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Abstract

It is widely accepted that antibiotic use drives the development of antibiotic resistance. Hence it is important that swine production uses antibiotics in a judicious manner. In addition, the label claim for livestock antibiotic growth promoters (AGP) of importance to humans has been removed in Canada. In reality, antibiotics have contributed greatly to efficiencies in meat production and animal health. A reduction in the use of growth promoting antibiotics has ramifications for costs of meat production and animal welfare given that sick animals need to be treated, often with antibiotics. Consequences of similar AGP bans in swine production in Europe included an immediate increase in therapeutic use of antibiotics considered important for humans, particularly for nursery stage pigs in Denmark and the Netherlands. It is important to identify and advance our knowledge through the existing research of alternative approaches to antibiotic use, in the nursery stage of pig production.

Scoping reviews are a relatively novel approach for synthesizing research evidence in the veterinary and livestock production research literature (Pham MT, 2014). They are useful for mapping the extent, range, and nature of existing literature on a broad topic area. In addition, scoping reviews are useful for identifying gaps in the literature and for determining the feasibility of conducting one or more systematic reviews to help answer a specific question about the effectiveness of a specific intervention in a specific population measuring a specific outcome (Arksey and O'Malley, 2005).

Disciplines

Large or Food Animal and Equine Medicine | Meat Science | Veterinary Preventive Medicine, Epidemiology, and Public Health | Veterinary Toxicology and Pharmacology

Protocol:

Non-antibiotic, alternative approaches to the nursery phase of swine production: a scoping review

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1. *The rationale*

It is widely accepted that antibiotic use drives the development of antibiotic resistance. Hence it is important that swine production uses antibiotics in a judicious manner. In addition, the label claim for livestock antibiotic growth promoters (AGP) of importance to humans has been removed in Canada. In reality, antibiotics have contributed greatly to efficiencies in meat production and animal health. A reduction in the use of growth promoting antibiotics has ramifications for costs of meat production and animal welfare given that sick animals need to be treated, often with antibiotics. Consequences of similar AGP bans in swine production in Europe included an immediate increase in therapeutic use of antibiotics considered important for humans, particularly for nursery stage pigs in Denmark and the Netherlands. It is important to identify and advance our knowledge through the existing research of alternative approaches to antibiotic use, in the nursery stage of pig production.

Scoping reviews are a relatively novel approach for synthesizing research evidence in the veterinary and livestock production research literature (Pham MT., 2014). They are useful for mapping the extent, range, and nature of existing literature on a broad topic area. In addition, scoping reviews are useful for identifying gaps in the literature and for determining the

feasibility of conducting one or more systematic reviews to help answer a specific question about the effectiveness of a specific intervention in a specific population measuring a specific outcome (Arksey and O'Malley, 2005).

2. Objective

The primary objective of this scoping review is to identify and describe the existing literature evaluating non-antibiotic approaches that may reduce the need for antibiotic use, through illness prevention, illnesses treatment, and enhance growth performance, at the nursery stage of pig production. A second objective is to determine the feasibility of conducting one or more systematic reviews to answer a specific question. A third objective is to identify gaps in the research on this broad topic area.

3. Stakeholder engagement

A stakeholder engagement process was employed to help inform the literature search and selection of identified topics of interest to the industry. Expert opinion was obtained from members of Canadian provincial and national swine associations, academia, and provincial governments.

4. The review question

What is the nature of the literature describing hypothesis testing studies, since 2000, evaluating non-antibiotic interventions (products or management practices) to prevent or treat illnesses and/or enhance the growth performance of pigs in the nursery stage of production in North America, Western Europe, or Australia/New Zealand?

