Pasteurella Infections in South Korea and Systematic Review and Meta-analysis of *Pasteurella* Bacteremia

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Learning Objectives

Upon completion of this activity, participants will be able to:

- Distinguish the most common species of *Pasteurella* implicated in infection in the current study
- Analyze characteristics of persons infected with *Pasteurella*
- Assess the management and outcomes of *Pasteurella* infection
- Estimate the global burden and outcomes of *Pasteurella* infection

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Pasteurella spp. can cause fatal zoonotic infections in humans. We performed a multicenter study to investigate the prevalence and clinical features of *Pasteurella* infections in South Korea during 2018–2022. We also conducted a collaborative systematic review and meta-analysis of the global burden of *Pasteurella* bacteremia. The study included 283 cases and found an increasing trend in *Pasteurella* infections. Blood cultures were positive in 8/35 (22.9%) cases sampled, for an overall bacteremia-associated rate of 2.8% (8/283). Aging was a significant risk factor for bacteremia (odds ratio 1.05 [95% CI 1.01–1.10]), according to multivariate analyses. For the meta-analysis, we included a total of 2,012 cases from 10 studies. The pooled prevalence of bacteremia was 12.4% (95% CI 7.3%–18.6%) and of mortality 8.4% (95% CI 2.7%–16.5%). Our findings reflect the need for greater understanding of the increase in *Pasteurella* infections and the global burden of *Pasteurella* bacteremia to determine appropriate case management.

Pasteurella spp. can cause fatal zoonotic infections in humans (*1*,*2*). *Pasteurella* spp., which are nonmotile, facultatively anaerobic bacteria, form the oral and gastrointestinal flora of many animals including companion and common livestock animals such as dogs, cats, and pigs (*3*–*5*). The health risk for humans and public health concerns regarding *Pasteurella* spp. should not be ignored when considering the increase in the numbers of those animals, caused by global economic and social development (*1*,*6*,*7*).

Strains of *P. multocida*, one of the most commonly isolated *Pasteurella* pathogens, have the capacity to invade human bronchial epithelial cells (*1*,*2*). The characteristics of human *Pasteurella* infections range from the commonly reported localized infection of a bite wound (*8*,*9*) to invasive infections such as bacteremia (*10*,*11*), meningitis (*12*), and infective endocarditis (*13*), especially in immunocompromised patients. Those invasive infections are associated with higher mortality rates in patients with pasteurellosis (*10*,*14*). However, only a few cohort studies on the epidemiology and clinical characteristics of *Pasteurella* infections have been published, mostly in Europe and the United States. Most studies regarding *Pasteurella* infections are reports of individual cases. Furthermore, the number of companion animals and the occurrence of humans having close contact with such animals have increased substantially (*15*).

We conducted a multicenter study of infections caused by *Pasteurella* spp. from various locations in South Korea during 2018–2022 to investigate their prevalence and clinical features. In addition, we conducted a comprehensive systematic review and meta-analysis to characterize the global burden of bacteremia as a representative disease of invasive infection caused by *Pasteurella* spp. We performed subgroup analyses stratified by publication periods and study locations. The Institutional Review Board of Kangnam Sacred Heart Hospital, Seoul (HKS 2023-01-008) approved the study and waived the need for informed consent because of participant anonymity.

Methods

Ethics

Study Design and Patients

We designed a retrospective multicenter study of the prevalence of infections caused by *Pasteurella* spp. combined with a meta-analysis to determine the burden of these infections, especially bacteremia. We obtained data for *Pasteurella* species infections during 2018–2022 from 7 university hospitals in metropolitan areas (4 in Seoul and 3 in Gyeonggi-do) and 1 reference laboratory, where samples from general and small- and medium-sized hospitals were tested, in South Korea to investigate the overall burden of these infections throughout the country. Patients were included if they had a microbiological examination that was positive for *Pasteurella* species. We identified isolated species by matrix-assisted laser desorption/ionization time-of-flight mass spectrometry on a Vitek-MS instrument (bioMérieux) or Bruker instrument (Bruker Daltonik), Vitek 2 system (bioMérieux), and the MicroScan Walkaway-96 system (Siemens). We obtained the following clinical variables from patient charts: basic demographics, hospital region of origin, sampling year, isolation site, the presence of polymicrobial infection, any animal contact such as bite or scratch history, and the antibiotics and therapies used. We also collected data for hospitalization and outcomes. From the 316 participants, we excluded 31 whose records lacked basic demographic information, such as age and sex (Figure 1). We included a total of 283 patients after excluding 2 patients whose *Pasteurella* species were isolated in 2017 and 2023. We obtained only basic data—age, sex, sampling year, isolation site, and region—for 213 participants from the reference laboratory.

Search Strategy and Selection Criteria for Meta-analysis

We performed a systematic review as described in the Cochrane handbook (*16*) to estimate the global prevalence of bacteremia caused by *Pasteurella* spp. We referred to the Preferred Reporting Items for Systematic Review and Meta-analysis (*17*,*18*)

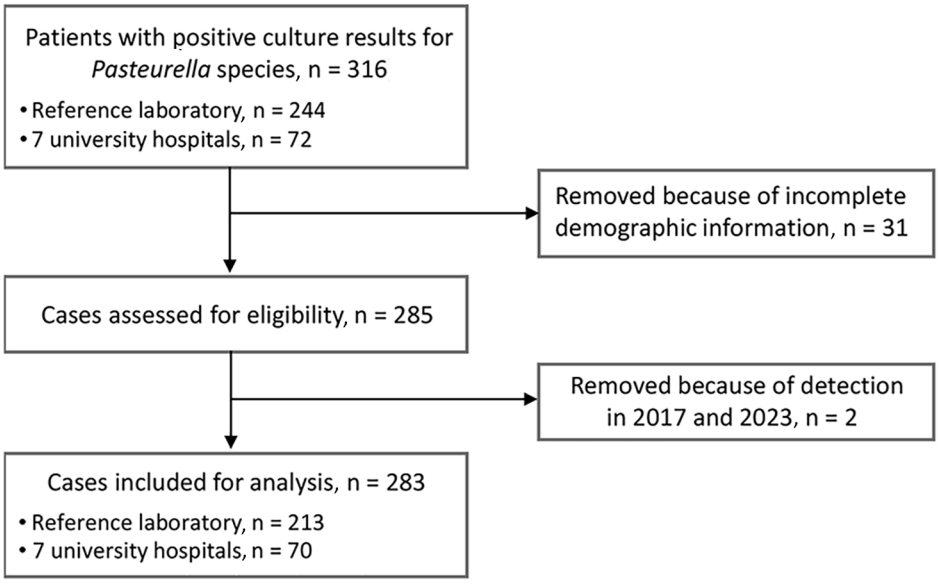

Figure 1. Flow diagram of study population selection for study of *Pasteurella* infection, South Korea, 2018–2022.

checklist (Appendix Table 1, https://wwwnc.cdc.gov/EID/article/30/10/24-0245-App1.pdf). We included studies that reported prevalence data for patients with *Pasteurella* species infection and bacteremia based on laboratory results. We included observational cohort studies, regardless of language or publication year. We excluded studies without the necessary data for the calculation of the prevalence of bacteremia (Appendix Table 2).

We performed a comprehensive search of PubMed, Ovid-EMBASE, and the Cochrane Library for articles published through November 1, 2023. The search strategy included use of the keywords "Pasteurella infections," "bacteremia," "prevalence," and "epidemiology." We included Medical Subject Heading and Emtree terms, text words, and equivalent subject heading and thesaurus terms to ensure inclusivity; we also performed manual searches of the references of relevant articles for completeness (Appendix Table 3). We registered the protocol in the international prospective register for systematic reviews (registration no. CRD42023484039).

Analysis of the Study Population Data and Meta-analysis

For statistical analysis of data from multiple centers in South Korea, we used the Mann-Whitney U test or Pearson's χ^2 test to compare groups. We applied multivariate binary logistic regression analyses to investigate variables that correlated independently with the occurrence of bacteremia in patients with *Pasteurella* spp. infections.

