6. Supplementary Materials

Additional notes about interpretation of screening

For the title and abstract screening form, Q1 and Q2 were omitted from the protocol because reviewers assessed records based only on their title and/or abstract. Additionally, Q1 was omitted from the protocol to specify that included studies must describe primary research, allowing reviewers to exclude review articles. For the full-text screening form, Q1 was added to identify non-English language articles, articles for which the full text could not be obtained, and conference abstracts that were considered too short (i.e., ¡ 500 words) to constitute a full-text report. Q2 and Q4 were not in the protocol but were added so that the full text could be assessed based on the same two questions used to assess the title/abstract. This was particularly pertinent for assessing records that lacked an abstract. The order of questions was changed in the protocol so that reviewers first assessed the records based on study design (Q3) and then population (Q5), intervention (Q6), and outcome (Q7). This was done to maximize efficiency of the form, with the questions most likely to be exclusionary occurring earlier in the form. If a reviewer answered "no" to any question between Q1 and Q6, they did not have to answer subsequent questions.

For Q5, studies of populations identified by investigators as "veal" or "dairy" were excluded, but studies of Holstein/Friesian cattle were not excluded provided the researchers did not use the term "veal" or "dairy" cattle. Studies of *Bos indicus* and *Bos taurus* cattle were included. Studies of calves persistently infected with BVDV prior to vaccination were excluded. For Q6, for a vaccine to be considered "commercial", it had to have a commercial name (e.g., Bovi-Shield Gold). Autogenous vaccines were also considered relevant; for a vaccine to be considered "autogenous", it had to be made by a commercial company from a farm isolate and then used on the farm of origin. Studies of preconditioning (i.e., vaccination occurring before weaning) were included provided that the only difference between the intervention groups was vaccination (i.e., not weaned or bunk broken, etc.).

Search Number	Search String	Hits
1	Cattle/ or Cattle Diseases/	331164
2	(cow or cows or cattle or heiferS or steer or steers or bull or bulls or calf or calves or youngstockS or young-stockS or beef or veal or bovineS or bovinae or buiatric$).ti,ab,kf	199453
3	1 or 2	396086
4	(respiratory disease$ or respiratory tract disease$ or respiratory virus$ or respiratory tract virus$ or shipping fever$ or undifferentiated fever$ or BRD or BRDC or pasteurellosis or pneumonia$ or pleuropneumonia$ or pneumonitis or pneumonitides).ti,ab,kf	194512
5	(herpesvirus$ or herpes virus$ or herpesviridae$ or herpes viridae$ or BoHV-1 or BoHV1 or BHV-1 or BHV1 or BHV or BoHV or rhinotracheitis or rhinotracheitides or IBRV or IBR).ti,ab,kf	31859
6	((viral or virus or viruses) adj3 (diarrhoea$ or diarrhea$)).ti,ab,kf	4953
7	(BVD or BVDV or BVDV1 or BVDV2 or pestivirus or coronavirus or BCV).ti,ab,kf	12378
8	(respiratory syncytial virus$ or BRSV or RSV).ti,ab,kf	15597
9	(parainfluenza3 or influenza3 or parainfluenza 3 or influenza 3 or parainfluenza three or influenza three or parainfluenza type 3 or influenza type 3 or parainfluenza type three or influenza type three or PI-3 or PI3).ti,ab,kf	13067
10	or/4-9	261171
11	3 and 10	11207
12	exp Bovine Respiratory Disease Complex/	719
13	herpesvirus 1, bovine/ or herpesvirus 5, bovine/	2137
14	exp Diarrhea Viruses, Bovine Viral/	2492
15	Coronavirus, Bovine/	244
16	Respiratory Syncytial Virus, Bovine/	378
17	Parainfluenza Virus 3, Bovine/	98
18	or/11-17	12192
19	exp immunization/ or exp vaccination/	162389
20	exp Vaccines/	211611
21	(vaccin$ or immunis$ or immuniz$ or innoculat$).ti,ab,kf	357356
22	or/19-21	447049
23	18 and 22	2659
24	limit 23 to yr="2014 -Current"	373
25	Mannheimia haemolytica/	935
26	Haemophilus somnus/	59
27	Pasteurella multocida/	1838
28	(mannheimia haemolytica or mannheimia hemolytica or m haemolytica or m hemolytica or pasteurella haemolytica or pasteurella hemolytica or p haemolytica or p hemolytica or mannheimios$).ti,ab,kf	1889
29	(haemophilus somn$ or hemophilus somn$ or histophilus somn$ or h somnus or h somni).ti,ab,kf	475
30	(pasteurella multocida or p multocida or mycoplasma).ti,ab,kf	23548
31	or/25-30	25515
32	3 and 22 and 31	627
33	24 or 32	936
34	remove duplicates from 33	935

Table S1: Search results for MEDLINE, MEDLINE In-Process, and MEDLINE Daily Epub Ahead of Print, Search date: 05/07/18, Interface: OVID, Database coverage dates: 1946 to current.

Search Number	Search String	Hits
# 17	#16 OR #11	2452
# 16	#15 AND #9 AND #1	1912
# 15	#14 OR #13 OR #12	29528
# 14	TS=("pasteurella multocida" OR "p multocida" OR "mycoplasma")	26716
# 13	TS=("haemophilus somn*" OR "hemophilus somn*" OR "histophilus somn*" OR "h somnus" OR "h somni")	981
# 12	TS=("mannheimia haemolytica" OR "mannheimia hemolytica" OR "m haemolytica" OR "m hemolytica" OR "pasteurella haemolytica" OR "pasteurella hemolytica" OR "p haemolytica" OR "p hemolytica" OR mannheimios*)	3388
# 11	#10 Timespan=2014-2018	694
# 10	#9 AND #8 AND #1	7024
# 9	TS=(vaccin* OR immunis* OR immuniz* OR innoculat*)	182791
# 8	#7 OR #6 OR #5 OR #4 OR #3 OR #2	149754
# 7	TS=("parainfluenza3" OR "influenza3" OR "parainfluenza 3" OR "influenza 3" OR "parainfluenza three" OR "influenza three" OR "parainfluenza type 3" OR "influenza type 3" OR "parainfluenza type three" OR "influenza type three" OR "PI-3" OR "PI3")	2925
# 6	TS=("respiratory syncytial virus*" OR "BRSV" OR "RSV")	3995
# 5	TS=("BVD" OR "BVDV" OR "BVDV1" OR "BVDV2" OR "pestivirus" OR "coronavirus" OR "BCV")	25929
# 4	TS=(("viral" OR "virus" OR "viruses") NEAR/3 (diarrhoea* OR diarrhea*))	9129
# 3	TS=(herpesvirus* OR "herpes virus*" OR herpesviridae* OR "herpes viridae*" OR "BoHV-1" OR "BoHV1" OR "BHV-1" OR "BHV1" OR "BHV" OR "BoHV" OR "rhinotracheitis" OR "rhinotracheitides" OR "IBRV" OR "IBR")	35842
# 2	TS=("respiratory disease*" OR "respiratory tract disease*" OR "respiratory virus*" OR "respiratory tract virus*" OR "shipping fever*" OR "undifferentiated fever*" OR "BRD" OR "BRDC" OR "pasteurellosis" OR pneumonia* OR pleuropneumonia* OR "pneumonitis" OR "pneumonitides")	91773
# 1	TS=("cow" OR "cows" OR "cattle" OR heifer* OR "steer" OR "steers" OR "bull" OR "bulls" OR "calf" OR "calves" OR "youngstock*" OR "young-stock*" OR "beef" OR "veal" OR bovine* OR "bovinae" OR buiatric*)	738516

Table S2: Search results for Cambridge Agricultural and Biological Index, Search date: 05/07/18, Interface: Web of Science, Database coverage dates: 1910 to current. All search stings were conducted for all years (Timespan=All years) except search line 11 which was limited to 2014-2018