5. Search strategy

Data platforms and databases:

Web of Science [SCI-EXPANDED, CPCI-S, ESCI] [Topic]

Web of Science MEDLINE [Topic]

ProQuest [4 databases: Agri&Envi Sci database, AGRICOLA & TOXLINE, Biological Sci. Database (MEDLILNE&TOXLINE), Dissertations & Theses Guelph, ProQuest Dissertations & theses] [anywhere except full text]

ProQuest AGICOLA [anywhere except full text]

PubMed [Title & Abstract]

Limitations: English, published since Jan. 1, 2000

Filters where available:

- Location [North America, Western Europe, or Australia/New Zealand]
- Document type [Article, Conference Paper, Conference Proceeding, Dissertation/Thesis, Government & Official Document, Industry Report, Technical Report, Working Paper/Pre-Print]
- Document source: ProQuest [Conference Papers & Proceedings, Dissertations & Theses, Government & Official Publications, Reports, Scholarly Journals, Working Papers]
- Subject filters where available [animals, swine, piglets, veterinary science, agriculture dairy or animal, agriculture multidisciplinary, agronomy]

Search terms and strings:

The search terms were combined using the boolean operator ‘OR’ and grouped according to population terms, intervention terms, and outcome terms. These three search term groupings were connected by the boolean operator ‘AND’ in a string. The search for interventions was divided into ‘products’ terms such as vaccines or direct fed microbials and ‘management’ terms such as sanitation or fermented feeds. The search for ‘products’ was conducted separately from the search for ‘management’ with the same filters applied according to the data platform/database.

Table of search terms and search strings

Population terms	AND Intervention terms – ‘products’	AND Outcome terms
(Piglet* OR weaner* OR “weaning pig*” OR “weanling pig*” OR “weaner pig*” OR “weaned pig*” OR “weaner stage” OR “weaner	(Antibiotic* OR antimicrobial* OR vaccin* OR immunization OR “sow vacc*” OR “dam vacc*” OR “gilt vacc*” OR “sow immunization” OR “dam immunization” OR “gilt immunization” OR “trace mineral*” OR “essential mineral*” OR “mineral source*” OR “mineral form*” OR	(health OR immun* OR diarrhea OR diarrhoea OR scours OR “colibacillosis” OR “fecal score” OR “clinical response*” OR “clinical parameters” OR “fecal shedding”