For the meta-analysis, we conducted title and abstract screening of studies selected through the search strategy on the basis of the eligibility criteria (Figure 2). Two reviewers (E.J. and N.L.) independently assessed the full texts of the studies. We settled disagreements by consensus after all reviewers reviewed the data. We extracted the following variables if they were available: demographic information about the study population, collection periods, the presence of animal exposure, the identified species, regions, and outcome measures. We documented the data for hospitalization and death, as well as the prevalence of bacteremia, our primary outcomes. We used the Joanna Briggs Institute checklist (*19*) to evaluate the quality of the included articles at the study level. We considered scores >70% as high quality. Two reviewers (E.J. and N.L.) assessed the quality of the included studies. S.J. resolved any disagreements.

We calculated the proportion of patients with positive blood cultures for the determining the rate of bacteremia among the total number of patients with bacterial infections. We based the calculation on all types of samples for which culture tests were requested (*3*,*4*,*10*,*20*). Although simultaneous blood culture is necessary for a more accurate determination of the rates of bacteremia, it was not routinely performed. Blood culture was performed only in 35/283 cases in which the clinician deemed it necessary. We transformed single raw prevalence using the Freeman-Tukey Double arcsine method (*21*) to stabilize variances. We used the random effects model to calculate the pooled prevalence with 95% CI across studies.

We assessed heterogeneity using Cochran's Q test and the degree of heterogeneity using the Higgins I^2 statistic. Indices with values of >75% represented high heterogeneity (*22*). We performed

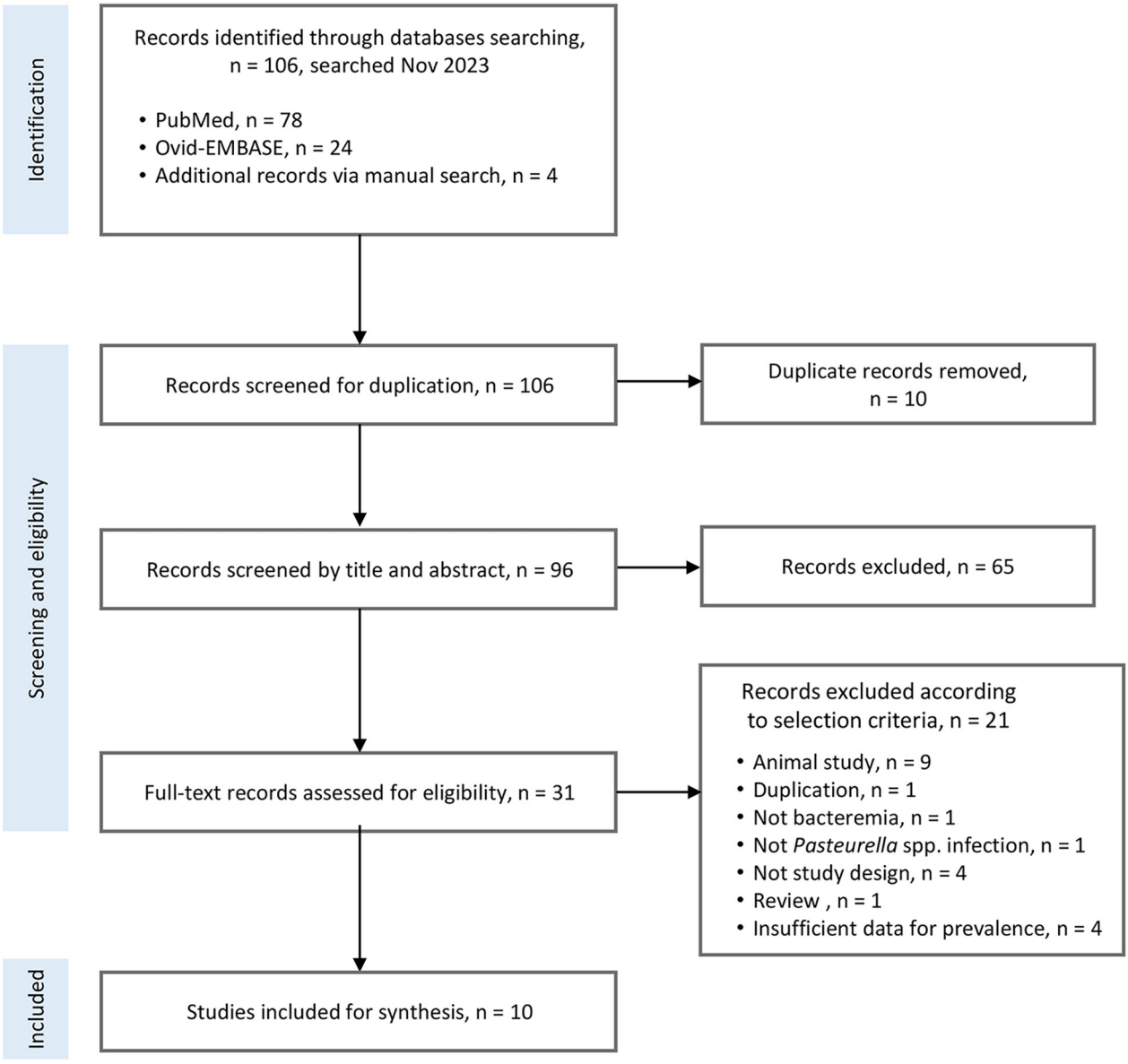

Figure 2. Flow diagram of study selection process in systematic review and meta-analysis of studies of human bacteremia caused by *Pasteurella* spp..

subgroup analyses to explore potential sources of heterogeneity by study location and period. In addition, we conducted sensitivity analysis to further assess the robustness of the estimates. The software we used for those analyses was the moonBook package in R (The R Project for Statistical Computing), MedCalc software, version 19.8 (MedCalc Software Ltd), Analyze-it Method Evaluation Edition software version 2.26 (Analyze-it Software Ltd), and Stata version 18 (StataCorp LLC). We have deposited the raw data used in this study (Appendix Tables 4, 5) in the Harvard Dataverse (https://doi.org/10.7910/DVN/1QQ9KK).

Results

Prevalence and Clinical Features of *Pasteurella* Infections

We included a total of 283 cases in the study, 70 from hospital patients with complete data and 213 cases from the main reference laboratory with basic information. We observed an increase in the number of infections caused by *Pasteurella* spp. from 2018 (n = 46) to 2022 (n = 72) (Figure 3); the increase was significant on the basis of the national population data extracted from the Korean Statistical Information Service (p = 0.012). The median number of cases per year

was 55. The predominant species were *P. multocida* (68.9%, 195/283) and *P. canis* (25.4%, 72/283), both of which contributed to the increase in infections. The median age of patients with positive culture results was 52.0 years. The number of *Pasteurella* isolation samples was higher in women (66.4%, 188/283) than in men (33.6%, 95/283). We observed the most cases in patients in the 50–59-year age group (Figure 3). The ratio of female to male patients was the highest (3.4:1) for patients 20–29 years of age. Most patients had a history of companion animal exposure (88.6%, 62/70) (Appendix Table 6); half had history of dog exposure and 38.7% (24/62) cat exposure. The rate of polymicrobial infection was 25.7% (18/70). The detected isolates were *Staphylococcus aureus* (n = 2), *Actinomyces* spp. (n = 2), *Streptococcus sanguinis* (n = 1), *Proteus mirabilis* (n = 1), and *Dermabacter hominis* (n = 1). The rate of hospitalization was 54.3% (38/70). We noted no significant differences in characteristics between inpatients and outpatients (Appendix Table 7). Among all the patients, most patients were mainly from Seoul (23.0%, 65/283), whereas those included in the reference laboratory study were predominantly from Gyeongsang-do (33.0%, 71/213) and Gyeonggi-do (17.4%, 37/213) (Appendix Figure 1). All patients, except for 3 outpatients, had received antimicrobial therapy. The most frequently prescribed antibiotics were penicillin/β-lactamase inhibitor combinations and first-generation cephalosporins (Appendix Table 4).

The rates of bacteremia were 2.8% (8/283) among all included infections and 7.1% (5/70) among the 7 university-hospital cases (Appendix Table 8). The median age was higher in bacteremia (68.5 years) than that in nonbacteremia (52.0 years). Patients with bacteremia had no animal exposure history. According to the multivariate regression analyses, including sex as the confounder, only increasing age was a significant risk factor for bacteremia (odds ratio 1.05, 95% CI 1.01–1.10; p = 0.024) (Figure 4). Among all bacteremia cases, 1 patient with septic shock caused by *P. multocida* died after 4 days of hospitalization; that patient had alcoholic liver cirrhosis and asthma as underlying diseases.

