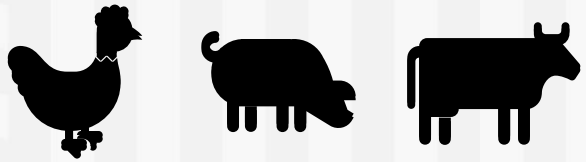
2nd RIBMINS scientific conference
Córdoba, Spain

SRUC

Using systematic reviews to assess the effectiveness of pre-harvest meat safety interventions to control foodborne pathogens in broilers, pigs and bovines

Maria Costa



7th and 8th of April, 2022

Team

SRUC

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Outline


Background
Methods
Results/ Discussion
Results/ Discussion
Results/ Discussion
Conclusions

Background

- “Prevention is better than cure” – and it’s the backbone of RIBMINS
- Stakeholder cooperation along the food chain is the central element of the risk-based approach to meat hygiene.

- **What are the most effective interventions on-farm to control foodborne zoonoses?**

- Objective: to use systematic reviews to assess the **effectiveness** of **pre-harvest meat safety interventions** for broilers, pigs and bovines.

Outputs

Current Clinical Microbiology Reports (2021) 8:21–30
https://doi.org/10.1007/s40588-021-00161-z

BACTERIOLOGY (N BOREL, SECTION EDITOR)

Assessment of the Effectiveness of Pre-harvest Meat Safety Interventions to Control Foodborne Pathogens in Broilers: a Systematic Review

Joana Pessoa [1,2] · Maria Rodrigues da Costa [3] · Truls Nesbakken [4] · Diana Meemken [5] · on behalf of the RIBMINS Cost Action

Accepted: 29 January 2021 / Published online: 14 February 2021

microorganisms

MDPI

Systematic Review

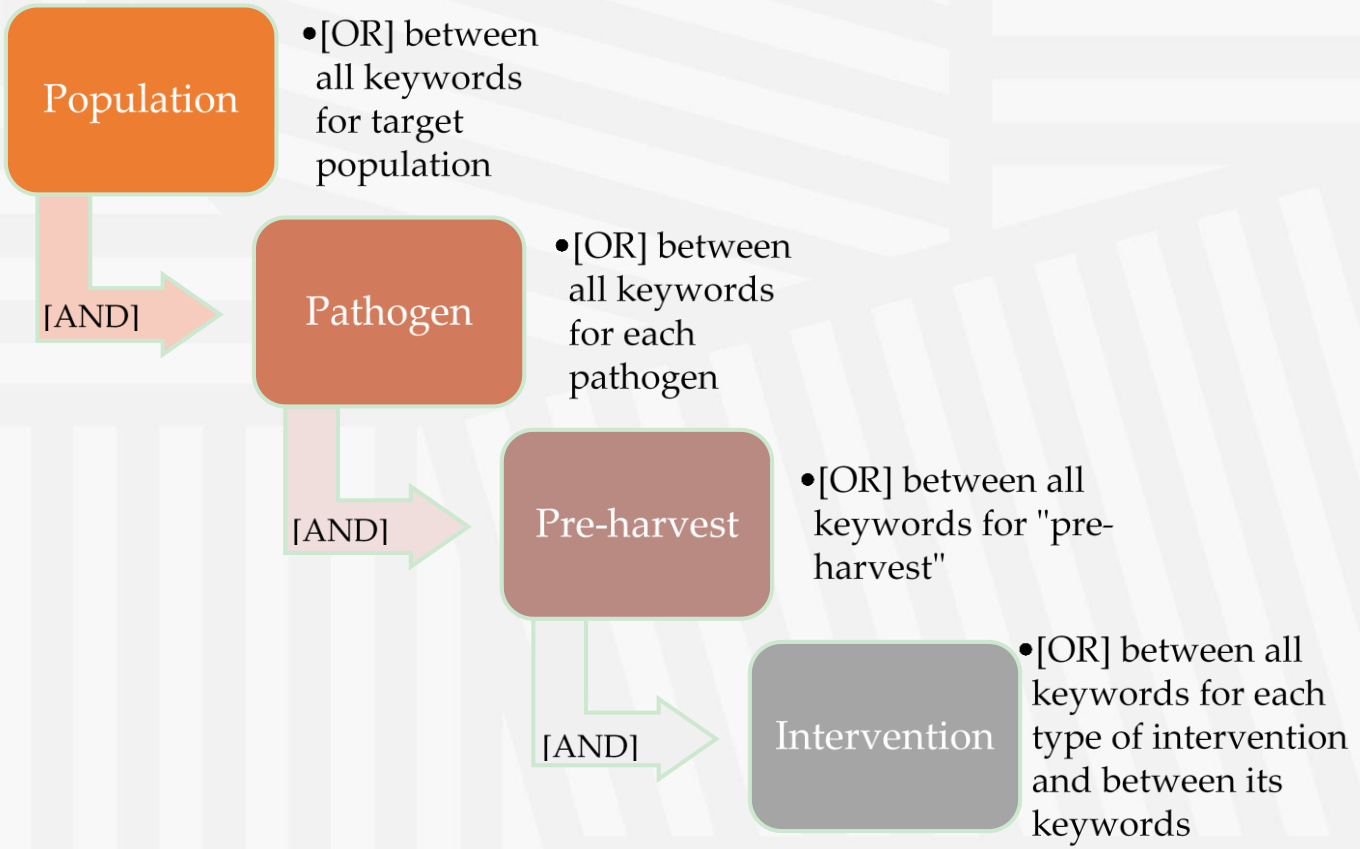
A Systematic Review on the Effectiveness of Pre-Harvest Meat Safety Interventions in Pig Herds to Control *Salmonella* and Other Foodborne Pathogens