Search Number	Search String	Hits
# 17	#16 OR #11	1185
# 16	#15 AND #9 AND #1	728
# 15	#14 OR #13 OR #12	27931
# 14	TS=("pasteurella multocida" OR "p multocida" OR "mycoplasma")	25520
# 13	TS=("haemophilus somn*" OR "hemophilus somn*" OR "histophilus somn*" OR "h somnus" OR "h somni")	608
# 12	TS=("mannheimia haemolytica" OR "mannheimia hemolytica" OR "m haemolytica" OR "m hemolytica" OR "pasteurella haemolytica" OR "pasteurella hemolytica" OR "p haemolytica" OR "p hemolytica" OR mannheimios*)	2531
# 11	#10 Timespan=2014-2018	569
# 10	#9 AND #8 AND #1	3225
# 9	TS=(vaccin* OR immunis* OR immuniz* OR innoculat*)	352857
# 8	#7 OR #6 OR #5 OR #4 OR #3 OR #2	285001
# 7	TS=("parainfluenza3" OR "influenza3" OR "parainfluenza 3" OR "influenza 3" OR "parainfluenza three" OR "influenza three" OR "parainfluenza type 3" OR "influenza type 3" OR "parainfluenza type three" OR "influenza type three" OR "PI-3" OR "PI3")	17456
# 6	TS=("respiratory syncytial virus*" OR "BRSV" OR "RSV")	19453
# 5	TS=("BVD" OR "BVDV" OR "BVDV1" OR "BVDV2" OR "pestivirus" OR "coronavirus" OR "BCV")	15890
# 4	TS=(("viral" OR "virus" OR "viruses") NEAR/3 (diarrhoea* OR diarrhea*))	6409
# 3	TS=(herpesvirus* OR "herpes virus*" OR herpesviridae* OR "herpes viridae*" OR "BoHV-1" OR "BoHV1" OR "BHV-1" OR "BHV1" OR "BHV" OR "BoHV" OR "rhinotracheitis" OR "rhinotracheitides" OR "IBRV" OR "IBR")	37131
# 2	TS=("respiratory disease*" OR "respiratory tract disease*" OR "respiratory virus*" OR "respiratory tract virus*" OR "shipping fever*" OR "undifferentiated fever*" OR "BRD" OR "BRDC" OR "pasteurellosis" OR pneumonia* OR pleuropneumonia* OR "pneumonitis" OR "pneumonitides")	202222
# 1	TS=("cow" OR "cows" OR "cattle" OR heifer* OR "steer" OR "steers" OR "bull" OR "bulls" OR "calf" OR "calves" OR "youngstock*" OR "young-stock*" OR "beef" OR "veal" OR bovine* OR "bovinae" OR buiatric*)	526270

Table S3: Search results for Science Citation Index (SCI), Search date: 05/07/18, Interface: Web of Science, Database coverage dates: 1900-03/07/18. All search stings were conducted for all years (Timespan=All years) except search line 11 which was limited to 2014-2018

Search Number	Search String	Hits
# 17	#16 OR #11	57
# 16	#15 AND #9 AND #1	44
# 15	#14 OR #13 OR #12	1306
# 14	TS=("pasteurella multocida" OR "p multocida" OR "mycoplasma")	1232
# 13	TS=("haemophilus somn*" OR "hemophilus somn*" OR "histophilus somn*" OR "h somnus" OR "h somni")	20
# 12	TS=("mannheimia haemolytica" OR "mannheimia hemolytica" OR "m haemolytica" OR "m hemolytica" OR "pasteurella haemolytica" OR "pasteurella hemolytica" OR "p haemolytica" OR "p hemolytica" OR mannheimios*)	82
# 11	#10 Timespan=2014-2018	16
# 10	#9 AND #8 AND #1	222
# 9	TS=(vaccin* OR immunis* OR immuniz* OR innoculat*)	27939
# 8	#7 OR #6 OR #5 OR #4 OR #3 OR #2	21011
# 7	TS=("parainfluenza3" OR "influenza3" OR "parainfluenza 3" OR "influenza 3" OR "parainfluenza three" OR "influenza three" OR "parainfluenza type 3" OR "influenza type 3" OR "parainfluenza type three" OR "influenza type three" OR "PI-3" OR "PI3")	1648
# 6	TS=("respiratory syncytial virus*" OR "BRSV" OR "RSV")	1496
# 5	TS=("BVD" OR "BVDV" OR "BVDV1" OR "BVDV2" OR "pestivirus" OR "coronavirus" OR "BCV")	1180
# 4	TS=(("viral" OR "virus" OR "viruses") NEAR/3 (diarrhoea* OR diarrhea*))	427
# 3	TS=(herpesvirus* OR "herpes virus*" OR herpesviridae* OR "herpes viridae*" OR "BoHV-1" OR "BoHV1" OR "BHV-1" OR "BHV1" OR "BHV" OR "BoHV" OR "rhinotracheitis" OR "rhinotracheitides" OR "IBRV" OR "IBR")	2543
# 2	TS=("respiratory disease*" OR "respiratory tract disease*" OR "respiratory virus*" OR "respiratory tract virus*" OR "shipping fever*" OR "undifferentiated fever*" OR "BRD" OR "BRDC" OR "pasteurellosis" OR pneumonia* OR pleuropneumonia* OR "pneumonitis" OR "pneumonitides")	14462
# 1	TS=("cow" OR "cows" OR "cattle" OR heifer* OR "steer" OR "steers" OR "bull" OR "bulls" OR "calf" OR "calves" OR "youngstock*" OR "young-stock*" OR "beef" OR "veal" OR bovine* OR "bovinae" OR buiatric*)	39545

Table S4: Search results for Conference Proceedings Citation Index Science (CPCI-S), Search date: 04/07/18, Interface: Web of Science, Database coverage dates: 1990-03/07/18. All search stings were conducted for all years (Timespan=All years) except search line 11 which was limited to 2014-2018

Search Number	Search String	Hits
#1	NOFT(cow OR cows OR cattle OR heifer* OR steer OR steers OR bull OR bulls OR calf OR calves OR youngstock* OR "young-stock*" OR beef OR veal OR bovine* OR bovinae OR buiatric*)	352207
#2	NOFT("respiratory disease*" OR "respiratory tract disease*" OR "respiratory virus*" OR "respiratory tract virus*" OR "shipping fever*" OR "undifferentiated fever*" OR BRD OR BRDC OR pasteurellosis OR pneumonia* OR pleuropneumonia* OR pneumonitis OR pneumonitides)	20219
#3	NOFT(herpesvirus* OR "herpes virus*" OR herpesviridae* OR "herpes viridae*" OR BoHV-1 OR BoHV1 OR BHV-1 OR BHV1 OR BHV OR BoHV OR rhinotracheitis OR rhinotracheitides OR IBRV OR IBR)	9692
#4	NOFT((viral OR virus OR viruses) NEAR/3 (diarrhoea* OR diarrhea*))	2816
#5	NOFT(BVD OR BVDV OR BVDV1 OR BVDV2 OR pestivirus OR coronavirus OR BCV)	3826
#6	NOFT("respiratory syncytial virus*" OR BRSV OR RSV)	1541
#7	NOFT(parainfluenza3 OR influenza3 OR "parainfluenza 3" OR "influenza 3" OR "parainfluenza three" OR "influenza three" OR "parainfluenza type 3" OR "influenza type 3" OR "parainfluenza type three" OR "influenza type three" OR PI-3 OR PI3)	1387
#8	S7 OR S6 OR S5 OR S4 OR S3 OR S2	35909
#9	NOFT(vaccin* OR immunis* OR immuniz* OR innoculat*)	57207
#10	S9 AND S8 AND S1	1632
#11	(S9 AND S8 AND S1) AND pd(20140101-20181231)	220
#12	NOFT("mannheimia haemolytica" OR "mannheimia hemolytica" OR "m haemolytica" OR "m hemolytica" OR "pasteurella haemolytica" OR "pasteurella hemolytica" OR "p haemolytica" OR "p hemolytica" OR mannheimios*)	1239
#13	NOFT("haemophilus somn*" OR "hemophilus somn*" OR "histophilus somn*" OR "h somnus" OR "h somni")	325
#14	NOFT("pasteurella multocida" OR "p multocida" OR mycoplasma)	8563
#15	S14 OR S13 OR S12	9808
#16	S15 AND S9 AND S1	423
#17	S16 OR S11	602

Table S5: Search results for AGRICOLA, Search date: 05/07/18, Interface: ProQuest, Database coverage dates: 1970 to current.