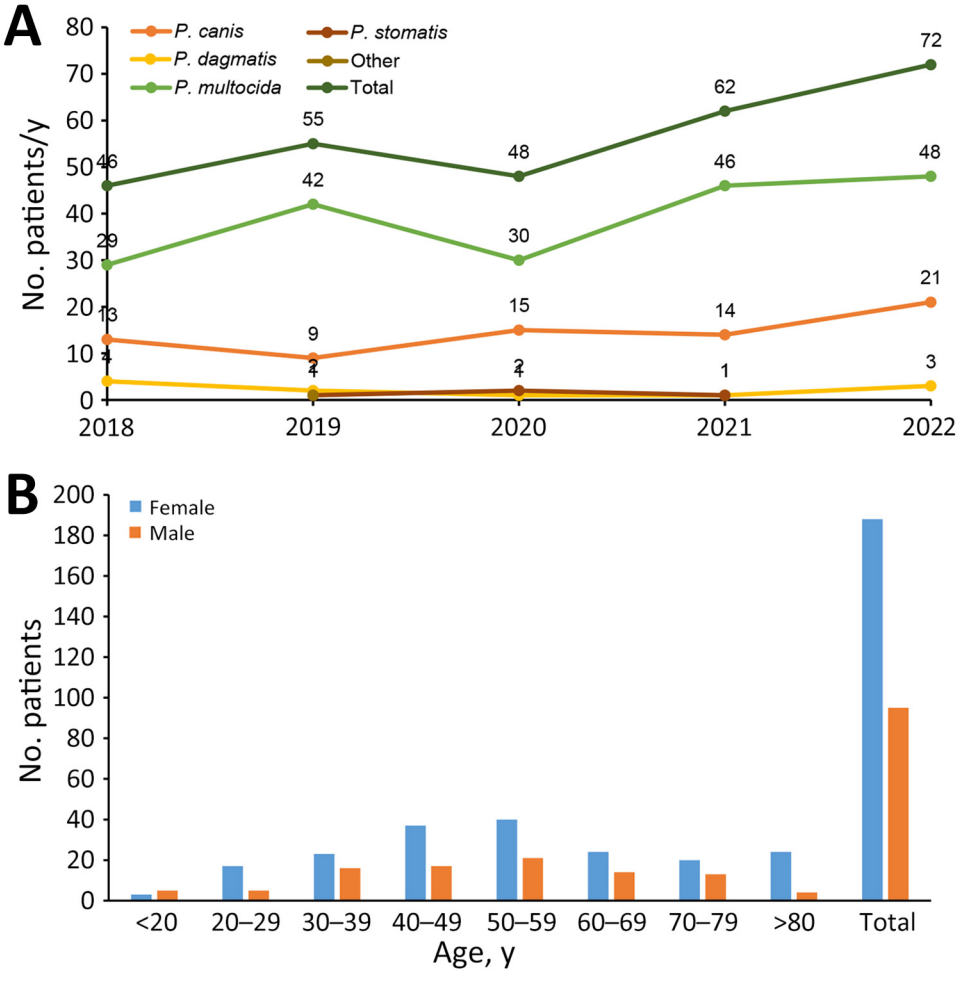

Figure 3. Prevalence of *Pasteurella* infections in South Korea, 2018–2022. A) Distribution of *Pasteurella* infections classified by year and species. B) Distribution of *Pasteurella* infections classified by age group and sex.

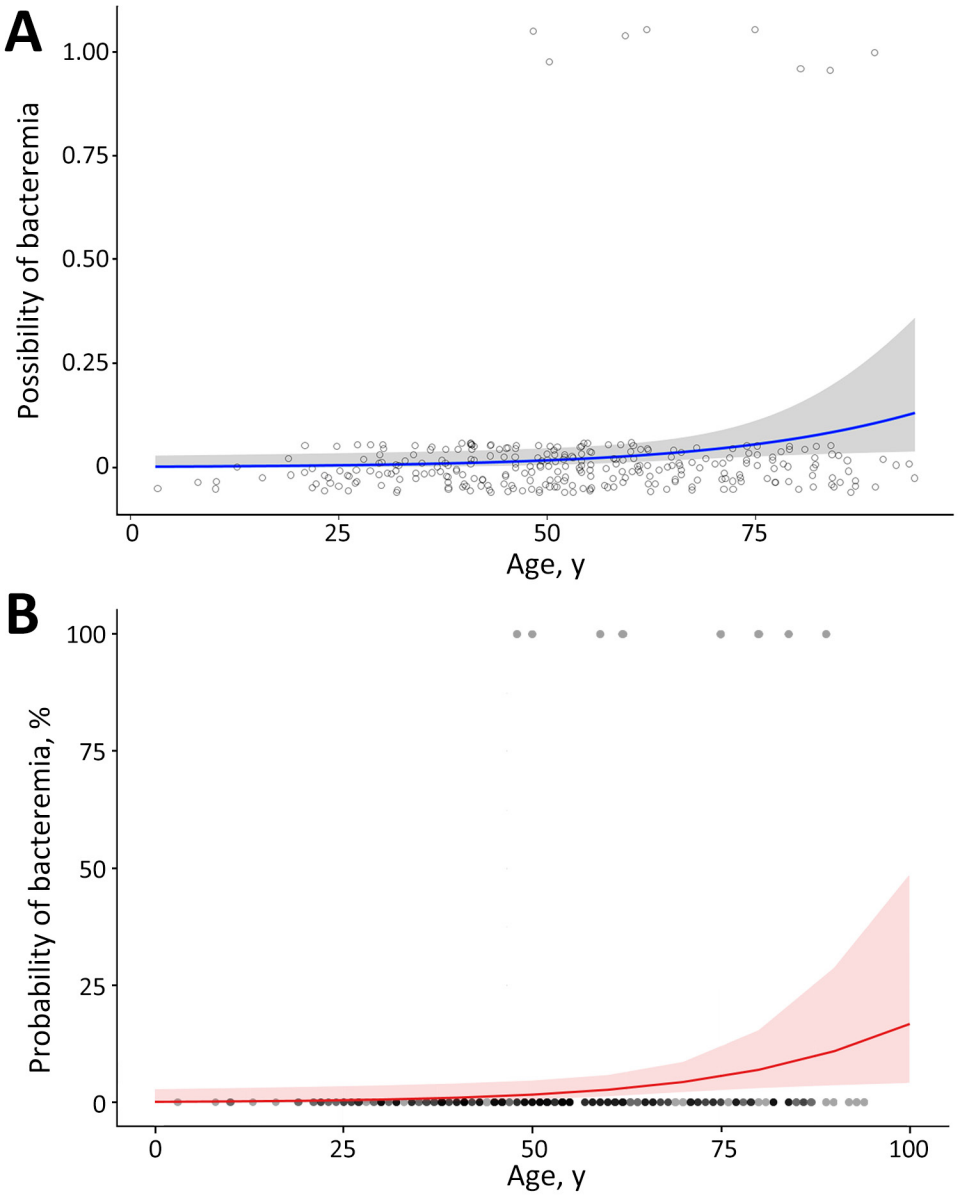

Figure 4. Regression model of bacteremia caused by *Pasteurella* spp., South Korea, 2018–2022. A) Univariate analysis of age and the probability of bacteremia caused by *Pasteurella* spp. The smoothing method was a generalized linear model. Blue line indicates the estimated values of the possibility of bacteremia; shading indicates 95% CI; black circles indicate cases with bacteremia; and gray circles indicate cases without bacteremia. B) Final model after multivariate analysis of age and sex for the predicted probability of bacteremia caused by *Pasteurella* spp. Red line indicates the estimated values of the probability of bacteremia; shading indicates 95% CI; black dots indicate cases with bacteremia; and gray dots indicate cases with nonbacteremia.