<p>phase" OR "nursery pig*" OR "young pig*" OR "younger pig*" OR "early-weaned pig*" OR "late-weaned pig*" OR "nursery-age*" OR "naïve pigs" OR "starter pig*" OR "neonate pig*" OR "neonatal pig*" OR "suckling pig*" OR "post-wean*" OR "nursery stage")</p>	<p>Zinc*OR vitamin* OR "dietary acid*" OR "organic acid*" OR "dietary fatty acid*" OR "medium chain fatty acid*" OR acidif* OR "feed enzyme*" OR fermentable OR fermented OR "plant extract*" OR herbal OR seaweed OR spice OR phytogetic OR "dietary lysine" OR "dietary tryptophan" OR lactoferrin OR lysozyme OR L-glutamine OR nutraceutical* OR nutraceutical* OR supplemental OR "dietary supplement*" OR "diet supplement*" OR "feed supplement*" OR "dietary additive*" OR "diet additive*" OR "feed additive*" OR inulin OR sweetener* OR oligosaccharide* OR polysaccharide* OR mannan* OR B-glucan* OR probiotic* OR prebiotic* OR synbiotic* OR "direct-fed microbial*" OR "competitive exclusion" OR yeast OR "Saccharomyces cerevisiae" OR "essential oil*" OR "fish meal" OR "blood meal" OR "spray-dried" OR immunoprophylaxis OR immunotherapeutic* OR "egg-yolk antibod*" OR "IgY antibod*" OR bacteriophages OR "antimicrobial peptide*" OR "bovine colostrum" OR "epidermal growth factor*" OR "rare earth" OR clay OR "natural alternative*" OR homeopath*)</p>	<p>OR "faecal shedding" OR morbidity OR mortality OR performance OR growth OR "daily weight gain" OR "average daily gain" OR "G:F" OR "gain-to-feed" OR "feed conversion" OR "feed intake" OR "ADG" OR ADFI OR "lightweight gain" OR productivity)</p>
<p>Population terms</p>	<p>AND Intervention terms – 'management'</p>	<p>AND Outcome terms</p>
<p>(Piglet* OR weaner* OR "weaning pig*" OR "weanling pig*" OR "weaner pig*" OR "weaned pig*" OR "weaner stage" OR "weaner phase" OR "nursery pig*" OR "young pig*" OR "younger pig*" OR "early-weaned pig*" OR "late-weaned pig*" OR "nursery-age*" OR "naïve pigs" OR "starter pig*" OR "neonate pig*" OR "neonatal pig*" OR "suckling pig*" OR "post-wean*" OR "nursery stage")</p>	<p>("natural pig*" OR "organic swine" OR "organic pig*" OR "natural conditions" OR "non-conventional" OR "antibiotic-free" OR "weaning practice*" OR "weaning method*" OR "weaning procedure*" OR "weaning regime*" OR "weaning system" OR "conventional weaning" OR "weaning age" OR "early weaning" OR "late wean*" OR "age at weaning" OR "creep feed*" OR "stocking" OR crowding OR overcrowding OR "floor space" OR "feeder space" OR "housing system*" OR "housing design*" OR "housing environment*" OR "housing type" OR ventilation OR "air quality" OR co-mingling OR "mingl*" OR "mixed litter" OR mixing OR "batch system" OR "batch management" OR biosecurity OR "sanit*" OR "disinfect*" OR "cleaning" OR hygiene OR "all-in-all-out" OR "pig flow" OR "disease eradication" OR "disease control*" OR "multi-site" OR "liquid feed" OR "liquid diet*" OR "pellet*" OR "low protein" OR "decreased protein" OR "restricted protein" OR "protein restrict*" OR "protein nutrition" OR "protein level" OR "protein source" OR "dietary protein" OR "restricted feed*" OR "feed restrict*" OR "control fed" OR "quality assurance" OR education)</p>	<p>(health OR immun* OR diarrhea OR diarrhoea OR scours OR "colibacillosis" OR "fecal score" OR "clinical response*" OR "clinical parameters" OR "fecal shedding" OR "faecal shedding" OR morbidity OR mortality OR performance OR growth OR "daily weight gain" OR "average daily gain" OR "G:F" OR "gain-to-feed" OR "feed conversion" OR "feed intake" OR "ADG" OR ADFI OR "lightweight gain" OR productivity)</p>

Search validation:

Reference lists of three review articles were used to identify ‘ideal’ articles that matched our review question. These ‘ideal’ articles were used to validate the search. The following three review article reference lists were used to identify the ‘ideal’ articles:

1. Advances in Ileitis Control, Diagnosis, Epidemiology and the Economic Impacts of Disease in Commercial Pig Herds
Alison M. Collins. *Agriculture* **2013**, 3, 536-555; doi:10.3390/agriculture3030536.
2. Husbandry practices and gut health outcomes in weaned piglets: A review
Balachandar Jayaraman, Charles M. Nyachoti. *Animal Nutrition* 3 (2017) 205e211.
3. Acidifier as an Alternative Material to Antibiotics in Animal Feed
Y. Y. Kim**, D. Y. Kil, H. K. Oh and In K. Han. *Asian-Aust. J. Anim. Sci.* 2005. Vol 18, No. 7: 1048-1060.