Vaccine	Abreviation
SINGLE AGENTS	
Placebo or Nothing	NAC
Presponse (aka Presponse SQ)	A
Presponse HM	B
Bovi-Shield IBR-PI3 (aka Bovi-Shield MLV)	C
IBR/PI-3 MLV (incl. Coopers IBR-PI3) incl intranasal	D
Pyramid 4	E
Reliant IBR	F
Pyramid 5	G
Bovi-Shield Gold	H
Rispoval	I
Bovi-Shield 4	J
PASTVAC	K
Poly-Bac B	L
PRECON-PH	M
Somubac	N
Pneumo-Star	O
Somnu-Star	P
Somnu-Star Ph	Q
Once PMH	R
No brand name 3-way vaccine (IBR/PI-3/BRSV MLV)	S
Resbo IBR-BVD	T
No brand name 4-day vaccine (IBR, BVDV, PI-3V, BRSV MLV)	U
IBR/PI-3/Somnugen	V
LktA-deficient *Mannhaemia haemolytica*	W
modified *Pasteurella haemolytica* biotype A serotype 1 leukotoxin vaccine	X
live lyophilized *Pasteurella haemolytica* serotype 1 intradermal (A.H. Robbins Co.)	Y
Bovi-Shield Gold One Shot	Z
COMBINATION INTERVENTIONS	
Pasteurella haemolytica vaccine + glycoprotein IV (gIV) of BHV-1 + Fermicon 7/Somnugen	PHBHSOM
Bovilan RP + Fermicon 7/Somnugen	BOVSOM
glycoprotein IV (gIV) of BHV-1 vaccine + Fermicon 7/Somnugen	BHSOM
Pasteurella haemolytica + Bovilan RP + Fermicon 7/Somnugen	PHBOVSOM
Presponse + Bovilan	PRESBOV
Bovi-Shield IBR-PI3-BRSV + Ultrabac 7/Somubac	BS3SOM
Bovi-Shield 4 + Ultrabac 7/Somubac	BS4SOM
Titanium 5 L5 + Presponse HM + MLV IBR, BVDV, PI-3V, and BRSV vaccine	T5PRE
Express 3 + Pulmo-guard PHM-1 + Fermicon 7/Somnugen	EXPMHSOM
Bovi-Shield 4 + One Shot + Fermicon 7/Somnugen	BS4ONESOM
Titanium 5 + Titanium BRSV	T5BRSV
Titanium 5 + Titanium BRSV + LktA-deficient *Mannhaemia haemolytica*	T5BRSVLKT
Leukotox, IM, 1 dose + Reliant IBR	LEUKOIBR
Pyramid 5 + Zelnate + Presponse SQ	P5ZELPRE
Express 5 twice + Bar-Vac 7/Somnus + Pulmo-guard PHM-1	EX5SOMPHM
Pyramid 5 + Bar-Vac 7/Somnus + Pulmo-guard PHM-1	P5SOMPHM
Presponse + Pyramid FP 5 + Ultrabac 7/Somubac	PREP5SOM
Pulmo-Guard PMH1 + Pyramid FP 5 + Ultrabac 7/Somubac	PMHP5SOM
Pulmo-Guard PMH1 + Pyramid 4	PMHP4
Bovalan-4K + Presponse	BOVA4PRE
Endovac-Bovi + Horizon 1 + VAC 3	ENDHOR3
Autogenous + Horizon 1 + VAC 3	AUTOHOR1V3
Horizon 1 + VAC 3	H1VAC3
Autogenous + IBR/PI-3/BRSV MLV	AUTONONAME3
commercially available hyperimmune serum of bovine origin + IBR/BVDV/PI-3 MLV + *Haemophilus somnus* bacterin	HYPER3SOM
IBR/BVDV/PI-3 MLV + *Haemophilus somnus* bacterin	NONAMESOM
Horizon IV (BRSV, PI-3, BVDV, IBR) + *Haemophilus somnus* bacterin	HSOM
Presponse + Horizon IV (BRSV, PI-3, BVDV, IBR) + *Haemophilus somnus* bacterin	PREHSOM
BRSV Vac + Presponse + IBR-PI3/Somnugen	BRSVPRESOM

Vaccine	Abreviation
BRSV Vac + IBR-PI3/Somnugen	BRSVIBRSOM
BRSV Vac + Coopers IBR-PI3	BRSVCOOP
Nasalgen (IBR) + Jencine (BVDV)	NAJEN
Encon-P, 2 doses + Nasalgen (IBR) + Jencine B (BVDV)	ENNAJEN
Somnugen, injected, 1 dose + Nasalgen (IBR) + Jencine (BVDV)	NAJENSOM
Pyramid 4, 2 doses + Vision 7 Somnus with Spur + Presponse	P4SOMPRE
Pyramid IBR, 2 doses + Vision 7 Somnus with Spur + Presponse	PIBRSOMPRE
Somnugen, injected, 1 dose + modified live virus intranasal vaccine for IBR/PI-3 (like V but apparently two products)	SOMIBR
Pasteurella bacterins + IBR/PI-3 vaccine	PAIBR
IBR/PI-3 vaccine [unclear if this is MLV or not] (could be V but the paper isn't clear about MLB or killed)	IBRPI
Vitamin E	Ignored as a treatment
Chromium (Metalosate)	Ignored as a treatment

Table S6: Single and combined vaccination products used in the studies included in the review.

Refid	Citation	Study ID	Country	Setting	Year	Pens	Concurrent treatments
72	(van Donkersgoed et al. 1993)		Canada	University/ Research feedlot	1990	NR	Nothing
73	(Harland et al. 1992)		Canada	Commercial feedlot	1989-1990	NR	Antiparasitic treatment(s), Implants (hormones), Antibiotics : oxytetracycline (Liquamycin LA)
75	(Thorlakson et al. 1990)	Auction calves	Canada	Commercial feedlot	1988-1989	4	Nothing reported
76	(Bateman 1988)		Canada	University/ Research feedlot	1987	NR	No other treatments
77	(Martin et al. 1984)		Canada	Unspecified feedlot	1980	NR	Nothing
414	(Grooms et al. 2014)		USA	University/ Research feedlot	2003	1	Antiparasitic treatment(s), Implants (hormones)
509	(Kirkpatrick et al. 2008)		USA	Unspecified feedlot	NR	NR	Antiparasitic treatment(s), Vaccine(s): 7-way clostridial bacterin-toxoid (Clostridium chauveoi-septicum-novyisordellii-perfringens type C-perfringens type D)
513	(Wildman et al. 2008)		Canada	Commercial feedlot	2002-2003	6	Antiparasitic treatment(s), Implants (hormones), Antibiotics : "Animals in the first 4 replicates received parenteral metaphylactic long-acting oxytetracycline (Tetradure LA 300; Merial Canada), 30 mg/kg BW, IM, and animals in replicates 5 and 6 received parenteral metaphylactic tilmicosin (Micotil; Provel, Division, Eli Lilly Canada, Guelph, Ontario).."
577	(Frank et al. 2003)		USA	University/ Research feedlot	NR	16	Antiparasitic treatment(s), Vaccine(s): Electroid 7 (Clostridial vaccine)
595	(Frank et al. 2002)	Prophylactic florfenicol	USA	Unspecified feedlot	NR	8	Antiparasitic treatment(s), Antibiotics: florfenicol (40 mg/kg SC), Vaccine(s): Electroid 7 (Clostridial)
608	(O'Connor et al. 2001)	Feedlot A	Canada	Unspecified feedlot	1998	NR	Antibiotics : oxytetracycline
622	(Gummow & Mapham 2000)		South Africa	Unspecified feedlot	1995	NR	Antiparasitic treatment(s), Implants (hormones)
772	(Ribble et al. 1988)		Canada	Commercial feedlot	1985-1986	36	Antiparasitic treatment(s), Implants (hormones)
808	(Purdy et al. 1986)		USA	University/ Research feedlot	NR	NR	Antiparasitic treatment(s), Vaccine(s): Convac CSNS (Clostridium vaccine)
836	(Confer et al. 1983)		USA	University/ Research feedlot	NR	NR	Nothing reported
863	(Wohler & Baugh 1980)		USA	NR	NR	NR	Nothing reported
1024	(White et al. 2017)		USA	Backgrounding yard	2015	1	Antiparasitic treatment(s), Antibiotics: gamithromycin (Zactran)
1115	(Rogers et al. 2016)		USA	Commercial feedlot	2015-2016	15	Antiparasitic treatment(s), Antibiotics: tilmicosin