Meta-analyses for Global Burden of *Pasteurella* Bacteremia

The study screening method for the meta-analysis (Figure 2) identified 106 studies, of which 96 articles were relevant and were subsequently screened. A total of 31 reports were available for full-text screening. We excluded papers with insufficient study populations and design and insufficient data for the calculation of the prevalence of *Pasteurella* spp. bacteremia from the current review (Appendix Table 2). Finally, we included 10 studies in the systematic review (*3*,*4*,*6*,*7*,*10*,*20*,*23*–*26*).

We included a total of 2,012 participants from the 10 studies in the meta-analysis (Table). The studies were published during 1985–2021, half before 2010 (*4*,*10*,*20*,*25*,*26*) and half after 2010 (*3*,*6*,*7*,*23*,*24*). We observed more than 50% of study participants were female in all the included studies. The occurrence of animal exposure calculated from available study data was 34.3%–97.3%. The most commonly isolated species were *P. multocida* and *P. canis*. The rates of hospitalization were higher in cases of invasive infection (83.3% [*23*] and 97.0% [*24*]) than those in other cases (*3*,*6*,*7*,*20*). The death rates range was 0.6%–27.2%. Six studies were conducted in Europe and the United States (*3*,*7*,*10*,*20*,*23*–*26*). Based on the assessment using the Joanna Briggs Institute checklist, all studies showed scores >70%, indicating that they were of high quality.

Four studies that included only *P. multocida* infections had lower scores in the samples frame appropriate to address the target population (*3*,*4*,*20*,*25*).

The prevalence of bacteremia caused by *Pasteurella* spp. from 10 studies was 3.4%–32.5%. The random effects pooled prevalence from the 2,012 cases was 12.4% (95% CI 7.3%–18.6%). The Cochran Q test revealed significant heterogeneity (Q = 52.1, p<0.001). The I^2 index of the included studies indicated high heterogeneity (I^2 = 90.7) (Figure 5).

We calculated the pooled prevalence estimates of *Pasteurella* infection stratified by publication year. The pooled value of 5 studies published before 2010 (*4*,*10*,*20*,*25*,*26*) was 12.7% (95% CI 4.1%–24.6%) and of 5 studies published after 2010 (*3*,*6*,*7*,*23*,*24*) was 12.1% (95% CI 6.6%–18.9%). Although the I^2 index for studies published after 2010 (78.9%) was lower than that for studies before 2010 (94.4%), we noted no significant differences in pooled prevalence and heterogeneity. In a subgroup analysis of different regions, the estimated prevalence infection in 6 studies conducted in Europe (9.8%, 95% CI 4.5%–16.6%) was not different from that of 2 studies conducted in the United States (11.6%, 95% CI 3.3%–23.6%). We excluded 1 of the 10 studies from the sensitivity analyses. We compared estimated prevalence to the estimated total prevalence (Appendix Table 9). The pooled estimates from the sensitivity analyses were 9.9%–13.8%, consistent with the total pooled prevalence without statistical differences. The pooled death rate was 8.4% (95% CI 2.7%–16.5%) (Appendix Figure 2).

Discussion

In this analysis of data from 8 centers in South Korea and a meta-analysis of the global burden of *Pasteurella* infections, we included 283 cases of infection caused by *Pasteurella* spp. in South Korea and 2,012 cases from 10 previous studies. We observed an increasing

Table. Characteristics of study of *Pasteurella* infections in South Korea and 10 studies included in meta-analysis of bacteremia caused by *Pasteurella* spp.*

Study location	No. patients	Collection period	Age, y†	Sex ratio, M:F	No. (%) with animal exposure	Species (no.)	Hospitalizations, no. (%)	No. (%) deaths	Ref
South Korea	283‡	2018–2022	52.0	95:188	62/70‡ (88.6)	*P. multocida* (195), *P. canis* (72), *P. dagmatis* (11), *P. stomatis* (4)	38/70‡ (54.3)	1/70‡ (1.4)	This study
Greece	13	1993–2004	64.4	10:3	5 (38.5); 2 unknown	*P. multocida* (13)	NR	3 (23.1)	(*25*)
France	215: 45 invasive, 170 local	2005–2018	59.8 for invasive, 49.1 for local	29:16 for invasive, 64:106 for local	16 of invasive, 21 of complicated local	*P. multocida* (169/215 total), *P. canis* (32/170 local)	65/67 (97.0) invasive and complicated local	10/45 (22.2) invasive	(*23*)
United States	179	1987–2007	66	6:8	7 (50.0) of 14 hospitalized	*P. multicida* (179)	14 (7.8)	1 (0.6)	(*20*)
France	958	1985–1991	NR	NR	35/102§ (34.3)	*P. multocida* (460), *P. canis* (105), *P. dagmatis* (48), *P. stomatis* (38)	NR	12/87 (13.8) with septicemia	(*10*)
United States	44	2000–2014	64	14:30	25 (56.8)	*P. multocida* (44)	27 (61.4)	4 (9.1)	(*3*)
Denmark	146	1989–1992	NR	NR	142 (97.3)	*P. multocida* (95), *P. canis* (28), *P. septica* (21), *P. stomatis* (10), *P. dagmatis* (5)	NR	NR	(*26*)
Hungary	162	2002–2015	57	78:84	114 (70.4)	*P. multocida* (160), *P. canis* (36), *P. pneumotropica* (11)	71/114 (62.3) local, 40/48 (83.3) invasive	44 (27.2)	(*24*)
Australia	190	2000–2021	49.7	93:97	145 (76.3)	*P. multocida* (121), *P. canis* (45), *P. dagmatis* (2)	148 (77.9)	2 (1.1)	(*6*)
France	102: 74 local, 28 invasive	2000–2015	63 for invasive, 50 for local	38:64	NR	*P. multocida* (86), *P. canis* (10), *P. dagmatis* (1), *P. stomatis* (1)	75 (73.5)	4 (3.9)	(*7*)
Israel	77	2000–2005	49.2	38:39	46 (59.7)	*P. multocida* (77)	NR	2 (2.6)	(*4*)

*NR, not reported; ref, reference.
†Mean or median, as reported in article.
§15 cases of bacteremia and 87 cases of septicemia.
‡70 hospital patients with complete data and 213 cases from the main reference laboratory records.