Maria Rodrigues da Costa [1], Joana Pessoa [2,3,4], Diana Meemken [5,*] and Truls Nesbakken [6]

- 2 published
- 1 manuscript in preparation

Methods

- PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
- EFSA's guidelines for conducting systematic reviews for food and feed safety assessments
- EFSA's scientific opinion on the public health hazards to be covered by inspection of broilers, pigs and bovine (2011, 2012, 2013)
- Structure outline of **text strings** used for the searches conducted in PubMed® and the Web of Science databases >
- Time restrictions: Broilers 2015-2020

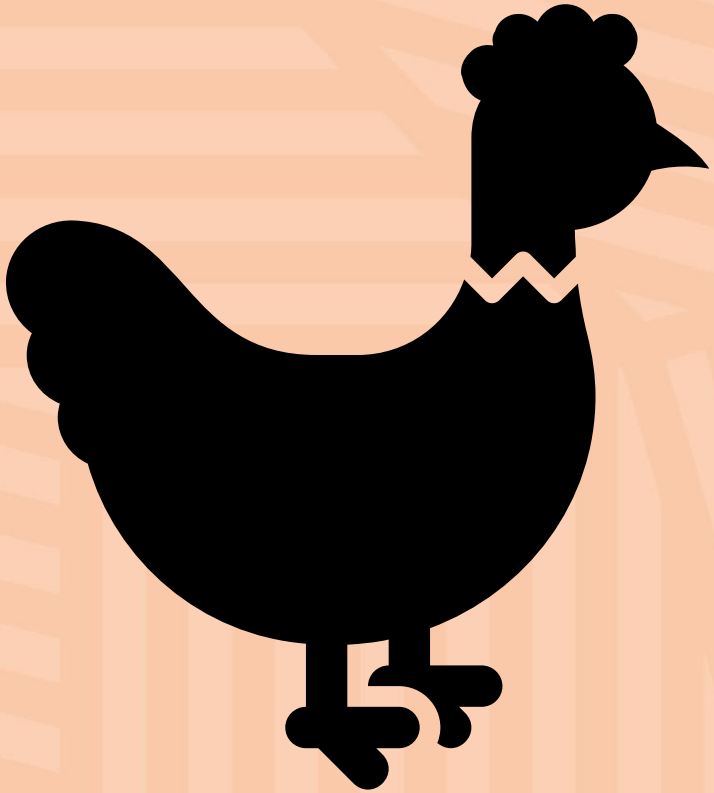


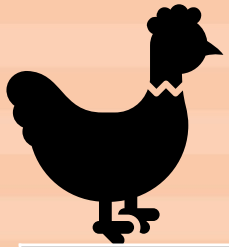
Methods

- Eligibility criteria used for the screening of title/abstracts and full texts.