Table of 29 ‘ideal articles’ for validation of the search

	Author (year)	Article Title	Country	Outcome	Terms in Ti/AB or keywords
Interventions using products in Nursery/weaned pigs					
1	Oliver (2014)	Lysozyme as an alternative to antibiotics improves performance in nursery pigs during an indirect immune challenge	USA	Immune challenge and growth	Yes Antibiotic lysozyme
2	Kahindi (2014)	Effect of dietary lysine content and sanitation conditions on performance of weaned pigs fed antibiotic-free diets	Canada	Growth, performance	Yes Sanitation lysine
3	Johnson (2017)	Evaluating the behavior, growth performance, immune parameters, and intestinal morphology of weaned piglets after simulated transport and heat stress when antibiotics are eliminated from the diet or replaced with L-glutamine	USA	Growth, gut morphology, immune parameters	Yes antibiotics L-glutamine
4	Chernysheva (2004)	The effect of dietary chicken egg-yolk antibodies on the clinical response in weaned pigs challenged with a	Canada	Diarrhea	Yes Egg-yolk

		K88+ <i>Escherichia coli</i> isolate			antibodies
5	Che (2011)	Mannan oligosaccharide improves immune responses and growth efficiency of nursery pigs experimentally infected with porcine reproductive and respiratory syndrome virus	USA	Immune response	Yes mannan
6	Che (2012)	Effect of dietary acids on growth performance of nursery pigs: A cooperative study	USA	Growth performance	Yes Dietary acids Organic acids
7	Busser (2011)	Effect of administration of organic acids in drinking water on faecal shedding of <i>E. coli</i> , performance parameters and health in nursery pigs	Belgium	Fecal shedding, clinical parameters	Yes Organic acids
8	Dierick (2002)	The combined use of triacylglycerols (TAGs) containing medium chain fatty acids (MCFAs) and exogenous lipolytic enzymes as an alternative for nutritional antibiotics in piglet nutrition. II. <i>In vivo</i> release of MCFAs in gastric cannulated and slaughtered piglets by endogenous and exogenous lipases; effects on the luminal gut flora and growth performance.	Belgium	Performance, Gut flora	Yes Medium chain Fatty acids
9	Muhl (2007)	No impact of a phytogetic feed additive on digestion and unspecific immune reaction in piglets.	Germany	Immunity, digestion	Yes Phytogetic Essential oil
10	Turner (2002)	Effects of a Quillaja saponaria extract on growth performance and immune function of weanling pigs challenged with <i>Salmonella typhimurium</i>	USA	Performance, immunity	Yes Plant extract
11	Turner (2002)	Effects of <i>Ascophyllum nodosum</i> extract on growth performance and immune function of young pigs challenged with <i>Salmonella typhimurium</i>	USA	Performance, immunity	Yes Seaweed
12	Harvey(2005)	Use of competitive exclusion to control enterotoxigenic strains of <i>Escherichia coli</i> in weaned pigs	USA	Mortality, tx costs, perf.	Yes Competitive exclusion

13	Laine(2008)	Risk factors for post-weaning diarrhoea on piglet producing farms in Finland	Finland	RFs, Observational	Yes Feed restriction
14	Zhao(2007)	Growth perf and intestinal morphology responses in early weaned pigs to supplemental antibiotic-free diets with an organic copper complex and spray-dried plasma sanitary and nonsanitary environments	USA	Performance, intestinal morph.	Yes Spray-dried sanitary
15	Sterk(2008)	Effects of sweeteners on individual feed intake characteristics and performance in group-housed weanling pigs	Netherlands	Performance, fecal score	Yes Sweetener*
16	Sorensen(2009)	Performance and diarrhoea in piglets following weaning at seven weeks of age: Challenge with E. coli O 149 and effect of dietary factors	Denmark	Performance, fecal score	Yes Vitamin Protein restriction Feed restriction
Interventions using management factors in Nursery/weaned pigs					
17	Pastorelli(2012)	Sanitary housing conditions modify the performance and behavioural response of weaned pigs to feed- and housing-related stressors	France	Immunity, performance,	Yes sanitary
18	Khafipour(2014)	Effect of crowding stress and <i>Escherichia coli</i> K88+ challenge in nursery pigs supplemented with anti- <i>Escherichia coli</i> K88+ probiotics	Canada	Immunity, performance	Yes probiotics
19	Cabrera(2013)	Effects of creep feeding and supplemental glutamine or glutamine plus glutamate (Aminogut) on pre- and post-weaning growth performance and intestinal health of piglets	USA	Performance, intestinal health	Yes Creep feed*
20	Bruininx(2002)	Effect of creep feed consumption on individual feed intake characteristics and performance of group-housed weanling pigs.	Netherlands	performance	Yes Creep feed*
21	Amezcu(2002)	A case control study investigating risk factors associated with post weaning <i>Escherichia coli</i> diarrhea in southern Ontario.	Canada	Observational RFs for post weaning diarrhea	Yes Weaning age Comingling Feeder space Pelleted