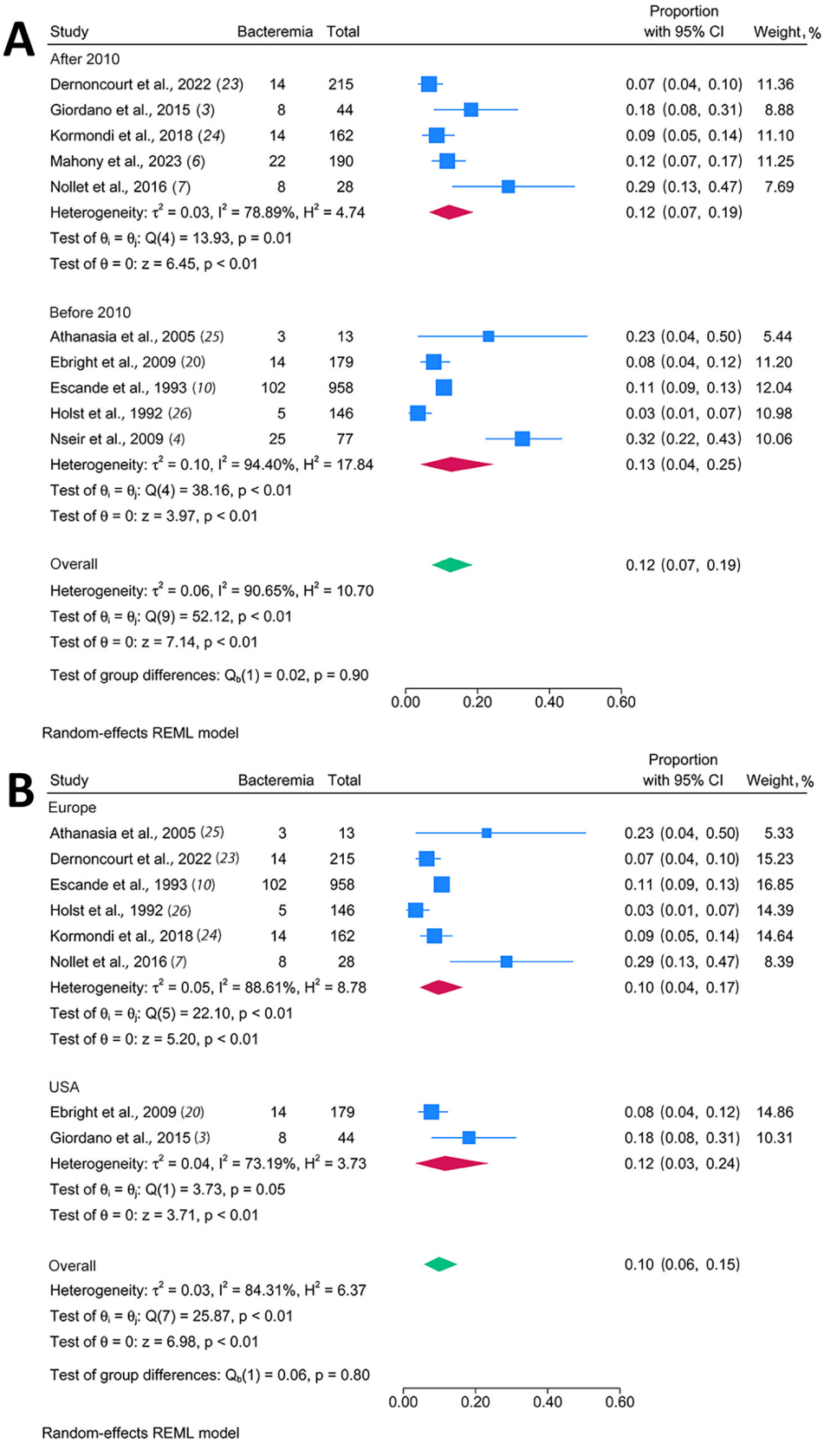

Figure 5. Forest plots for the pooled prevalence rates in systematic review and meta-analysis of studies of human bacteremia caused by *Pasteurella* spp. A) Subgroup analysis by year study was published. B) Subgroup analysis by study location. Blue squares indicate the rates of bacteremia of the included studies; error bars indicate 95% Cis. Red diamonds indicate the pooled rates of the included studies in the subgroup analysis, and green diamonds indicate the pooled rates of all studies presented in each subgroup analysis.

trend of *Pasteurella* infections during 2018–2022; South Korea had a median of 55 cases/year. The increasing trend of *Pasteurella* infections we observed in this study was consistent with the results of studies conducted in Australia (*6*) and Hungary (*24*). Those findings can be attributed to the increasing number of companion animals and their close contact with humans in South Korea. In Canada, ≈57% of households have ≥1 companion animal (*27*). The mean number of animal bites per year in Israel is 15,000, according to data from the Israeli Ministry of Health (*4*). In the United States, emergency departments observe ≈3 million dog bite injuries that lead to 10,000 hospitalizations and 20 deaths annually (*28*).

Among *Pasteurella* species, *P. multocida* is the most frequently isolated, followed by *P. canis* (*6*,*7*,*10*,*23*,*24*). Our results were consistent with those findings. The polymicrobial nature of *Pasteurella* infection was persistently reported. Mahony et al. (*6*) reported that 23.8% of cases exhibited polymicrobial infection, which was similar to the rate (25.7%) we observed in our study. *Staphylococcus aureus*, *Actinomyces* spp., *Streptococcus sanguinis*, and *Dermatobia hominis*, which were the co-isolated strains in this study, usually act as commensal bacteria in humans. *S. aureus* has been frequently isolated in several studies (*6*,*24*), concordant to our results.

For the demographic distribution, our study confirmed the predominance of infections in female patients, which has been consistently observed in previous studies, despite some variations (*3*,*7*,*24*). Dernoncourt et al. (*23*) observed this female predominance in localized infection cases rather than invasive infection cases, which might be associated with the higher proportions of localized infection we observed. Patients 50–59 years of age exhibited the most infections in this study. A survey in Canada found that the rate of pet ownership was highest among middle-aged persons (*27*), which supports our results, considering that pet-associated infections are frequently derived from injuries or animal bites (*24*). The high ratio of female to male patients 20–29 years of age could be because the primary responsibility for the care of companion animals is mostly that of female persons (72.8%) within households (*29*); another possible cause is that some nonmarried women spend substantial time with their cats (*29*).

Regarding bacteremia, older age groups are associated with bacteremia caused by *Pasteurella* spp. (*4*,*6*,*7*), consistent with the results of our study. Age-related dysfunction of the immune system and underlying diseases contribute to the increased risk for invasive infections (*24*). Underlying conditions such as diabetes mellitus and cirrhosis were commonly reported risk factors for bacteremia (*11*,*30*). Nollet et al. (*7*) determined by univariate analysis that chronic liver disease and alcohol consumption were risk factors for invasive *Pasteurella* infection; however, multivariate analysis showed that age was a significant risk factor (*7*). For animal contact, bacteremia was associated with the absence of animal bites or contacts (*7*,*24*), similar to our results. A previous study reported acute epiglottis without animal exposure (*31*), and a review described 79 cases including 34 of nonbite transmission (*14*). This type of transmission was related to comorbidities resulting in life-threatening infections. For example, contaminating a metatarsal ulcer by stepping on dog drool or wearing socks covered with cat hair could lead to bacteremia. The protection of open wounds is necessary for prevention because they were the most common entry method for non–bite-associated infections.

Several case reports or reviews have described severe systemic infections caused by *Pasteurella* spp., such as bacteremia and endocarditis. A review of *P. multocida* bacteremia presented the clinical features and outcome of 13 patients (*32*). A recent review focused on epidemiology, diagnosis, host–pathogen interactions, clinical manifestation, management, and prognosis of *P. multocida* infections (*2*). In addition, a systematic review of infective endocarditis caused by *Pasteurella* species described the clinical characteristics and outcomes of patients on the basis of data from 28 studies (*13*). However, meta-analyses with specified values have not been performed. Therefore, we conducted meta-analyses assessing the global burden of *Pasteurella* bacteremia as a representative invasive infection.

The pooled prevalence from 10 studies was 12.4%, which was higher than the rate of bacteremia observed in this study (2.8% from all episodes and 7.1% from 7 hospital cases). The study populations of the included studies included patients in tertiary and university hospitals (*3*,*6*,*23*–*26*) or with hospitalization (*4*), which may have influenced this high prevalence. In addition, high medical accessibility with a reimbursement system and health screenings for the elderly could be the cause of the significantly low prevalence of bacteremia we observed in our study. The high heterogeneity may be derived from the different periods of isolation and publication and by the variation across geographic regions of the country. We performed subgroup analyses stratified by publication year and study locations, which showed no significant differences, except for a slightly lower I^2 index (from 94.4% before 2010 to

78.9% after 2010). The overlap of data collection periods caused by long (median 13 years) study durations might have affected these results. In addition, the small number of studies on *Pasteurella* bacteremia used for this analysis might have affected the statistical results.

The number of deaths caused by *Pasteurella* infection is increasing in the United States (*33*). Meta-analyses revealed that the pooled estimate of deaths was 8.4%, which was much higher than the death rate measured in our study (0.4% for all and 1.4% for hospital cases). The low rate in our study is consistent with the low prevalence of bacteremia in our cohort; the mortality rate for patients with invasive infections was higher (*10*,*23*). Although the rate of infections is low, mortality rate may increase as the prevalence of *Pasteurella* infection increases.

One limitation of this study was its retrospective nature; some clinical information documented in the medical record was incomplete or missing. In particular, only basic demographic information was available for patients from the reference laboratory. Therefore, we included data from hospitals; data from multiple centers are a strength of this study. However, diverse identification methods and the inherent limitations of the applied methods may affect the results (*12*). The relatively small size of our cohort might influence the statistical analysis. Studies with larger study populations, including hospitals in rural and farming areas, are necessary. Detailed descriptions of the methods used for calculating the bacteremia rate would be useful to estimate the specified rate of bacteremia; in addition, further studies with concurrent blood culture data are needed to determine more accurate rates of bacteremia. For meta-analyses, additional studies from diverse countries are necessary for generalization. We could not sufficiently analyze publication bias because we included a limited number of studies. In addition, the heterogeneity of the included studies may have affected the results; we conducted subgroup analyses, a random effects model, and sensitivity analyses to overcome this limitation.