PICO [1]	Inclusion Criteria	Exclusion Criteria
Population	Animal species being evaluated: must include (but not limited to) pigs	Does not include actual or theoretical <pathogen> infection/contamination in pigs
	Unit of study [animal, herd, house, barn, farm] and [surfaces, food, water, environment, drinkers, feeder, other animals]	Others
Intervention	Interventions to control/reduce/eradicate <pathogen> in pigs	Studies not mentioning control/reduce/eradicate interventions for < pathogen> in pigs
	Interventions on-farm or during transport (pre-harvest)	Interventions on lairage, at slaughter and post-harvest
	Field/experimental studies	Lab/bench studies
Comparison	**Control group present** [group subjected to no intervention]	Control group absent
Outcomes	Provides some measure of the efficacy of the intervention	Efficacy of the intervention not measured
Others	Language: English	Other languages
	Peer-reviews	Grey literature

BROILERS: Results

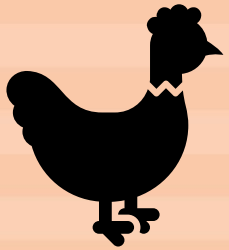




BROILERS: Results

SRUC

Pathogen	Records identified	Records after duplicate removal	Records retained after abstract screening	Records retained after full text screening
B. cereus	3	3	0	0
Campylobacter	230	208	34	24
C. botulinum	3	2	0	0
C. difficile	0	0	0	0
C. perfringens	23	22	5	3
ESBL-Amp C *E. coli*	57	53	6	2
ESBL-Amp C *Salmonella*	9	9	0	0
Listeria monocytogenes	14	13	0	0
MRSA	17	17	0	0
Salmonella spp.	301	282	33	20
VTEC	201	191	8	1
Y. enterocolitica	6	6	0	0
T. gondii	10	9	0	0



BROILERS: Results

SRUC

- 51 Studies retained (1 not obtained)
- 44 studies in Campylobacter and Salmonella
  - total of 71 and 62 trials, respectively
  - Most of these trials were **lab-based** challenge trials (65% and 82%), remaining trials were **field trials** where no experimental infection was performed

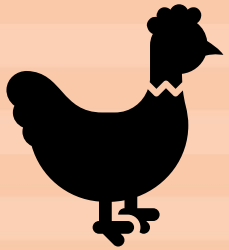
Campylobacter spp.

Salmonella spp.

VTEC

ESBL-AmpC

Clostridium perfringens



BROILERS: Results

SRUC

- Use of **feed additives** (probiotics, prebiotics, and essential oils): results showed **great variability** in the effectiveness of this group of control measures.
- **Research is lacking** on the development of **targeted immunisation strategies** for each pathogen.

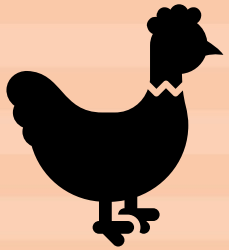
Campylobacter spp.

Salmonella spp.

VTEC

ESBL-AmpC

Clostridium perfringens



BROILERS: Discussion

SRUC

- Most studies, including vaccination studies, were performed under controlled research settings
- We need for more large-scale randomised, blinded trials conducted with different vaccination strategies on commercial farms.
  - These would ascertain the efficacy of these interventions under field conditions.

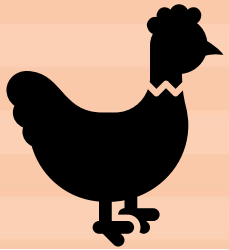
Campylobacter spp.

Salmonella spp.

VTEC

ESBL-AmpC

Clostridium perfringens



BROILERS: Discussion

SRUC

- Interventions to control other less prominent hazards were much less frequent or non-existent, in spite of their relevance as stated in the 2012 EFSA report.
- Public health burden associated with broilers as sources of human infection is still controversial or low (ESBL AmpC, VTEC, *Y. enterocolitica*)
- Only indoor farms considered in this study (T. gondii prevalence is lower)
- *L. monocytogenes*, *B. cereus*, C. *botulinum*, C. *perfringens*, and *S. aureus* are mainly controlled by post-harvest interventions.