22	Dunshea(2000)	Supplemental fermented milk increase growth performance of early-weaned pigs.	Aust.	performance	Yes Fermented
23	Beaulieu(2006)	The effects of dietary energy concentration and weaning site on weaning pig performance.	Canada	performance	No
24	Heo(2009)	Feeding a diet with decreased protein content reduces indices of protein fermentation and the incidence of post-weaning diarrhea in weaned pigs challenged With an enterotoxigenic strain of Escherichia coli	Aust.	diarrhea	Yes decreased protein
25	Heo(2008)	Effects of feeding low protein diets to piglets on plasma urea nitrogen, faecal ammonia nitrogen, the incidence of diarrhea and performance after weaning.	Aust.	diarrhea	Yes Low protein
26	Wellock(2007)	Effects of weaning age, protein nutrition and enterotoxigenic Escherichia coli challenge on the health of newly weaned piglets.	UK	Fecal score, E.coli shedding	Yes Protein level
27	Opapeju(2009)	Effect of dietary protein level on growth performance, indicators of enteric health and gastrointestinal microbial ecology of weaned pigs induced with post weaning colibacillosis.	Canada	Performance, intestinal health,	Yes protein level
28	Davis(2006)	Effect of weaning age and co-mingling after the nursery phase of pigs in a wean-to-finish facility on growth, humoral and behavioral indicators of well-being.	USA	Performance, immunity,	Yes comingling
29	Jayaraman(2017)	Effects of different dietary tryptophan: lysine ratios and sanitary conditions on growth performance, plasma urea nitrogen, serum haptoglobin and ileal histomorphology of weaned pigs	Canada	Performance	Yes Lysine

A trial search was conducted *a priori* to validate the search.

Trial search results

Platform	Intervention product +	Product	Management	Total	After
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	management terms before deduplication	interventions after deduplication [exact match]	interventions after deduplication [exact match]	interventions after deduplication [exact match]	deduplication [close match in Distiller]
WoS with Agr Dairy	2830+1608=4438	2284	923	3207	
WoS MEDLINE	1809+619=2428	1246	221	1467	
ProQuest [4]	2665+1116=3781			1272	
AGRICOLA- ProQuest	2274+1015=3289	1151	389	1540	
PubMed	1469+717=2186	965	323	1288	
Total hits	16,122			8783 (54.5% of hits)	6656 (41.3% of hits)

6. Relevance screening

[Relevance screening will be based on interpretation of the title and abstract by two independent reviewers with disagreements resolved by consensus or a third reviewer]

Relevance Screening inclusion/exclusion criteria form [See the Guide to relevance screening inclusion/exclusion below]

1. Is this a **hypothesis-testing primary research** study involving live pigs? [choose one]
Hypothesis testing study involving pigs: clinical trial, challenge trial, or analytical observational study.
 Yes
 Unclear
 No [and SUBMIT]*
2. Does this study report an outcome measured in **nursery stage pigs**? [choose one]
 Yes
 Unclear
 No [and SUBMIT]*
3. Does this study report an **intervention or management practice** of interest? [choose one]