Refid	Citation	Study ID	Country	Setting	Year	Pens	Concurrent treatments
1165	(Bailey et al. 2016)		USA	University/ Research feedlot	NR	8	Antiparasitic treatment(s), Vaccine(s): Vision 7 with SPUR (Clostridial)
1287	(Richeson et al. 2015)		USA	University/ Research feedlot	2009-2010	8	Antiparasitic treatment(s), Antibiotics: tilmicosin (Micotil), Vaccine(s): Covexin-8 (Clostridium vaccine)
1288	(Rogers et al. 2015)		USA	Commercial feedlot	2013-2014	15	Antiparasitic treatment(s), Implants (hormones), Antibiotics: tilmicosin (Micotil), monensin (in feed), tylosin (in feed)
1631	(Rogers et al. 2009)		USA	Commercial feedlot	2007	12	Antiparasitic treatment(s), Implants (hormones), Antibiotics: tilmicosin (Micotil), monensin (in feed), tylosin (in feed)
1632	(Wildman et al. 2009)		USA	Commercial feedlot	2004	5	Antiparasitic treatment(s), Implants (hormones), Antibiotics: tilmicosin (Micotil 300)
1650	(Perrett et al. 2008)		Canada	Commercial feedlot	2005-2006	10	Antiparasitic treatment(s), Implants (hormones), Antibiotics: oxytetracycline (Tetradure LA 300)
1792	(MacGregor et al. 2003)		USA	Commercial feedlot	1997-1998	15	Antiparasitic treatment(s), Implants (hormones)
1974	(Malcolm-Callis et al. 1994)		USA	University/ Research feedlot	NR	3	Antiparasitic treatment(s), Vaccine(s): Barvac 7 (Clostridial)
1979	(Wright et al. 1994)		Canada	University/ Research feedlot	NR	11	Antiparasitic treatment(s)
2038	(Koevering et al. 1992)		USA	University/ Research feedlot	1991-1992	16	Antiparasitic treatment(s), Vaccine(s): 4-way Clostridial bacterin
2059	(Mills 1991)		USA	Unspecified feedlot	NR	NR	Vaccine(s): Site-guard (clostridial)
2060	(Bechtol et al. 1991)	1988 study	USA	Commercial feedlot	1988	NR	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): 4-way Clostridial bacterin
2078	(McLean et al. 1990)		USA	University/ Research feedlot	1988-1989	8	Antiparasitic treatment(s), Vaccine(s): 7-way clostridial
2140	(Jim et al. 1988)		Canada	Commercial feedlot	1987-1988	7	Antiparasitic treatment(s), Implants (hormones), Antibiotics: oxytetracycline (Oxymycine LA, Oxymycine LP), Vaccine(s): TASVAX (Clostridial)
2165	(Smith et al. 1986)		USA	University/ Research feedlot	1984-1985	12	Antiparasitic treatment(s), Vaccine(s): *Leptospira pomona* bacterin, *Clostridia chauvoie, septicum, novyi and sordellii baceterin*
2176	(Thomas et al. 1986)		England	Beef rearing farm	NR	NR	Nothing reported
2215	(Morter et al. 1984)		USA	Unspecified feedlot	1983	4	Antiparasitic treatment(s), Vaccine(s): 7-way clostridial bacterin toxoid
2255	(Morter & Amstutz 1983)		USA	Unspecified feedlot	NR	6	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): IM heptavalent clostridial bacterin-toxoid
2281	(Bennett 1982)		USA	Commercial feedlot	1978-1979	28 or 46	Antiparasitic treatment(s), Implants (hormones), Antibiotics : chlorotetracycline in feed

Refid	Citation	Study ID	Country	Setting	Year	Pens	Concurrent treatments
2282	(Morter et al. 1982)		USA	Unspecified feedlot	NR	NR	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): Electroid 7 (Clostridial)
2297	(Amstutz et al. 1981)		USA	Unspecified feedlot	1979	NR	Implants (hormones)
2339	(Griffin et al. 1979)		USA	University/ Research feedlot	NR	6	Antiparasitic treatment(s), Implants (hormones)
3305	(Schunicht et al. 2003)		Canada	Commercial feedlot	1999-2000	10	Antiparasitic treatment(s), Implants (hormones), Antibiotics : oxytetracycline (Tetradure LA-300)
4016	(McKaig & Taylor 2015)		USA	NR	NR	NR	Nothing reported
4166	(Frank et al. 2002)	No prophylactic florfenicol	USA	Unspecified feedlot	NR	8	Antiparasitic treatment(s), Vaccine(s): Electroid 7 (Clostidial)
4167	(O'Connor et al. 2001)	Feedlot B	Canada	Unspecified feedlot	1998	NR	Implants (hormones), Antibiotics : oxytetracycline if body temp less than 40 degrees C; tilmicosin if body temperature greater than 40 degrees C.
4168	(O'Connor et al. 2001)	Feedlot C	Canada	Unspecified feedlot	1998	NR	No other treatments
4169	(Bechtol et al. 1991)	1989 study	USA	Commercial feedlot	1989	NR	Nothing
4170	(Thorlakson et al. 1990)	Ranch calves	Canada	Commercial feedlot	1988-1989	11	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): Tasvax (Clostridial)
5003	(Stilwell et al. 2008)		Portugal	Unspecified feedlot	2003	1: "All calves are kept in the same open barn with slated concrete floor."	Nothing reported
5005	(Van Donkersgoed et al. 1990)	Trial #1	Canada	Custom feedlot	1988-1989	NR	Implants (hormones), Antibiotics: oxytetracycline (Liquamycin LA), Vaccine(s): Clostribac 7
5006	(Van Donkersgoed et al. 1990)	Trial #3	Canada	University/ Research feedlot	1987-1988	NR	Nothing
5007	(Van Donkersgoed et al. 1990)	Trial #4	Canada	Commercial feedlot	1988	NR	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): Tasvax 8 (Clostridial)
5008	(Van Donkersgoed et al. 1990)	Trial #5, Yearlings	Canada	Commercial feedlot	1988-1989	NR	Antiparasitic treatment(s), Antibiotics: oxytetracycline (Liquamycin LA), Vaccine(s): Tasvax 8 (Clostridial)
5009	(Van Donkersgoed et al. 1990)	Trial #5, Calves	Canada	Commercial feedlot	1988-1989	NR	Antiparasitic treatment(s), Implants (hormones), Vaccine(s): Tasvax 8, Coopers IBR-PI3, some calves got Somnugen, some calves got Presponse

Table S7: Characteristics of studies of the prevention of BRD incidence using vaccines included in the review. NR = not reported.

REFID	Citation	StudyID	Status	Fate of BRD cases diagnosed at arrival
72	(van Donkersgoed et al. 1993)	None	Not included in meta-analysis	Treated for BRD, randomly assigned to experimental group after initial treatment on day 0
73	(Harland et al. 1992)	None	Not included in meta-analysis	Excluded from study, treated for BRD
75	(Thorlakson et al. 1990)	Auction calves	Included in meta-analysis	NR
76	(Bateman 1988)	None	Included in meta-analysis	NR
77	(Martin et al. 1984)	None	Not included in meta-analysis	Not reported
414	(Grooms et al. 2014)	None	Not included in meta-analysis	Not reported
509	(Kirkpatrick et al. 2008)	None	Not included in meta-analysis	Not reported
513	(Wildman et al. 2008)	None	Not included in meta-analysis	Not reported
577	(Frank et al. 2003)	None	Not included in meta-analysis	Not reported
595	(Frank et al. 2002)	Prophylactic florfenicol	Not included in meta-analysis	Not reported
608	(O'Connor et al. 2001)	Feedlot A	Not included in meta-analysis	Not reported
622	(Gummow & Mapham 2000)	None	Not included in meta-analysis	Not reported
772	(Ribble et al. 1988)	None	Not included in meta-analysis	Not reported
808	(Purdy et al. 1986)	None	Included in meta-analysis	Received antibiotic treatment
836	(Confer et al. 1983)	None	Included in meta-analysis	Not reported
863	(Wohler & Baugh 1980)	None	Included in meta-analysis	Not reported
1024	(White et al. 2017)	None	Not included in meta-analysis	Not reported
1115	(Rogers et al. 2016)	None	Not included in meta-analysis	Excluded from study
1165	(Bailey et al. 2016)	None	Not included in meta-analysis	Received antibiotic treatment
1287	(Richeson et al. 2015)	None	Included in meta-analysis	Not reported
1288	(Rogers et al. 2015)	None	Included in meta-analysis	Excluded from study
1631	(Rogers et al. 2009)	None	Not included in meta-analysis	Not reported
1632	(Wildman et al. 2009)	None	Not included in meta-analysis	Not reported
1650	(Perrett et al. 2008)	None	Not included in meta-analysis	Not reported
1792	(MacGregor et al. 2003)	None	Not included in meta-analysis	Not reported
1974	(Malcolm-Callis et al. 1994)	None	Not included in meta-analysis	Not reported
1979	(Wright et al. 1994)	None	Included in meta-analysis	Not reported
2038	(Koevering et al. 1992)	None	Not included in meta-analysis	Not reported
2059	(Mills 1991)	None	Not included in meta-analysis	Not reported
2060	(Bechtol et al. 1991)	1988 study	Not included in meta-analysis	Not reported
2078	(McLean et al. 1990)	None	Included in meta-analysis	Received antibiotic treatment
2140	(Jim et al. 1988)	None	Not included in meta-analysis	Excluded from study, received antibiotic treatment, kept in same pen as study calves
2165	(Smith et al. 1986)	None	Not included in meta-analysis	Excluded from study, received antibiotic treatment
2176	(Thomas et al. 1986)	None	Included in meta-analysis	Not reported
2215	(Morter et al. 1984)	None	Not included in meta-analysis	Excluded from study
2255	(Morter & Amstutz 1983)	None	Not included in meta-analysis	Excluded from study
2281	(Bennett 1982)	None	Not included in meta-analysis	Not reported
2282	(Morter et al. 1982)	None	Not included in meta-analysis	Excluded from study
2297	(Amstutz et al. 1981)	None	Not included in meta-analysis	Excluded from study
2339	(Griffin et al. 1979)	None	Included in meta-analysis	Not reported
3305	(Schunicht et al. 2003)	None	Not included in meta-analysis	Not reported
4016	(McKaig & Taylor 2015)	None	Included in meta-analysis	Not reported
4166	(Frank et al. 2002)	No prophylactic florfenicol	Not included in meta-analysis	Not reported
4167	(O'Connor et al. 2001)	Feedlot B	Not included in meta-analysis	Received antibiotic treatment
4168	(O'Connor et al. 2001)	Feedlot C	Included in meta-analysis	Not reported
4169	(Bechtol et al. 1991)	1989 study	Not included in meta-analysis	Not reported