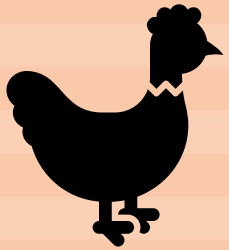
Campylobacter spp.

Salmonella spp.

VTEC

ESBL-AmpC

Clostridium perfringens

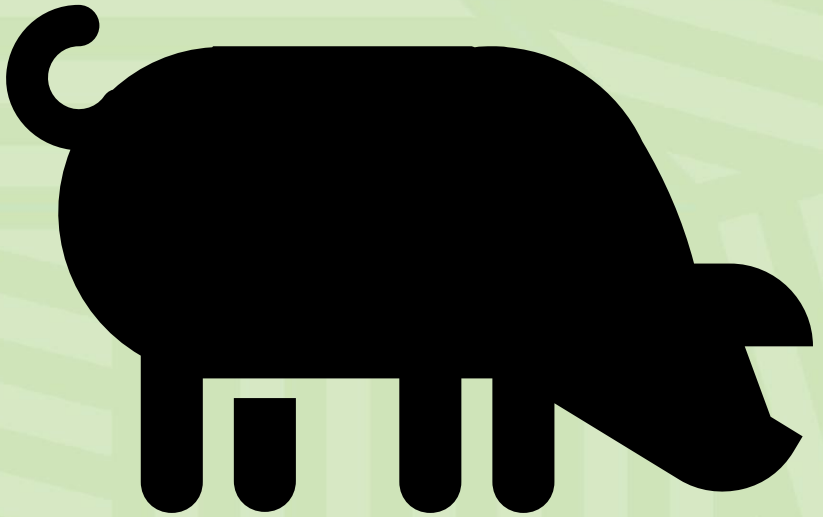


BROILERS: Summary

SRUC

- Between 2015 and 2020, several studies have been published on preharvest interventions to control foodborne pathogens in broilers.
- Focus on **two main hazards** (*Salmonella* spp. and *Campylobacter* spp.), which reflects the **high burden of disease**.
- Research is lacking on the development of **targeted immunisation** strategies for each pathogen.
- Vaccination strategies should **always be implemented in combination** with other interventions, especially those which are related to best farming practices.
  - Indeed, interventions such as good cleaning and disinfection and strict biosecurity may be enough to prevent the introduction and/ or control less prevalent pathogens.

PIGS: Results



PIGS: Results

Pathogen	Records Identified	Records after Duplicates' Removal	Records Retained after Abstract Screening	Records Retained after Full Text Screening
Clostridium botulinum	3	3	0	0
Clostridioides difficile	8	7	0	0
Clostridium perfringens	43	33	9	5
Campylobacter spp.	156	115	3	2
Herpes virus type E	101	77	0	0
Listeria monocytogenes	12	11	0	0
MRSA	194	139	9	1
Mycobacterium avium complex	27	23	3	1
Salmonella spp.	785	555	57	43
Sarcocystis spp.	9	7	0	0
Taenia solium	12	12	0	0
Toxoplasma gondii	101	77	2	0
Trichinella spiralis	63	50	2	0
VTEC	5	5	1	0
Yersinia enterocolitica	87	66	1	0
TOTAL	**1606**	**1180**	**87**	**52**

PIGS: Results

- Altogether, 52 studies published from 1983 to 2020 were retained and analysed.
- Research was mostly focused on *Salmonella* (n = 43 studies describing 86 trials).
- In-feed and/or water treatments, and vaccination were the most tested interventions and were, overall, successful (72% and 87%)

Salmonella spp.

Campylobacter spp.

MRSA

Mycobacterium avium

Clostridium perfringens

PIGS: Results

- Most *Salmonella* studies were done in commercial farms (n=34 of 43, 79%).
- 8 trials tested the efficacy of antimicrobials to control *Salmonella*. Only 1 had positive results and it was a combined treatment with early off-site weaning.
- Across all trials, the results for *Salmonella* are very encouraging, with 76% (65/86) of the trials assessed reporting positive results.