Yes

Unclear

No [and SUBMIT]*

4. Does the study measure a **health or performance outcome** of interest? [choose one]

Yes

Unclear

No [and SUBMIT]*

5. Was the study conducted in a **country of interest**? [choose one]

Yes

Unclear

No [and SUBMIT]*

Guide to relevance Screening Inclusion/exclusion criteria and Rationale

	Question	Answer Options	Action within Distiller Included (rationale)	Action within Distiller Excluded (rationale)
1	Is this a hypothesis testing research study involving live pigs?	Yes	a) Clinical trial [i.e., experiment without induced disease exposure] b) Challenge trial [i.e., experiment with an induced disease or immune exposure to a pathogen or immune stimulant given to the treatment groups) c) Observational study [cohort, case-control, or cross sectional].	
		unclear	kept for full text eligibility screening	
		No, other [and SUBMIT]		NOT: <ul style="list-style-type: none">○ <i>In vitro</i> study, bioassays○ Reviews [narrative, systematic, meta-analysis, scoping]○ Outbreak report○ Case study/case series○ Models [mathematical, risk assessments, etc.]

				<ul style="list-style-type: none"> ○ Pig studies as models for human disease ○ Other document types: [commentary, testimonials, business reports] ○ product reports <u>UNLESS</u> a trial is described ○ prevalence/ incidence studies ○ evaluation of diagnostic tests ○ pharmacodynamics studies <p>NOT: Another species</p>
2	<p>Does the study report an outcome measured in pigs at the nursery stage [i.e., weaned pigs, weaners, etc.]?</p> <p>[NOTE: These parameters vary by country somewhat]. Age at weaning: [average of <i>three weeks</i> (18 – 23 days)] Wt. at weaning: [average 6 kg] Nursery stage pigs are 6.0-22kg (20-50lb), Growers [>22 kg]</p>	<p>Yes</p> <p>[intervention is given to nursery stage pigs or at a prior stage BUT a relevant outcome was measured at nursery stage]</p>	<p>(Piglet* OR weaner* OR “weaning pig*” OR “weanling pig*” OR “weaner pig*” OR “weaned pig*” OR “weaner stage” OR “weaner phase” OR “nursery pig*” OR “young pig*” OR “younger pig*” OR “early-weaned pig*” OR “late-weaned pig*” OR “nursery-age*” OR “naïve pigs” OR “starter pig*” OR “neonate pig*” OR “neonatal pig*” OR “suckling pig*” OR “post-wean*” OR “nursery stage”)</p>	
		Unclear	Unclear – kept for full text eligibility screening	

		No, other [and SUBMIT]		NOT: Nursing piglets, neonates, growers/finishers, breeders, and NOT guinea pigs
3	Does the study report on an intervention product or management practice of interest?	Yes	<u>Intervention products:</u> (Antibiotic* OR antimicrobial* OR vaccin* OR immunization OR "sow vacc*" OR "dam vacc*" OR "gilt vacc*" OR "sow immunization" OR "dam immunization" OR "gilt immunization" OR "trace mineral*" OR "essential mineral*" OR "mineral source*" OR "mineral form*" OR Zinc*OR vitamin* OR "dietary acid*" OR "organic acid*" OR "dietary fatty acid*" OR "medium chain fatty acid*" OR acidif* OR "feed enzyme*" OR fermentable OR fermented OR "plant extract*" OR herbal OR seaweed OR spice OR phytogetic OR "dietary lysine" OR "dietary tryptophan" OR lactoferrin OR lysozyme OR L-glutamine OR nutraceutical* OR nutraceutical* OR supplemental OR "dietary supplement*" OR "diet supplement*" OR "feed supplement*" OR "dietary additive*" OR "diet additive*" OR "feed additive*" OR inulin OR sweetener* OR oligosaccharide* OR polysaccharide* OR mannan* OR B-glucan* OR probiotic* OR prebiotic* OR synbiotic* OR "direct-fed microbial*" OR "competitive exclusion" OR yeast OR "Saccharomyces cerevisiae" OR "essential oil*" OR "fish meal" OR " blood meal" OR "spray-dried" OR immunoprophylaxis OR immunotherapeutic* OR "egg-yolk antibod*" OR "IgY antibod*" OR bacteriophages OR "antimicrobial peptide*" OR "bovine colostrum" OR "epidermal growth factor*" OR "rare earth" OR clay OR "natural alternative*" OR homeopath*) <u>Management practice:</u> ("natural pig*" OR "organic swine" OR "organic pig*" OR	