In conclusion, this study highlights the increasing trend and clinical features of *Pasteurella* infections, the rate of bacteremia, and older age as a risk factor for bacteremia based on data from 8 centers in South Korea. We estimated the global prevalence of bacteremia and related death rates through a collaborative approach with systematic meta-analysis. Our findings indicate that more attention needs to be paid to *Pasteurella* infection to enable appropriate management of these cases.

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The protocol was registered in PROSPERO (registration no. CRD42023484039). The raw data used in this study (Appendix Table 4, 5) are available in the Harvard Dataverse (https://doi.org/10.7910/DVN/1QQ9KK).

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K.L. and W.S. conceptualized and designed the study. H.S.K., H.-SK., J.-SK., Y.A.K., C.K.K., H.L., and S.H.J. contributed to data collection and curation. E.C., N.L., and S.J. performed the formal analysis and visualization. S.J. prepared the first draft of the manuscript. K.L. and W.S. reviewed, edited, and verified all the data reported in the study.

About the Author

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Pasteurella Infections in South Korea and Systematic Review and Meta-analysis of *Pasteurella* Bacteremia

Appendix

Appendix Table 1. Preferred reporting Items for the systematic review and meta-analysis checklist

Section And Topic	Item #	Checklist item	Location where item is reported
Title			
Title	1	Identify the report as a systematic review.	Title of paper
Abstract			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	We have checked.
Introduction			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Introduction, Paragraph 1 and 2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Introduction, Paragraph 3
Methods			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Methods, Subsection “Search strategy and selection criteria for meta-analysis”
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Methods, Subsection “Search strategy and selection criteria for meta-analysis”
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Table S3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Methods, Subsection “Data analysis for study population and meta-analysis”
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Methods, Subsection “Data analysis for study population and meta-analysis”
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Methods, Subsection “Data analysis for study population and meta-analysis”
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Methods, Subsection “Data analysis for study population and meta-analysis”

Section And Topic	Item #	Checklist item	Location where item is reported
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Methods, Subsection “Data analysis for study population and meta-analysis”
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Methods, Subsection “Data analysis for study population and meta-analysis”
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Methods, Subsection “Data analysis for study population and meta-analysis”
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Methods, Subsection “Data analysis for study population and meta-analysis”
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Methods, Subsection “Data analysis for study population and meta-analysis”
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Methods, Subsection “Data analysis for study population and meta-analysis”
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Methods, Subsection “Data analysis for study population and meta-analysis”
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Methods, Subsection “Data analysis for study population and meta-analysis”
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Methods, Subsection “Data analysis for study population and meta-analysis”
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Methods, Subsection “Data analysis for study population and meta-analysis”
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Results, Paragraph 3 and Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	Results, Paragraph 4 and Table 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Results, Paragraph 4
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Results, Paragraph 5 and Figure 4
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Results, Paragraph 4
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Results, Paragraph 5 and Figure 4
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Results, Paragraph 6 and Figure 4
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Results, Paragraph 6 and Table S8
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Results, Paragraph 6 and Table S8
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Results, Paragraph 6 and Figure 4
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Discussion, Paragraphs 1-8
	23b	Discuss any limitations of the evidence included in the review.	Discussion, Paragraphs 9

Section And Topic	Item #	Checklist item	Location where item is reported
	23c	Discuss any limitations of the review processes used.	Discussion, Paragraphs 9
	23d	Discuss implications of the results for practice, policy, and future research.	Discussion, Paragraphs 10
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Abstract and Methods
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Abstract and Methods
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Methods, Subsection “Role of the funding source” and Acknowledgments
Competing interests	26	Declare any competing interests of review authors.	Section “Declaration of interests”
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	HARVARD Dataverse (https://doi.org/10.7910/DVN/1QQ9KK)

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Appendix Table 2. Excluded studies and the corresponding reasons

Reference (date)	Reason for exclusion	Reference
Chandranaik (2015)	Animal study	(*1*)
Chomnawang (2009)	Animal study	(*2*)
Dunbar (2000)	Animal study	(*3*)
Kawasaki (2015)	Animal study	(*4*)
Martrenchar (1994)	Animal study	(*5*)
Moustafa (2013)	Animal study	(*6*)
Qudratullah (2017)	Animal study	(*7*)
Sarangi (2016)	Animal study	(*8*)
Voigts (1997)	Animal study	(*9*)
Prakash (2009)	Duplication	(*10*)
Levy (1989)	Not bacteremia	(*11*)
Bardhan (2020)	Not *Pasteurella* species infection	(*12*)
Biswas (2004)	Not study design	(*13*)
MacPhillamy (2020)	Not study design	(*14*)
Mondal (2014)	Not study design	(*15*)
Tomer (2002)	Not study design	(*16*)
Kannangara (2020)	Review	(*17*)
Bhonsle (1951)	Insufficient data for prevalence	(*18*)
Carter (1982)	Insufficient data for prevalence	(*19*)
Martrenchar (1993)	Insufficient data for prevalence	(*20*)
Rimler (1994)	Insufficient data for prevalence	(*21*)

Appendix Table 3. Search strategy
(PubMed Search; adapted for other searches)
PubMed (2023.11.01)

No.	Query	Items found
#1	“Pasteurella Infections”[Mesh] OR “Pasteurella Infections”[TW] OR “Pasteurellosis”[TW] OR “Pasteurelloses”[TW] OR “Infections, Pasteurella”[TW] OR “Infection, Pasteurella”[TW] OR “Pasteurella Infection”[TW]	4,949
#2	“Bacteremia”[Mesh] OR “Bacteremia”[TW] OR “Bacteremias”[TW] OR “Septicemia”[TW] OR “Hemorrhagic Septicemia”[Mesh] OR “Hemorrhagic Septicemia”[TW]	63,552
#3	“Prevalence”[MeSH] OR “Epidemiology”[MeSH] OR “prevalence”[TW] OR “epidemiology”[TW] OR “incidence”[TW]	3,245,301
#4	#1 AND #2 AND #3	88
#5	#4 NOT ("Review"[Publication Type] OR "Review literature as topic"[MeSH])	78

Appendix Table 4. Dataset of infections caused by *Pasteurella* species from a multicenter study

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
Kangnam	P1	2018	Wound	Face	No	Yes	F	35	Gyeonggi-do	No	1. Ampicillin sodium/sulbactam sodium 2. Sultamicillin	Clinical cure
Kangnam	P2	2019	Wound	Upper extremity	No	Yes	F	51	Seoul	Yes	1. Ampicillin sodium/sulbactam sodium 2. Amox/clavulanic acid	Clinical cure
Kangnam	P3	2020	Wound	Upper extremity	No	Yes	M	80	Seoul	Yes	1. Ampicillin sodium/sulbactam sodium 2. Amox/clavulanic acid	Clinical cure
Kangnam	P4	2020	Wound	Other	No	Yes	F	26	Seoul	No	1. Ampicillin sodium/sulbactam sodium 2. Amox/clavulanic acid	Clinical cure
Kangnam	P5	2020	Blood	Blood	No	No	F	75	Gangwon-do	Yes	1. Ceftazidime 2. Ceftriaxone sodium 3. Vancomycin 4. Levofloxacin	Clinical cure
Kangnam	P6	2020	Wound	Face	Yes	Yes	F	32	Seoul	No	1. Cefalexin 2. Cefuroxime 3. Netilmicin	Clinical cure
Kangnam	P7	2020	Wound	Face	Yes	Yes	M	3	Seoul	No	1. Amox/clavulanic acid 2. Netilmicin	Clinical cure
Kangnam	P8	2020	Wound	Face	Yes	Yes	F	57	Seoul	No	1. Ampicillin sodium/sulbactam sodium 2. Sultamicillin	Clinical cure
Kangnam	P9	2021	Wound	Upper extremity	No	Yes	F	59	Seoul	No	1. Amox/clavulanic acid 2. Doxycycline 3. Ampicillin sodium/sulbactam sodium	Clinical cure
Kangnam	P10	2021	Wound	Face	Yes	Yes	M	48	Seoul	No	1. Ampicillin sodium/sulbactam sodium 2. Sultamicillin	Clinical cure
Kangnam	P11	2022	Wound	Face	No	Yes	F	32	Seoul	No	1. Ampicillin sodium/sulbactam sodium 2. Sultamicillin	Clinical cure
Kangnam	P12	2022	Wound	Face	No	Yes	F	52	Seoul	No	1. Cefalexin 2. Cefazolin 3. Ampicillin sodium/sulbactam sodium	Clinical cure