Salmonella spp.

Campylobacter spp.

MRSA

Mycobacterium avium

Clostridium perfringens

PIGS: Results

- 2 studies retained for *Campylobacter* spp. tested the efficacy of probiotics to reduce the colonisation of this pathogen as (competitive exclusion)
- 5 studies retained for *C. perfringens* assessed the efficacy of vaccinations (n = 4) and probiotics (n = 1).
  - All studies reported positive outcomes for the interventions tested.

Salmonella spp.

Campylobacter spp.

Clostridium perfringens

MRSA

Mycobacterium avium

PIGS: Results

- MRSA: 1 study – RCT cleaning and disinfection of sows and environment.
  - the tested disinfection protocol reduced temporarily the sow and piglet MRSA status, but no effect in MRSA at weaning or in the nursery unit.
- *M. avium*: 1 study tested the efficacy of vaccination with two vaccines (killed and subunit) in preventing infection and disease in experimentally challenged pigs.
  - The killed vaccine did not prevent infection but attenuated its severity with regard to gross and macroscopic lesions, when compared to the pigs vaccinated with the subunit vaccine. The subunit vaccine did not prevent infection or lesions.

Salmonella spp.

Campylobacter spp.

Clostridium perfringens

MRSA

Mycobacterium avium

PIGS: Discussion

- *Salmonella*: eligibility criteria may have eliminated effective interventions from our study
  - At national level, Finland, Norway and Sweden have documented that the successful control of *Salmonella* in cattle, pigs and poultry through pre-harvest interventions is possible
  - Heat-treatment of feed, and starting with breeding animals free from *Salmonella* at the top of the breeding pyramid have probably been the most important measures.
- *Campylobacter*: It seems more cost-efficient to control this agent post-harvest
- *C. perfringens*: In studies retained, the clinical outcome in pigs seemed to be the main worry, not shedding.
  - Low risk, post-harvest interventions seem more appropriate once "risk of disease seems not to be correlated with occurrence in raw meat but rather to improper hygiene and storage"

