention	Description	MD	95%-CI	Weight
Stopforth (2004)	Cetylpyridinium chloride 0.5% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 24 h	-4.70	[-4.94; -4.46]	6.3%
Stopforth (2004)	Cetylpyridinium chloride 0.5% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 36 h	-3.60	[-3.84; -3.36]	6.3%
Stopforth (2004)	Lactic acid 2% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 24 h	-3.20	[-3.49; -2.91]	6.3%
Stopforth (2004)	Cetylpyridinium chloride 0.5% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 48 h	-3.10	[-3.26; -2.94]	6.3%
Stopforth (2004)	Ammonium hydroxide 0.05% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 24 h	-2.50	[-2.79; -2.21]	6.3%
Stopforth (2004)	Lactic acid 2% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 36 h	-2.40	[-2.69; -2.11]	6.3%
Stopforth (2004)	Lactic acid 2% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 48 h	-2.30	[-2.66; -1.94]	6.2%
Stopforth (2004)	Acidified sodium chlorite 0.12% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 24 h	-2.20	[-2.54; -1.86]	6.2%
Stopforth (2004)	Acidified sodium chlorite 0.12% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 48 h	-1.60	[-2.03; -1.17]	6.2%
Stopforth (2004)	Ammonium hydroxide 0.05% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 36 h	-1.50	[-1.75; -1.25]	6.3%
Stopforth (2004)	Acidified sodium chlorite 0.12% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 36 h	-1.40	[-2.01; -0.79]	6.0%
Stopforth (2004)	Ammonium hydroxide 0.05% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 48 h	-1.30	[-1.53; -1.07]	6.3%
Kalchayanand (2019)	Aqueous ozone spray chilling	Intermittent (5°C, 12 ppm ozone at 8 lb/in2, 1.5 min on every 30 min for 12 h)	-0.76	[-0.91; -0.61]	6.3%
Stopforth (2004)	Sodium hypochlorite 0.005% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 24 h	-0.70	[-1.10; -0.30]	6.2%
Stopforth (2004)	Sodium hypochlorite 0.005% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 36 h	0.00	[-0.29; 0.29]	6.3%
Stopforth (2004)	Sodium hypochlorite 0.005% spray chilling	Intermittent (-3°C, 3 x every 30 min for 10 h), then air at 1°C, in total 48 h	0.40	[0.17; 0.63]	6.3%
Heterogeneity: I^2=99.2% t^2=1.80, p=0			**-1.93**	**[-2.65; -1.21]**	**100.0%**

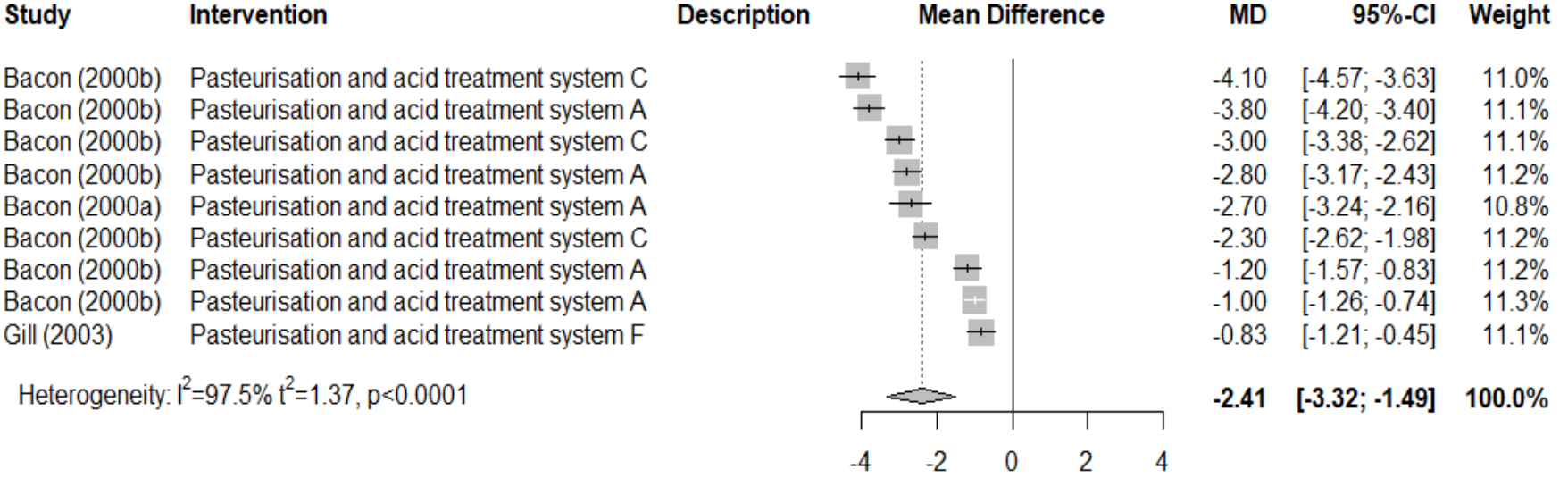


Forest plot of the results of **challenge trials** performed under **laboratory** conditions to investigate the efficacy of spray chilling with chemicals vs. water spray chilling in reducing ***E. coli* O157:H7 numbers** (log_{10} CFU) on beef (high heterogeneity, positive effect)

WG3 Results – **multiple pasteurization and acid interventions**



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of multiple pasteurisation and acid interventions in reducing **generic *E. coli* prevalence** on beef carcass sides (high heterogeneity, positive effect)