REFID	Citation	StudyID	Status	Fate of BRD cases diagnosed at arrival
4170	(Thorlakson et al. 1990)	Ranch calves	Not included in meta-analysis	Randomly assigned to experimental group after initial treatment on day 0
5003	(Stilwell et al. 2008)	None	Included in meta-analysis	No sick animals at arrival
5005	(Van Donkersgoed et al. 1990)	Trial #1	Not included in meta-analysis	Received antibiotic treatment
5006	(Van Donkersgoed et al. 1990)	Trial #3	Not included in meta-analysis	Excluded from study, received antibiotic treatment
5007	(Van Donkersgoed et al. 1990)	Trial #4	Not included in meta-analysis	Not reported
5008	(Van Donkersgoed et al. 1990)	Trial #5, Yearlings	Not included in meta-analysis	Excluded from study, received antibiotic treatment
5009	(Van Donkersgoed et al. 1990)	Trial #5, Calves	Not included in meta-analysis	Excluded from study, Received antibiotic treatment

Table S8: Fate of Bovine Respiratory Disease (BRD) cases diagnosed at arrival in studies relevant to the review.

REFID	Citation	Study	Status	BRD Outcome Definition
72	(van Donkersgoed et al. 1993)	None	Not included in meta-analysis	"The case definition of bovine respiratory disease (BRD) included the presence of fever (rectal temperature greater than or equal to 40 degrees C), depression, and clinical signs restricted to the respiratory system."
73	(Harland et al. 1992)	None	Not included in meta-analysis	"Calves were selected as BRD cases when they appeared depressed or inappetent, and/or if they had symptoms attributable to the respiratory system, and they had to have a rectal temperature greater than or equal to 40.0 degrees C."
75	(Thorlakson et al. 1990)	Auction calves	Included in meta-analysis	Morbidity with temperature greater than 39.5 degrees C.
76	(Bateman 1988)	None	Included in meta-analysis	"Calves were monitored for visual signs of respiratory disease (depression, anorexia, gauntness, or polypnea) and if upon examination found to be febrile (greater than 39.5 degrees C), treated according to a standard antimicrobial therapy protocol."
77	(Martin et al. 1984)	None	Not included in meta-analysis	Not reported
414	(Grooms et al. 2014)	None	Not included in meta-analysis	Not reported
509	(Kirkpatrick et al. 2008)	None	Not included in meta-analysis	"Calves were observed for signs of BRD by experienced farm personnel and treated according to subjective assessments of severity of illness and rectal temperature greater than 39.7 degrees C (103.5 degrees F)."
513	(Wildman et al. 2008)	None	Not included in meta-analysis	Undifferentiated Fever: "A diagnosis of UF was made when an animal showed evidence of depression, as characterized by lack of response to stimulation, reluctance to move, and/or abnormal posture/carriage of the head; a lack of abnormal clinical signs referable to body systems other than the respiratory system; a rectal temperature greater than 40.5 degrees C; and no previous treatment history for UF/BRD."
577	(Frank et al. 2003)	None	Not included in meta-analysis	Respiratory tract disease: "Clinical signs included nasal or ocular discharge, labored breathing, lethargy, and emaciated body condition. Calves that had clinical signs of RTD were taken to a processing facility, and those with a rectal temperature greater than 39.7 degrees C received medical treatment"
595	(Frank et al. 2002)	Prophylactic florfenicol	Not included in meta-analysis	"Signs monitored included nasal or ocular discharge, labored breathing, lethargy, and emaciated body condition. Steers that had signs of RTD were moved to a processing facility, and those with rectal temperature greater than 39.7 degrees C received antibiotics."
608	(O'Connor et al. 2001)	Feedlot A	Not included in meta-analysis	Not reported
622	(Gummow & Mapham 2000)	None	Not included in meta-analysis	"The case definition included one or more of the symptoms of listlessness, anorexia, dyspnoea, hyperpnoea, coughing, mucopurulent discharge from the eyes or nostrils and the absence of symptoms of disease of any other organ system."
772	(Ribble et al. 1988)	None	Not included in meta-analysis	Not reported
808	(Purdy et al. 1986)	None	Included in meta-analysis	"A point system was used, with one point being recorded for each of the following: ocular discharge, nasal discharge, gaunt appearance, or depression. If a calf was assigned 2 points it was isolated and its rectal temperature was recorded. If the temperature exceeded 40 degrees C, 2 more points were assigned. A calf with 4 points or more was considered sick and antibiotic therapy was instituted."

REFID	Citation	Study	Status	BRD Outcome Definition
836	(Confer et al. 1983)	None	Included in meta-analysis	"Health status was determined by the assignment of points to clinical signs of disease as follows: 2 points, absolute anorexia; 2 points, rectal temperature of 40 degrees C or greater; 1 point, nasal discharge; 1 point, ocular discharge; 1 point, severe depression. An animal with four or more of seven possible points on a given day was considered sick and treated with antibiotics for 4 days."
863	(Wohler & Baugh 1980)	None	Included in meta-analysis	Not reported
1024	(White et al. 2017)	None	Not included in meta-analysis	BRD morbidity (clinical signs observed by human and REDI (remote early disease identification) system)
1115	(Rogers et al. 2016)	None	Not included in meta-analysis	"Standard feedlot protocol specified that cattle must have a rectal temperature of greater than or equal 104 degrees F (40 degrees C), and any 1 of the following clinical signs of BRD, including depression, lowered head carriage, nasal and/or ocular discharge, coughing, stiff gait or depressed ruminal fossa to qualify for treatment for respiratory disease."
1165	(Bailey et al. 2016)	None	Not included in meta-analysis	"Calves displaying symptoms of BRD, based on criteria from the DART system (Pharmacia Upjohn Animal Health, Kalamazoo, MI; Step et al., 2008), were removed from pens and evaluated. Each calf with clinical signs of BRD was weighed, rectal temperature was measured, and a clinical illness score was assigned (scale: 1 to 4; 1 equals normal, 4 equals moribund). Calves that presented a clinical illness score greater than 1 and a rectal temperature greater than 40 degrees C were treated with therapeutic antibiotics according to label directions (first incidence - Baytril, Bayer Animal Health, Shawnee Mission, KS; second incidence - Nuflor, Merck Animal Health, Summit, NJ)."
1287	(Richeson et al. 2015)	None	Included in meta-analysis	"Cattle observed with greater than or equal to 2 visual signs of BRD were removed from their pen, restrained and rectal temperature (RT) was determined using a digital thermometer. Calves with RT greater than or equal to 104 degrees F (40 degrees C) were considered morbid and were treated with an antimicrobial according to a pre-determined protocol specific for the current study."
1288	(Rogers et al. 2015)	None	Included in meta-analysis	"Standard feedlot protocol specified that cattle must have a rectal temperature of greater than or equal to 104 degrees F (40 degrees C), and clinical signs of BRD, including depression, lowered head carriage, nasal and/or ocular discharge, coughing, stiff gait, or depressed ruminal fossa, to qualify for treatment."
1631	(Rogers et al. 2009)	None	Not included in meta-analysis	"A diagnosis of BRD was made when a calf demonstrated clinical signs of depression (e.g. unresponsive to activity in the pen, lowered head, dropped ears, inappetance), absence of signs ascribed to other body systems, and a rectal temperature of 104 degrees F (40 degrees C) or higher."
1632	(Wildman et al. 2009)	None	Not included in meta-analysis	UF (undifferentiated fever/BRD): "A diagnosis of UF was made when an animal showed evidence of depression, as characterized by lack of response to stimulation, reluctance to move and/or abnormal posture/carriage of the head; a lack of abnormal clinical signs referable to body systems other than the respiratory system; a rectal temperature greater than 104.5 degrees F (40.3 degrees C) and no previous treatment history for UF/BRD."