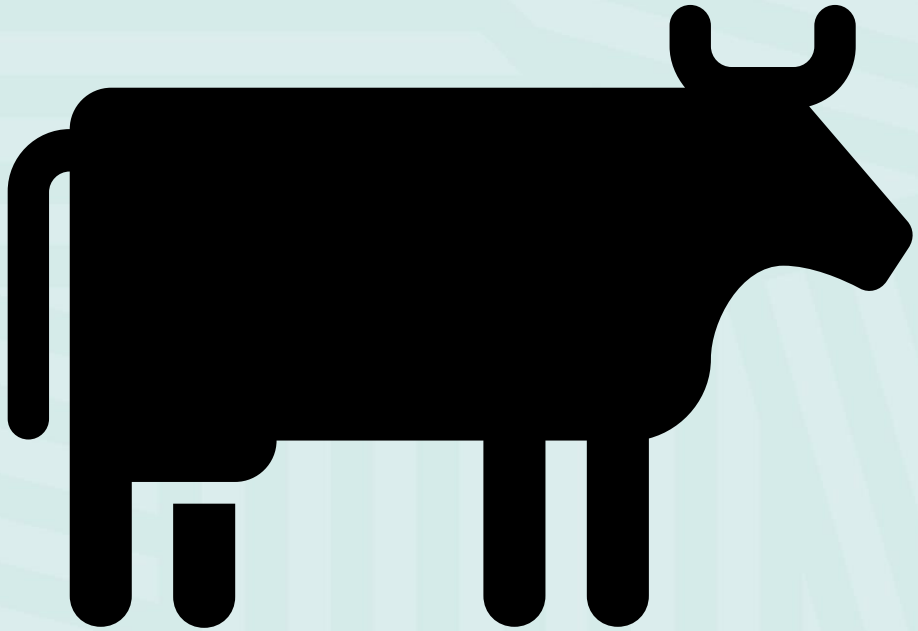
PIGS: Discussion

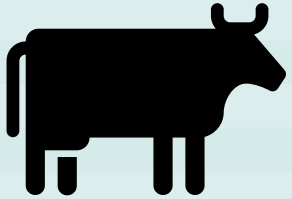
- *MRSA*: national control seems to be possible
  - Norway has established a unique control strategy in their pig population, which includes population-wide annual surveillance, in addition to contact tracing upon detection of MRSA in pig farms and farm workers.
- Hepatitis E: new research in recent years, no papers meeting criteria defined. Vaccination could help control.
- *Y. enterocolitica*: one of the most important hazards.
  - Specific pathogen free programs seem to work – though not included in our study
- *T. gondii*: outdoor pigs not included in this study.
  - Control of cat population may be helpful

PIGS: Summary

- Some foodborne **pathogens** appear to be **best** controlled at a **post-harvest level**.
- Overall, high herd health status coupled with good management and biosecurity **were effective** to control or prevent most foodborne pathogens in pork.
- In spite of not having been included in the review, the SPF herd principle, stamping out and repopulating with disease-free animals, has been reported as a feasible and effective intervention to control foodborne pathogens like *Salmonella*, *Y. enterocolitica* and MRSA.

BOVINES: Results





BOVINES: Results

SRUC

Pathogens	Records Identified	Records after Duplicates' Removal	Records Retained after Abstract Screening	Records Retained after Full Text Screening
Bacillus anthracis	48	42	3	0
Bacillus cereus	30	30	0	0
Campylobacter	244	211	9	1
C. botulinum	31	27	5	2
C. perfringens	40	38	3	2
VTEC	363	323	32	13
ESBL_AmpC	107	90	2	1
Listeria monocytogenes	94	84	3	0
Salmonella	541	456	43	16
MRSA	108	100	0	0
Sarcocystis	9	8	0	0
Taenia saginata	41	37	4	0
Toxoplasma	77	68	0	0
TOTAL	1733	1514	104	35

BOVINES: Results

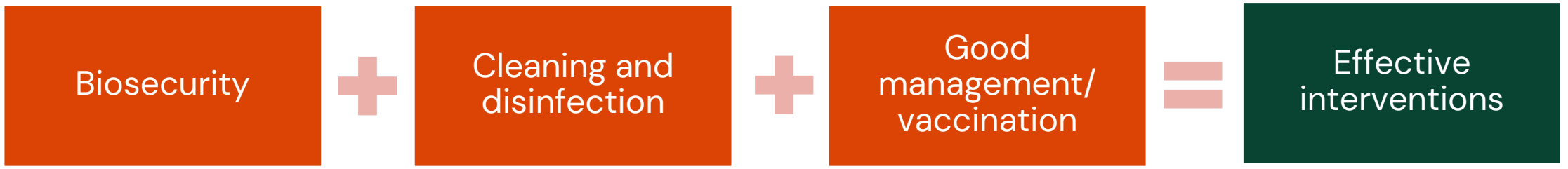
1514 studies // 13 pathogens

After screenings, 35 studies for 6 pathogens

- *Salmonella* spp. (n=16)
- VTEC (n=13)
- *C. Botulinum* (n=2)
- *C. Perfringens* (n=2)
- *Campylobacter* (n=1)
- *ESBL AmpC* (n=1)

Conclusions

- Across broilers and pigs, results were similar:



- Limitations: eligibility criteria might have eliminated effective interventions
- Some pathogens are frequently controlled by post-harvest interventions

References

- Pessoa, J.C., Rodrigues da Costa, M., Nesbakken, T, Meemken, D. 2021. Assessment of the effectiveness of pre-harvest meat safety interventions to control foodborne pathogens in broilers: a systematic review. Current Clinical Microbiology Reports (2021). https://doi.org/10.1007/s40588-021-00161-z [Systematic review]
- Rodrigues da Costa, M., Pessoa, J.C, Meemken, D. Nesbakken, T. 2021. A Systematic Review on the Effectiveness of Pre-Harvest Meat Safety Interventions in Pig Herds to Control Salmonella and Other Foodborne Pathogens. Microorganisms, 9, 1825. https://doi.org/10.3390/microorganisms9091825 [Systematic review]

Thank you for your attention!

Questions?

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