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
Kangnam	P13	2022	Wound	Upper extremity	No	Yes	M	49	Seoul	Yes	1. Ampicillin sodium/sulbactam sodium 2. Amox/clavulanic acid	Clinical cure
Hallym	P14	2018	Blood	Blood	No	No	M	59	Gyeonggi-do	Yes	Piperacillin/tazobactam	Clinical cure
Hallym	P15	2018	Wound	Lower extremity	No	Yes	M	55	Gyeonggi-do	No	Amox/clavulanic acid	Clinical cure
Hallym	P16	2018	Wound	Lower extremity	No	Yes	F	67	Gyeonggi-do	Yes	Amox/clavulanic acid	Clinical cure
Hallym	P17	2019	Wound	Upper extremity	No	Yes	M	30	Gyeonggi-do	Yes	Amox/clavulanic acid	Clinical cure
Hallym	P18	2019	Wound	Upper extremity	No	Yes	F	45	Gyeonggi-do	Yes	Amox/clavulanic acid	Clinical cure
Hallym	P19	2021	Wound	Upper extremity	No	Yes	F	68	Gyeonggi-do	Yes	Amox/clavulanic acid	Clinical cure
Ilsan	P20	2018	Wound	Upper extremity	No	Yes	F	71	Gyeonggi-do	No	Cefazolin	Clinical cure
Ilsan	P21	2018	Wound	Upper extremity	No	Yes	F	74	Gyeonggi-do	Yes	1. Cefazolin 2. Ampicillin-sulbactam 3. Sultamicillin	Clinical cure
sIlsan	P22	2021	Wound	Upper extremity	Yes	Yes	M	78	Gyeonggi-do	Yes	1. Cefazolin 2. Amikacin	Clinical cure
Ilsan	P23	2021	Wound	Upper extremity	No	Yes	F	54	Gyeonggi-do	No	1. Cefoxitin 2. Amoxacillin/clavulanic acid 3. Amikacin 4. Cefazolin 5. Piperacillin-tazobactam 6. Ampicillin sodium/sulbactam sodium	Clinical cure
Gseverance	P24	2019	Wound	Upper extremity	Yes	Yes	F	38	Gyeonggi-do	Yes	1. Ampicillin/sulbactam 2. Ceftriaxone	Clinical cure
Gseverance	P25	2019	Wound	Upper extremity	Yes	Yes	F	25	Seoul	No	1. Cefazolin 2. Amoxcillin/clavulanate	Clinical cure
Gseverance	P26	2019	Wound	Upper extremity	No	Yes	M	54	Seoul	No	1. Ceftriaxone 2. Cefdinir	Clinical cure
Gseverance	P27	2019	Wound	Upper extremity	No	Yes	M	54	Seoul	No	1. Ceftriaxone 2. Cefdinir	Clinical cure
Gseverance	P28	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P29	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
Gseverance	P30	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P31	2019	Wound	Upper extremity	Yes	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P32	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P33	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P34	2019	Wound	Upper extremity	No	Yes	F	41	Seoul	Yes	1. Ampicillin/sulbactam 2. Levofloxacin 3. Sultamicillin	Clinical cure
Gseverance	P35	2021	Wound	Upper extremity	No	Yes	M	10	Seoul	No	1. Cefazolin 2. Cefadroxil	Clinical cure
Gseverance	P36	2022	Wound	Upper extremity	No	Yes	M	42	Seoul	Yes	1. Amikacin 2. Cefazolin 3. Amoxcillin/clavulanate	Clinical cure
Gseverance	P37	2022	Wound	Upper extremity	No	Yes	M	42	Seoul	Yes	1. Amikacin 2. Cefazolin 3. Amoxcillin/clavulanate	Clinical cure
Gseverance	P38	2022	Wound	Upper extremity	Yes	Yes	M	32	Seoul	Yes	1. Cefazolin 2. Amikacin 3. Ampicillin/sulbactam 4. Amoxcillin/clavulanate	Clinical cure
Gseverance	P39	2022	Wound	Upper extremity	Yes	Yes	M	32	Seoul	Yes	1. Cefazolin 2. Amikacin 3. Ampicillin/sulbactam 4. Amoxcillin/clavulanate	Clinical cure
Gseverance	P40	2022	Wound	Lower extremity	No	Yes	F	32	Seoul	No	Amoxcillin/clavulanate	Clinical cure
Gseverance	P41	2022	Wound	Upper extremity	No	Yes	F	40	Seoul	No	1. Clindamycin 2. Ampicillin/sulbactam 3. Amoxcillin/clavulanate	Clinical cure
Dongtan	P42	2018	Wound	Lower extremity	No	Yes	F	66	Seoul	No	1. Levofloxacin 2. Amikacin sulfate 3. Cefazedone Sodium	Clinical cure
Dongtan	P43	2018	Wound	Lower extremity	No	Yes	F	66	Gyeonggi-do	No	1. Levofloxacin 2. Amikacin sulfate 3. Cefazedone Sodium	Clinical cure
Dongtan	P44	2018	Wound	Lower extremity	No	Yes	F	54	Gyeonggi-do	Yes	1. Amoxicillin/dilute clavulanate potassium 2. Cefotaxime sodium 3. Levofloxacin	Clinical cure

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
Dongtan	P45	2018	Wound	Lower extremity	No	Yes	F	54	Gyeonggi-do	Yes	1. Ampicillin sodium/sulbactam sodium 2. Amox/clavulanic acid	Clinical cure
Dongtan	P46	2020	Wound	Lower extremity	No	Yes	F	49	Gyeonggi-do	Yes	1. Cefazolin sodium 2. Amoxicillin/dilute clavulanate potassium	Clinical cure
Dongtan	P47	2021	Wound	Upper extremity	No	Yes	M	34	Gyeonggi-do	Yes	1. Ceftriaxone sodium hydrate 2. Teicoplanin	Clinical cure
Dongtan	P48	2021	Wound	Upper extremity	No	Yes	M	34	Gyeonggi-do	Yes	1. Ceftriaxone sodium hydrate 2. Teicoplanin	Clinical cure
Sseverance	P49	2018	Blood	Blood	No	No	M	50	Jeollanam-do	Yes	1. Piperacillin/tazobactam 2. Moxifloxacin 3. Cefoperazone/sulbactam	Clinical cure
Sseverance	P50	2018	Wound	Upper extremity	Yes	Yes	M	66	Seoul	No	Amox/clavulanic acid	Clinical cure
Sseverance	P51	2018	Wound	Lower extremity	Yes	No	M	75	Seoul	Yes	Tazobactam	Clinical cure
Sseverance	P52	2018	Wound	Upper extremity	No	Yes	M	84	Seoul	No	None	Clinical cure
Sseverance	P53	2018	Wound	Upper extremity	No	Yes	F	87	Seoul	No	None	Clinical cure
Sseverance	P54	2018	Blood	Blood	Yes	No	F	62	Seoul	No	None	Clinical cure
Sseverance	P55	2019	Wound	Upper extremity	Yes	Yes	F	51	Seoul	No	1. Cephalosporins 2. Amox/clavulanic acid	Clinical cure
Sseverance	P56	2019	Wound	Upper extremity	Yes	Yes	F	36	Seoul	Yes	Amox/clavulanic acid	Clinical cure
Sseverance	P57	2020	Wound	Face	No	Yes	F	87	Seoul	No	1. Cefazolin 2. Amox/clavulanic acid	Clinical cure
Sseverance	P58	2020	CAPD fluid	CAPD fluid	No	No	M	71	Seoul	No	Cefazolin/sulbactam	Clinical cure
Sseverance	P59	2020	CAPD fluid	CAPD fluid	No	Yes	M	71	Seoul	No	1. Ceftriaxone/sulbactam 2. Vancomycin 3. Amikacin 4. Doxycycline 5. Rifampin 6. Fluconazole 7. Moxifloxacin	Clinical cure
Sseverance	P60	2021	Wound	Upper extremity	No	Yes	F	92	Seoul	No	1. Amoxaciliin 2. Cefdinir	Clinical cure
Sseverance	P61	2021	Blood	Blood	No	No	F	84	Seoul	Yes	1. Piperacillin/tazobactam 2. Levofloxacin	Death