REFID	Citation	Study	Status	BRD Outcome Definition
1650	(Perrett et al. 2008)	None	Not included in meta-analysis	Undifferentiated fever (UF): "A diagnosis of UF was made when an animal showed evidence of depression, as characterized by lack of response to stimulation, reluctance to move and/or abnormal posture/carriage of the head; a lack of abnormal clinical signs referable to systems other than the respiratory system; a rectal temperature greater than 105.0 degrees F (40.6 degrees C); and no previous treatment history for BRD with no fever (NF)."
1792	(MacGregor et al. 2003)	None	Not included in meta-analysis	"Calves were observed daily for signs of respiratory disease (depression, lack of rumen fill, and ocular or nasal discharge). Calves classified as morbid had at least one of these signs and a rectal temperature greater than or equal to 103.5 degrees F."
1974	(Malcolm-Callis et al. 1994)	None	Not included in meta-analysis	"Calves with BRD symptoms (i.e. nasal discharge, labored breathing, lethargy and/or emaciated body condition) were removed from their pens and weighed. If rectal temperature of 103 degrees F or greater was obtained, sick calves were treated with antibiotics."
1979	(Wright et al. 1994)	None	Included in meta-analysis	"Briefly, steers were observed following the morning feeding and late in the afternoon, for signs of nasal discharge, ocular discharge, gaunt appearance, depression or other signs including coughing, irregular, labored or rapid breathing, and shivering. One point was assigned for each of the symptoms observed. Rectal temperature was recorded for steers receiving two or more points. If rectal temperature was greater than or equal to 40 degrees C the steer was classed as morbid and treated according to established protocol for the EBRC."
2038	(Koevering et al. 1992)	None	Not included in meta-analysis	"Calves were monitored twice daily for sickness (rectal temperature greater than 104 degrees F or visually depressed.)"
2059	(Mills 1991)	None	Not included in meta-analysis	"The number of ill calves removed (sick pulls) from the pen on the basis of exhibiting respiratory clinical signs..."
2060	(Bechtol et al. 1991)	1988 study	Not included in meta-analysis	"All calves exhibiting signs of coughing, depression, dullness, anorexia, labored breathing or excessive nasal discharge were removed from the pens for individual examination and treatment. Based on these clinical signs, a diagnosis of undifferentiated BRD was made and antibiotic therapy was administered."
2078	(McLean et al. 1990)	None	Included in meta-analysis	"Signs used to diagnose the disease were excessive nasal discharge, coughing, labored breathing, lethargy, reluctance to eat, and a rectal temperature exceeding 104 degrees F."
2140	(Jim et al. 1988)	None	Not included in meta-analysis	"A diagnosis of undifferentiated bovine respiratory disease was made if the following criteria were satisfied: 1) the individual animal treatment record showed no history of treatment for sickness, 2) the rectal temperature was greater than or equal to 104 degrees F, 3) there were no clinical signs referable to organ systems other than the respiratory tract, 4) there were no clinical signs indicating possible advanced lung pathology such as obvious weakness, dyspnea, or severe dehydration."
2165	(Smith et al. 1986)	None	Not included in meta-analysis	"If the body temperature exceeded 104 degrees F the animal was considered sick. Animals could also be classified as sick based on clinical signs."
2176	(Thomas et al. 1986)	None	Included in meta-analysis	Not reported
2215	(Morter et al. 1984)	None	Not included in meta-analysis	"The judgment of the investigators of the clinical condition of the calf, not just a temperature of 104 degrees F or greater determined initiation of antimicrobial treatment."
2255	(Morter & Amstutz 1983)	None	Not included in meta-analysis	"Some steers with rectal temperatures of less than 104 degrees F, but other clinical signs of BRD were put on treatment."
2281	(Bennett 1982)	None	Not included in meta-analysis	"Animals with rectal temperatures in excess of 103.5 degrees F or those with persisting signs of clinical disease..."

REFID	Citation	Study	Status	BRD Outcome Definition
2282	(Morter et al. 1982)	None	Not included in meta-analysis	"The criteria for establishing a diagnosis of BRD were serous nasal discharge, respiratory rate, general attitude, gait and rectal temperature of 104.0 degrees F or higher."
2297	(Amstutz et al. 1981)	None	Not included in meta-analysis	"A rectal temperature of 104 degrees F or greater and/or the clinical condition of the animal indicated that antibiotic therapy should be initiated."
2339	(Griffin et al. 1979)	None	Included in meta-analysis	"All calves were observed daily, calves showing early signs of BRD; cough, mild anorexia, changes in attitude and gait, dyspnea, and serious occulonasal discharges were removed from the pen for examination. Animals with a rectal temperature greater than 39.4 degrees C were treated by the following regimen."
3305	(Schunicht et al. 2003)	None	Not included in meta-analysis	"In this study, the case definition for UF (undifferentiated fever) was a lack of abnormal clinical signs referable to body systems other than the respiratory system and an elevated rectal temperature of greater than 40.5 degrees C."
4016	(McKaig & Taylor 2015)	None	Included in meta-analysis	Not reported
4166	(Frank et al. 2002)	No prophylactic florfenicol	Not included in meta-analysis	"Signs monitored included nasal or ocular discharge, labored breathing, lethargy, and emaciated body condition. Steers that had signs of RTD (respiratory tract disease) were moved to a processing facility, and those with rectal temperature greater than 39.7 degrees C received antibiotics."
4167	(O'Connor et al. 2001)	Feedlot B	Not included in meta-analysis	Not reported
4168	(O'Connor et al. 2001)	Feedlot C	Included in meta-analysis	Not reported
4169	(Bechtol et al. 1991)	1989 study	Not included in meta-analysis	Not reported
4170	(Thorlakson et al. 1990)	Ranch calves	Not included in meta-analysis	Body temperature greater than 39.5 degrees C. "A diagnosis of undifferentiated BRD was made on these 'pulled' calves if, on the first examination by animal health staff, the animal had no clinical signs which indicated that organ systems other than the respiratory system were involved. Most, but not all, cases of BRD were febrile (greater than 39.5 degrees C) on examination."
5003	(Stilwell et al. 2008)	None	Included in meta-analysis	"Clinical signs used in the selection of BRD affected animals were: isolation from herdmates, decreased appetite, depression (first signs detected by herdsman) and dyspnea, cough, nasal and ocular discharge and hyperthermia (greater than 39.5 8 degrees C), that resulted from the vet-conducted physical examination. Only animals showing all of these signs (albeit with different severities) were included in the BRD-affected group."
5005	(Van Donkersgoed et al. 1990)	Trial #1	Not included in meta-analysis	"The case definition of first time treatment for BRD was as follows: 1) a rectal temperature greater than or equal to 40.0 degrees C (fever); 2) an appearance that was subjectively different from penmates; and 3) the absence of clinical signs attributable to any organ system other than the respiratory system."
5006	(Van Donkersgoed et al. 1990)	Trial #3	Not included in meta-analysis	"The case definition of first time treatment for BRD was as follows: 1) a rectal temperature greater than or equal to 40.0 degrees C (fever); 2) an appearance that was subjectively different from penmates; and 3) the absence of clinical signs attributable to any organ system other than the respiratory system."
5007	(Van Donkersgoed et al. 1990)	Trial #4	Not included in meta-analysis	"The case definition of first time treatment for BRD was as follows: 1) a rectal temperature greater than or equal to 40.0 degrees C (fever); 2) an appearance that was subjectively different from penmates; and 3) the absence of clinical signs attributable to any organ system other than the respiratory system."

REFID	Citation	Study	Status	BRD Outcome Definition
5008	(Van Donkersgoed et al. 1990)	Trial #5, Yearlings	Not included in meta-analysis	"The case definition of first time treatment for BRD was as follows: 1) a rectal temperature greater than or equal to 40.0 degrees C (fever); 2) an appearance that was subjectively different from penmates; and 3) the absence of clinical signs attributable to any organ system other than the respiratory system."
5009	(Van Donkersgoed et al. 1990)	Trial #5, Calves	Not included in meta-analysis	"The case definition of first time treatment for BRD was as follows: 1) a rectal temperature greater than or equal to 40.0 degrees C (fever); 2) an appearance that was subjectively different from penmates; and 3) the absence of clinical signs attributable to any organ system other than the respiratory system."