Forest plot of the results of before-and-after trials performed under **commercial abattoir** conditions to investigate the efficacy of multiple pasteurisation and acid interventions in reducing **generic *E. coli* counts** (log_{10} CFU) on beef carcass sides (high heterogeneity, positive effect)

WG3 Results – **multiple pasteurization and acid interventions**

Pasteurisation and acid treatment system A: (i) **steam vacuuming** (104 to 110°C, 138 to 345 kPa steam, negative 7 to 12 mm of Hg vacuum),
(ii) **pre-evisceration** carcass washing (29 to 38°C **water** at 193 to 331 kPa, 6 to 8 s),
(iii) **pre-evisceration acetic acid** solution rinsing (1.6 to 2.6% acetic acid solution, 43 to 60°C, 317 to 324 kPa, 2 to 4 s),
(iv) **thermal pasteurising** (71 to 77°C water, 69 to 228 kPa, 10 to 14 s),
(v) **final** carcass **washing** (16 to 32°C water, 483 to 897 kPa, 10 to 14 s), and
(vi) **post-evisceration acetic acid** solution rinsing (1.6 to 2.6% acetic acid solution, 43 to 60°C, 317 to 324 kPa, 2 to 4 s)

Pasteurisation and acid treatment system F: (i) **pre-evisceration** carcass washing (55°C **water** at 280 psi, 10 s),
(ii) **pre-evisceration** spraying with 2% **lactic acid** (25°C);
(iii) **post-evisceration steam vacuuming** of visible contamination from the rump, brisket and forelegs;
(iv) **post-splitting trimming** visible contamination;
(v) **final** carcass **washing** (40°C, 280 psi, 25 s);
(vi) **steam pasteurisation** (steam at 88-94°C, 12 s); and
(vii) **final** spraying with 2% **lactic acid** (700 psi)

Pasteurisation and acid treatment system G: (i) **pre-evisceration** carcass washing (55°C **water** at 280 psi, 10 s),
(ii) **pre-evisceration** spraying with 2% **lactic acid** (25°C);
(iii) **post-evisceration steam vacuuming** of visible contamination from the rump, brisket and forelegs;
(iv) **post-splitting trimming** visible contamination;
(v) **final** carcass **washing** (40°C, 280 psi, 12 s);
(vi) **peroxyacetic acid** spray (200 ppm, 280 psi); and
(vii) **steam pasteurisation** (steam at 88-94°C, 12 s)

WG3 Discussion & Conclusions

- 25 years of literature reviewed,
- Insufficient data for some interventions, such as standard procedures for carcasses and GHPs, organic acid and other carcass chemical washes
- Limited data for knife trimming, steam vacuuming, lactic acid and other organic acid washes and multiple interventions - efficacy is inconclusive and more research is needed
- Sufficient data for carcass water wash, hot water wash, steam pasteurisation and chilling
- Data on pathogenic *E. coli* mostly from challenge trials conducted under laboratory or pilot plant conditions:
  - efficacies investigated using artificially inoculated bacteria - consequently the effects are likely exaggerated and would not reflect real life conditions that exist in abattoirs.
  - Nevertheless, the results are useful to provide some indication of the relative efficacy of specific interventions
- Only 43% paper with low risk of bias – insufficient methodological quality and lack of adequate reporting of intervention protocols
- Not all studies had extractable data (around 50% !) - lack of adequate reporting of results
- High heterogeneity of studies (>2/3)

WG3 Discussion & Conclusions

- Steam and hot water carcass pasteurisation had the largest individual impact on decreasing the prevalence and concentration of *E. coli*
- Multiple pasteurisation and acid interventions – up to 2.5 logs reduction
- Recommendations:
  - Carcass pasteurisation treatments and organic (lactic) acid washes can be recommended for consideration as hazard-based interventions when applied after dehiding and pre-chill.
  - More research is needed (particularly large commercial controlled trials)
  - Methodologies and data recording needs to be harmonised
  - These data can be used for further quantitative microbial risk assessment

WG3 Systematic review and Meta-analysis of beef interventions

- Big thanks to all contributors in this task (2019-2022) and co-authors of this work and future publication(s)
- The project was commissioned and funded by the UK Food Standards Agency (FS430388)

John Tulloch [UK]
Catherine McCarthy [UK]
Kurt Houf [BE]
Bojan Blagojevic [RS]
Nikolaos Dadios [UK]
Dragan Antic [UK]

WG3 Specific objectives: what next ?

- 3.1 Assessment of effectiveness of new tools | methods for detection of carcass contamination
- 3.2 Assessment of the significant intervention strategies and alternative methods for the slaughtering | the carcass dressing

Years 1 & 2

- 3.3 Assessment of the performance of food safety management systems
- 3.4 Harmonised Epidemiological Indicators (HEI) in risk categorisation of abattoirs

Years 3 & 4

Specific objectives: what next ?

3.3 Assessment of the performance of food safety management systems

Progress so far:

- **Hazards agreed (from past EFSA reports)**
- **FSMS in abattoirs defined**
- **FSMS components breakdown and analysis**

Specific objectives: what next ?

3.3 Assessment of the performance of food safety management systems

(Potential) Next steps

- **Model A. Components-based assessment of FSMSs**

- Assessment of effectiveness of each FSMS component against agreed hazards

- **Model B. Outcome-based assessment of FSMSs**

- Establishing agreed assessment outcome parameters (in cooperation with WG 3.4 work on HEIs)
- Holistic assessment FSMSs only from the outcomes, irrespective of components etc.

Thank you for the attention.

Please join us at

RIBMINS

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Funded by the 2020 Framework Programme
of the European Union

www.cost.eu

www.ribmins.com
scan this