			<p>“natural conditions” OR “non-conventional” OR “antibiotic-free” OR “weaning practice*” OR “weaning method*” OR “weaning procedure*” OR “weaning regime*” OR “weaning system” OR “conventional weaning” OR “weaning age” OR “early weaning” OR “late wean*” OR “age at weaning” OR “creep feed*” OR “stocking” OR crowding OR overcrowding OR “floor space” OR “feeder space” OR “housing system*” OR “housing design*” OR “housing environment*” OR “housing type” OR ventilation OR “air quality” OR co-mingling OR “mingl*” OR “mixed litter” OR mixing OR “batch system” OR “batch management” OR biosecurity OR “sanit*” OR “disinfect*” OR “cleaning” OR hygiene OR “all-in-all-out” OR “pig flow” OR “disease eradication” OR “disease control*” OR “multi-site” OR “liquid feed” OR “liquid diet*” OR “pellet*” OR “low protein” OR “decreased protein” OR “restricted protein” OR “protein restrict*” OR “protein nutrition” OR “protein level” OR “protein source” OR “dietary protein” OR “restricted feed*” OR “feed restrict*” OR “control fed” OR “quality assurance” OR education)</p>	
		Unclear	Unclear – kept for full text eligibility screening	
		No, other [and SUBMIT]		<p>NOT:</p> <ul style="list-style-type: none"> ○ heritability or genetic/breeding ○ Dewormers/anthelmintics Anticoccidial drugs, pyrethroid ○ Toxins ○ Test technology/test comparisons [accuracy/sensitivity/specificity] ○ Detection of sick animals ○ Antibiotic vs. a placebo or another antibiotic or different level or route of administration

				of the antibiotic being tested [ONLY include antibiotic if it is the comparison to a non-antibiotic intervention]
4.	Does the study measure a health or performance outcome of interest?	Yes	(health OR diarrhea OR diarrhoea OR scours OR "colibacillosis" OR "fecal score" OR "clinical response*" OR "clinical parameters" OR "fecal shedding" OR "faecal shedding" OR morbidity OR mortality OR performance OR growth OR "daily weight gain" OR "average daily gain" OR "G:F" OR "gain-to-feed" OR "feed conversion" OR "feed intake" OR "ADG" OR ADFI OR "lightweight gain" OR productivity) Immunity [direct or indirect] if it is a vaccine study in which immunity was the ONLY outcome measured otherwise it can be excluded	
		Unclear	Unclear – kept for look at full text	
		No, other [and SUBMIT]		NOT: <ul style="list-style-type: none"> ○ mechanistic studies ○ prevalence/ incidence studies ○ descriptive studies [UNLESS risk factors analyzed] ○ gene expression ○ clinicopathologic variables (i.e., blood parameters) ○ clinical parameters (i.e., heart rate) [UNLESS fever/pyrexia as an indication of morbidity] ○ fertility/reproductive efficiency ○ digestibility ○ antimicrobial/antibiotic resistance (AMR)

				<ul style="list-style-type: none"> ○ meat nutrients [e.g., fatty acids, Omega-3 fatty acids] ○ meat tenderness ○ parasitic [worms/nematodes, ticks, lice] and protozoan diseases ○ methane production ○ Asymptomatic food-borne pathogen carriage/shedding [e.g., Campylobacter, Salmonella, E. coli (EHEC) grp.] ○ Lameness or ill health associated with toxin or congenital disease ○ Immunity measures [direct or indirect] UNLESS it is a vaccination study in which immunity was the ONLY outcome measured
5	Was the study conducted in a country of interest?	Yes	Canada, USA, Western EU [include Poland, Hungary, and Czech Republic] Britain, Australia/NZ	
		Unclear	Unclear	
		No [and SUBMIT]		NOT: [Asian or African countries, Kurdistan or other ‘...stans’, Middle Eastern countries or Turkey, Mexico, South American, Caribbean Islands, Russia, Greece, Alaska]

* SUBMIT the form after a ‘No’ option. These citations will be excluded from the review.