Table S9: Definitions of Bovine Respiratory Disease (BRD) reported by authors of studies relevant to the review.

REFID	Citation	Random Sequence	Sequence Concealment	Baseline Imbalances	Intended Interventions	Missing Outcome Data	Mismeasured Outcomes	Selective Outcome Reporting
72	(van Donkersgoed et al. 1993)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
73	(Harland et al. 1992)	No information random	No information	No information	Low	Low	Low	Some concerns
75	(Thorlakson et al. 1990)	Probably no	Probably yes	No information	Low	Low	Low	Some concerns
76	(Bateman 1988)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
77	(Martin et al. 1984)	No information random	Probably yes	No information	Low	High	Some concerns	Some concerns
414	(Grooms et al. 2014)	Yes	Probably yes	Probably no	Low	Low	Low	Some concerns
509	(Kirkpatrick et al. 2008)	Yes	Probably yes	No	Low	Low	Low	Some concerns
513	(Wildman et al. 2008)	Yes	Probably yes	No	Low	Low	Low	Some concerns
577	(Frank et al. 2003)	NC	NC	NC	NC	NC	NC	NC
595	(Frank et al. 2002)	No	Probably yes	No information	Low	Low	Low	Some concerns
608	(O'Connor et al. 2001)	No	Probably yes	No information	Low	Low	Some concerns	Some concerns
622	(Gummow & Mapham 2000)	No information random	Probably yes	No	Low	Low	Low	Some concerns
772	(Ribble et al. 1988)	Probably no	Probably yes	No information	Low	Low	Low	Some concerns
808	(Purdy et al. 1986)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
836	(Confer et al. 1983)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
863	(Wohler & Baugh 1980)	No	Probably yes	No information	Low	Low	Low	Some concerns
1024	(White et al. 2017)	Yes	Probably yes	No	Low	Some concerns	Low	Some concerns
1115	(Rogers et al. 2016)	Yes	Probably yes	No	Low	Low	Low	Some concerns
1165	(Bailey et al. 2016)	No information random	Probably yes	No	Low	Low	Low	Some concerns
1287	(Richeson et al. 2015)	No information random	Probably yes	Probably no	Low	Some concerns	Low	Some concerns
1288	(Rogers et al. 2015)	Yes	Probably yes	No	Low	Low	Low	Some concerns
1631	(Rogers et al. 2009)	No information random	Probably yes	No	Low	Low	Low	Some concerns
1632	(Wildman et al. 2009)	Yes	Probably yes	No	Low	Low	Low	Some concerns

REFID	Citation	Random Sequence	Sequence Concealment	Baseline Imbalances	Intended Interventions	Missing Outcome Data	Mismeasured Outcomes	Selective Outcome Reporting
1650	(Perrett et al. 2008)	Yes	Probably yes	No	Low	Low	Low	Some concerns
1792	(MacGregor et al. 2003)	Yes	Probably yes	No information	Low	Some concerns	Low	Some concerns
1974	(Malcolm-Callis et al. 1994)	No information at all	Probably yes	No information	Low	Low	Low	Some concerns
1979	(Wright et al. 1994)	No information random	Probably yes	Probably no	Low	Low	Low	Some concerns
2038	(Koevering et al. 1992)	No information at all	Probably yes	Probably yes	Low	Low	Low	Some concerns
2059	(Mills 1991)	No information random	Probably yes	No information	Low	Low	Some concerns	Some concerns
2060	(Bechtol et al. 1991)	Yes	Probably yes	No information	Low	Low	Low	Some concerns
2078	(McLean et al. 1990)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
2140	(Jim et al. 1988)	Probably no	Probably yes	No information	Low	Low	Low	Some concerns
2165	(Smith et al. 1986)	No information random	Probably yes	Probably no	Low	Low	Some concerns	Some concerns
2176	(Thomas et al. 1986)	No information at all	Probably yes	No information	Low	Low	Low	Some concerns
2215	(Morter et al. 1984)	Yes	Probably yes	No information	Low	Low	Some concerns	Some concerns
2255	(Morter & Amstutz 1983)	Yes	Probably yes	No information	Low	Low	Some concerns	Some concerns
2281	(Bennett 1982)	No information at all	Probably yes	Probably yes	Low	Low	Some concerns	Some concerns
2282	(Morter et al. 1982)	Yes	Probably yes	No information	Low	Low	Low	Some concerns
2297	(Amstutz et al. 1981)	Yes	Probably yes	Probably yes	Low	Low	Some concerns	Some concerns
2339	(Griffin et al. 1979)	No information random	Probably yes	No information	Low	Some concerns	Low	Some concerns
3305	(Schunicht et al. 2003)	Yes	Probably yes	No	Low	Low	Low	Some concerns
4016	(McKaig & Taylor 2015)	Yes	Probably yes	No information	Low	Some concerns	Low	Some concerns
4166	(Frank et al. 2002)	No	Probably yes	No information	Low	Low	Low	Some concerns
4167	(O'Connor et al. 2001)	No	Probably yes	No information	Low	Low	Some concerns	Some concerns
4168	(O'Connor et al. 2001)	No	Probably yes	No information	Low	Low	Some concerns	Some concerns
4169	(Bechtol et al. 1991)	No information at all	Probably yes	No information	Low	Low	Some concerns	Some concerns

REFID	Citation	Random Sequence	Sequence Concealment	Baseline Imbalances	Intended Interventions	Missing Outcome Data	Mismeasured Outcomes	Selective Outcome Reporting
4170	(Thorlakson et al. 1990)	No information random	Probably yes	No information	Low	Low	Low	Some concerns
5003	(Stilwell et al. 2008)	No	Probably yes	Probably yes	Low	Low	Low	Some concerns
5005	(Van Donkersgoed et al. 1990)	Yes	Probably yes	No information	Low	Low	Low	High
5006	(Van Donkersgoed et al. 1990)	No information random	Probably yes	No information	Low	Low	Low	High
5007	(Van Donkersgoed et al. 1990)	No information random	Probably yes	No information	Low	Low	Low	High
5008	(Van Donkersgoed et al. 1990)	No	Probably yes	No information	Low	Low	Low	High
5009	(Van Donkersgoed et al. 1990)	No	Probably yes	No information	Low	Low	Low	High

Table S10: Risk of bias for studies included in the review. NC = not conducted because no numerical results were reported.

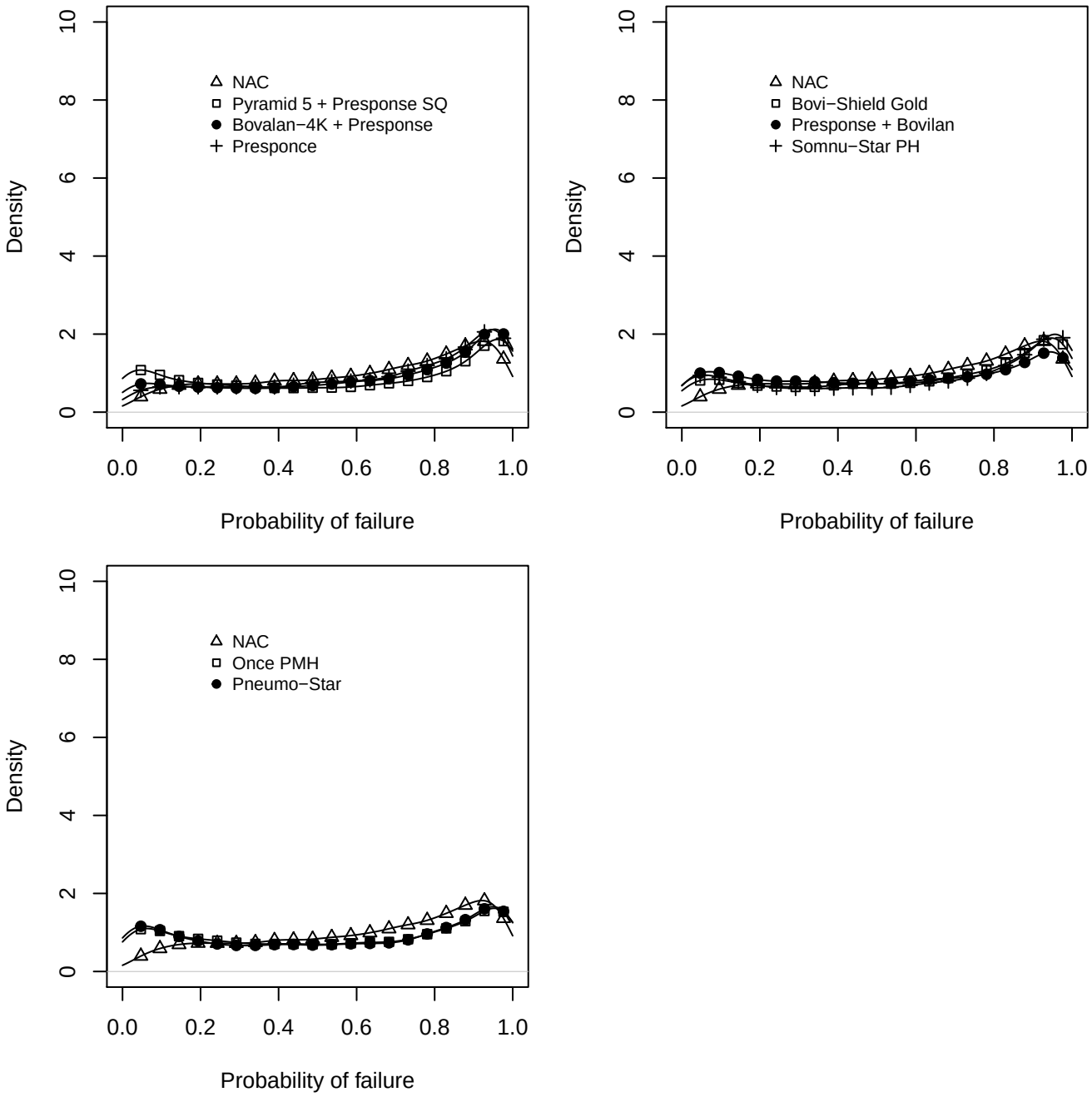

Figure S1: Distributions of the probability of response for each treatment.

Comparison	Number of studies	Randomization	Blinding	Across.studies.bias	Imprecision	Heterogeneity
A:NAC	2	Major concerns	Some concerns	Undetected	Major concerns	No concerns
BOVA4PRE:NAC	1	Major concerns	Major concerns	Undetected	Major concerns	No concerns
I:NAC	2	Some concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:O	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:P	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:Q	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:R	1	Major concerns	No concerns	Undetected	Major concerns	No concerns
NAC:Z	1	Major concerns	No concerns	Undetected	Major concerns	No concerns
O:P	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
O:Q	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
P:Q	1	Major concerns	Some concerns	Undetected	Major concerns	No concerns
R:Z	1	Major concerns	No concerns	Undetected	Major concerns	No concerns
A:BOVA4PRE	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
A:I	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
A:O	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
A:P	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
A:Q	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
A:R	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
A:Z	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
BOVA4PRE:I	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
BOVA4PRE:O	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
BOVA4PRE:P	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
BOVA4PRE:Q	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
BOVA4PRE:R	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
BOVA4PRE:Z	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
I:O	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
I:P	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
I:Q	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
I:R	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
I:Z	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
O:R	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
O:Z	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
P:R	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
P:Z	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
Q:R	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
Q:Z	0	Major concerns	Some concerns	Undetected	Major concerns	No concerns
H:NAC	1	Some concerns	Some concerns	Undetected	Major concerns	No concerns
L:NAC	1	Some concerns	Some concerns	Undetected	No concerns	Major concerns
M:NAC	1	Some concerns	Major concerns	Undetected	Major concerns	No concerns
NAC:PRESBOV	1	Some concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:T	1	Some concerns	Some concerns	Undetected	Major concerns	No concerns
NAC:Y	1	Some concerns	Major concerns	Undetected	Major concerns	No concerns
A-G:AUTONONAME3	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
A-G:H	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
A-G:L	0	Some concerns	Some concerns	Undetected	Some concerns	Some concerns
A-G:M	0	Some concerns	No concerns	Undetected	Major concerns	No concerns
A-G:NAC	0	Major concerns	No concerns	Undetected	Major concerns	No concerns
A-G:PRESBOV	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
A-G:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
A-G:Y	0	Some concerns	No concerns	Undetected	Major concerns	No concerns
AUTONONAME3:H	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
AUTONONAME3:L	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
AUTONONAME3:M	0	Some concerns	Major concerns	Undetected	Major concerns	No concerns
AUTONONAME3:NAC	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
AUTONONAME3:PRESBOV	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
AUTONONAME3:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
AUTONONAME3:Y	0	Some concerns	Major concerns	Undetected	Major concerns	No concerns
H:L	0	Some concerns	Some concerns	Undetected	No concerns	Major concerns
H:M	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
H:PRESBOV	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
H:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
H:Y	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
L:M	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
L:PRESBOV	0	Some concerns	Some concerns	Undetected	No concerns	Major concerns
L:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
L:Y	0	Some concerns	Some concerns	Undetected	Some concerns	Some concerns
M:PRESBOV	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
M:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
M:Y	0	Some concerns	Major concerns	Undetected	Major concerns	No concerns
PRESBOV:T	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
PRESBOV:Y	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns
T:Y	0	Some concerns	Some concerns	Undetected	Major concerns	No concerns

Table S11: Risk of bias for randomization, blinding, across-study bias, imprecision, and heterogeneity.

Question	Response and action
Title and abstract screening	
Q1) Based on the title/abstract, does the study describe primary research involving assessment of vaccines for the prevention of BRD in feedlot cattle?	Yes/Unclear (proceed to next question)
	No (exclude)
	No, but is a relevant review (exclude)
Q2) Based on the title/abstract, is there a concurrent comparison group (i.e., controlled trial with natural or deliberate disease exposure or analytical observational study)?	Yes/Unclear (proceed to full-text assessment)
	No (exclude)
Full-text screening	
Q1) Is the full text available in English?	Yes (proceed to next question)
	No (not in English) (specify language) (exclude)
	No (unable to obtain .pdf) (exclude)
	No (conference abstract, less than 500 words) (exclude)
Q2) Based on the full text, does the study involve primary research on the assessment of vaccines for the prevention of BRD in feedlot cattle?	Yes (proceed to next question)
	No (exclude)
Q3) Correct study design: Is the study a field trial (where an investigator is allocating animals to groups) with naturally occurring BRD?	Yes (proceed to the next question)
	No Challenge study (Indicate the organism(s) studied) (exclude)
	No - Observational study (Indicate the organism(s) studied) (exclude)
Q4) Based on the full text, is there a concurrent comparison group?	Yes (proceed to next question)
	No (exclude)
Q5) Correct population: Is the study population weaned calves in a non-grazing situation with naturally occurring BRD, i.e., feedlot cattle?	Yes (proceed to next question)
	No (exclude)
Q6) Correct Interventions and Comparator: Does the study assess the use of a commercially available monovalent or polyvalent vaccine for one of the following organisms (*Mannheimia haemolytica, Pasteurella heamolytica, Pasteurella multocida, Histophilus somni* or *Mycoplasma bovis*, bovine herpesvirus, bovine viral diarrhea virus, bovine respiratory syncytial virus, and parainfluenza type 3 virus)?	Yes (proceed to next question)
	No (exclude)
Q7) Correct outcome: Does the study report the risk of BRD in the study groups?	Yes (proceed to data extraction)
	No (exclude)

Table S12: Screening questions, response options and resulting actions for title/abstract and full-text screening.

	Mean	Median	Min	Max	0.025 quantile	0.975 quantile
NAC	0.61	0.67	0.00	1.00	0.07	0.98
Pyramid 5 + Presponse SQ	0.57	0.63	0.00	1.00	0.00	1.00
Bovalan-4K + Presponse	0.62	0.70	0.00	1.00	0.02	1.00
Presponse	0.63	0.71	0.00	1.00	0.04	0.99
Bovi-Shield Gold	0.60	0.67	0.00	1.00	0.02	1.00
Rispoval	0.69	0.79	0.00	1.00	0.05	1.00
Poly-Bac B	0.87	0.97	0.00	1.00	0.14	1.00
PRECON-PH	0.65	0.75	0.00	1.00	0.02	1.00
Somnu-Star	0.59	0.66	0.00	1.00	0.01	1.00
Resbo IBR-BVD	0.66	0.76	0.00	1.00	0.02	1.00
LLPH	0.64	0.74	0.00	1.00	0.02	1.00
Bovi-Shield Gold One Shot	0.56	0.60	0.00	1.00	0.01	1.00
Autog	0.65	0.76	0.00	1.00	0.01	1.00
Presponse + Bovilan	0.54	0.58	0.00	1.00	0.01	0.99
Somnu-Star PH	0.59	0.67	0.00	1.00	0.01	1.00
Once PMH	0.55	0.58	0.00	1.00	0.01	1.00
Pneumo-Star	0.55	0.58	0.00	1.00	0.01	1.00

Table S13: Summary of probability of treatment response.