7. Data extraction

[The data extraction will be based on full text utilizing two independent reviewers with disagreements resolved by consensus or a third reviewer]

Data extraction form

1. Does this study meet the Level 1 inclusion criteria?

Is this a primary hypothesis-testing study [clinical trial, challenge trial, analytical observational study] that meets the inclusion criteria as outlined in the level 1 screening process [nursery stage pig population, intervention/management practice, health, or production outcome]?

Yes

No [SUBMIT]

2. In what country was the study conducted (if it is not clear then list the institutional affiliation of the first author)

Canada [list province code]

USA [list state code]

EU [list country]

Australia or New Zealand

none of the above [SUBMIT]

3. What is the citation type?

full text article

full text thesis

full text proceedings (e.g., short research paper cited in association with a conference or meeting), research report, or product report

abstract only [SUBMIT]

4. What type of study is this? [choose one]

clinical trial

challenge trial [list challenge agent]

- observational study
 - none of the above [SUBMIT]
5. Year of publication _____
 6. What was the sample size at the level of which the outcome was analyzed [give combined total for all studies/experiments reported]
 - [choose all that apply]
 - individual (n=___)
 - pen/group/litter (n=___)
 - herd (n=___)
 7. Was the nursery stage [at which the outcome was measured] clearly identified?
 - nursery stage identified
 - part of multiple stages
 8. Was the population an experimental population or commercial
 - [experimental populations are raised on a university or pharmaceutical company experimental farm]
 - experimental
 - commercial
 - unclear
 9. Was the intervention intended to:
 - [choose all that apply]
 - prevent disease
 - treat disease
 - improve growth performance
 - unclear
 10. What intervention/management practice categories(s) or intervention/management type risk factors were studied
 - [choose all that apply]
 - feeding regime [amount, schedule, etc.][list] [e.g., protein restriction, feed restriction, etc.]
 - diet type or format [list] [e.g., [e.g., distillers grains, pelleted feed, liquid feed]

- feed or water additive- non-antibiotic [list] [e.g., feed enzymes, probiotics, plant extracts, etc.]
- Non-antibiotic medication administered directly [list] [e.g., a medication individually injected or given orally]
- vaccination to piglets [list]
- maternal vaccination [list]
- weaning method [list]
- biosecurity [from other farm site comingling/mixing, introductions, disease eradication etc.]
- bio-containment [within farm mixing, moving, pig-flow, all-in-all-out, etc.]
- infection control [cleaning, disinfection, sanitation]
- air quality [e.g., ventilation, etc.]
- housing or flooring [animal density, physical factors regarding feed bunk and water supply, indoor/outdoor]
- producer education, quality assurance program
- other, please specify

11. What comparison group was used [choose all that apply]

- no treatment [just usual or conventional practices]
- placebo or sham treatment
- exposure [no exposure, different level of exposure or treatment]
- antibiotic
- zinc oxide

12. What **health** outcome(s) were measured [choose all that apply]

- none
- mortality
- diarrhea/fecal score/scours
- respiratory disease
- morbidity due to other condition than diarrhea or respiratory disease
- presence or concentration of infectious disease agent [list]
- treatment rate [number of sequential treatments for clinically ill pigs]
- ONLY immunity [direct or indirect] [to capture the vaccine studies in which only immunity +/- performance was measured]

13. What **production** outcome was measured? [choose all that apply]

none

performance [weight, ADG, feed intake, etc.] [list]

farm economics or treatment costs

8. References

Arksey H. and O'Malley L. (2005) Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8:1, 19-32

Pham MT. (2014) A scoping review of scoping reviews: advancing the approach and enhancing consistency. *Research Synthesis Methods* 5: 371–385