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
											3. Meropenem 4. Teicoplanin	
Sseverance	P62	2021	Wound	Upper extremity	Yes	Yes	F	52	Seoul	No	1. Tazobactam 2. Sulbactam 3. Cephalosporins 4. Amox/clavulanic acid	Clinical cure
Sseverance	P63	2021	Wound	Upper extremity	Yes	Yes	F	84	Seoul	No	1. Sulbactam 2. Amox/clavulanic acid	Clinical cure
Gangdong	P65	2022	Wound	Lower extremity	No	Yes	F	46	Gyeonggi-do	Yes	Cephalosporins	Clinical cure
Gangdong	P66	2022	Wound	Lower extremity	Yes	No	M	72	Jeollabuk-do	Yes	Ceftriaxone	Clinical cure
Gangdong	P67	2022	Wound	Lower extremity	No	Yes	M	55	Seoul	Yes	Amox/clavulanic acid	Clinical cure
Gangdong	P68	2021	Wound	Upper extremity	No	Yes	M	33	Seoul	No	Amox/clavulanic acid	Clinical cure
Gangdong	P70	2021	Wound	Upper extremity	No	Yes	F	49	Seoul	Yes	Amox/clavulanic acid	Clinical cure
Gangdong	P71	2021	Wound	Upper extremity	No	Yes	F	37	Seoul	Yes	1. Amox/clavulanic acid 2. Moxifloxacin	Clinical cure
Gangdong	P72	2021	Wound	Upper extremity	No	Yes	F	52	Gyeonggi-do	Yes	Amox/clavulanic acid	Clinical cure
SCL	P73	2018	Pus				M	74	Jeollanam-do			
SCL	P74	2018	Pus				F	77	Chungcheongbuk-do			
SCL	P75	2018	Wound				M	47	Gyeongsangbuk-do			
SCL	P76	2018	Pus				M	55	Gyeongsangnam-do			
SCL	P77	2018	Pus				F	30	Gyeongsangbuk-do			
SCL	P78	2018	Pus				M	34	Gyeongsangnam-do			
SCL	P79	2018	Wound				F	41	Gyeongsangnam-do			
SCL	P80	2018	Pus				M	30	Gyeongsangbuk-do			
SCL	P82	2018	Wound				M	65	Gyeongsangnam-do			
SCL	P84	2018	Pus				M	37	Chungcheongnam-do			
SCL	P86	2018	Wound				F	94	Gyeongsangbuk-do			
SCL	P87	2018	Wound				M	22	Gyeongsangnam-do			
SCL	P88	2018	Wound				F	50	Gyeonggi-do			
SCL	P89	2018	Wound				M	46	Chungcheongbuk-do			
SCL	P91	2018	Pus				M	43	Gyeongsangnam-do			
SCL	P92	2018	Pus				F	51	Gyeongsangbuk-do			
SCL	P93	2018	Wound				F	59	Gyeongsangbuk-do			
SCL	P94	2018	Wound				M	58	Seoul			
SCL	P96	2018	Wound				F	62	Gyeongsangbuk-do			
SCL	P97	2018	Wound				F	46	Gyeongsangnam-do			
SCL	P98	2018	Pus				M	36	Jeollanam-do			
SCL	P100	2018	Wound				F	49	Gyeongsangnam-do			
SCL	P101	2018	Wound				F	43	Chungcheongbuk-do			
SCL	P102	2018	Pus				F	23	Seoul			
SCL	P103	2018	Wound				F	26	Jeollanam-do			
SCL	P104	2018	Fluid				F	57	Gyeongsangbuk-do			

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
SCL	P105	2018	Fluid				M	64	Gyeongsangnam-do			
SCL	P106	2018	Wound				F	47	Gyeongsangbuk-do			
SCL	P107	2018	Pus				F	77	Seoul			
SCL	P108	2018	Wound				F	62	Gyeongsangbuk-do			
SCL	P110	2019	Pus				F	39	Gyeongsangnam-do			
SCL	P111	2019	Wound				F	62	Gyeongsangbuk-do			
SCL	P113	2019	Wound				M	75	Seoul			
SCL	P114	2019	Wound				F	65	Gyeongsangbuk-do			
SCL	P115	2019	Pus				M	61	Jeollanam-do			
SCL	P116	2019	Wound				F	38	Gyeongsangbuk-do			
SCL	P117	2019	Wound				M	38	Chungcheongbuk-do			
SCL	P118	2019	Pus				F	54	Gyeongsangbuk-do			
SCL	P119	2019	Wound				F	30	Gyeongsangnam-do			
SCL	P120	2019	Pus				M	66	Gyeongsangnam-do			
SCL	P121	2019	Blood				M	48	Incheon			
SCL	P123	2019	Wound				F	27	Gyeonggi-do			
SCL	P124	2019	Wound				F	39	Incheon			
SCL	P125	2019	Pus				F	41	Seoul			
SCL	P126	2019	Pus				M	77	Gyeongsangbuk-do			
SCL	P127	2019	Wound				F	72	Gyeongsangnam-do			
SCL	P128	2019	Blood				F	89	Jeollabuk-do			
SCL	P129	2019	Pus				F	59	Gyeongsangnam-do			
SCL	P130	2019	Pus				M	8	Gyeongsangbuk-do			
SCL	P131	2019	Wound				M	21	Gyeongsangbuk-do			
SCL	P132	2019	Pus				F	81	Gyeongsangnam-do			
SCL	P133	2019	Wound				F	84	Gyeongsangbuk-do			
SCL	P134	2019	Wound				M	45	Chungcheongbuk-do			
SCL	P135	2019	Wound				F	74	Gyeongsangnam-do			
SCL	P136	2019	Wound				M	45	Gyeonggi-do			
SCL	P137	2019	Wound				M	10	Chungcheongbuk-do			
SCL	P138	2019	Pus				F	61	Jeollanam-do			
SCL	P139	2019	Wound				M	68	Chungcheongbuk-do			
SCL	P140	2019	Pus				F	53	Gyeongsangnam-do			
SCL	P141	2019	Pus				F	50	Gyeongsangbuk-do			
SCL	P142	2019	Wound				F	25	Gyeongsangnam-do			
SCL	P143	2019	Wound				F	28	Chungcheongbuk-do			
SCL	P144	2019	Pus				F	79	Gyeonggi-do			
SCL	P145	2019	Pus				F	45	Gyeongsangnam-do			
SCL	P146	2019	Pus				M	57	Jeollanam-do			
SCL	P147	2019	Pus				F	62	Gyeongsangbuk-do			
SCL	P148	2019	Pus				M	58	Gyeongsangnam-do			
SCL	P150	2019	Wound				F	65	Seoul			
SCL	P151	2019	Wound				M	40	Gyeongsangnam-do			
SCL	P153	2020	Pus				F	53	Seoul			
SCL	P154	2020	Wound				F	82	Gyeongsangbuk-do			
SCL	P155	2020	Wound				F	60	Chungcheongnam-do			
SCL	P156	2020	Wound				M	82	Gyeongsangnam-do			
SCL	P157	2020	Wound				M	46	Gyeongsangbuk-do			

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
SCL	P158	2020	Wound				F	50	Gyeongsangbuk-do			
SCL	P159	2020	Pus				F	52	Gyeongsangnam-do			
SCL	P160	2020	Pus				F	40	Jeollanam-do			
SCL	P161	2020	Wound				F	60	Seoul			
SCL	P162	2020	Pus				F	58	Gyeonggi-do			
SCL	P163	2020	Pus				F	40	Gyeongsangbuk-do			
SCL	P164	2020	Wound				F	31	Gyeonggi-do			
SCL	P165	2020	Pus				F	31	Jeollanam-do			
SCL	P166	2020	Wound				F	29	Gyeongsangbuk-do			
SCL	P168	2020	Wound				M	50	Gyeongsangbuk-do			
SCL	P169	2020	Wound				M	49	Gyeongsangnam-do			
SCL	P170	2020	Wound				F	22	Gyeonggi-do			
SCL	P171	2020	Wound				F	48	Gyeonggi-do			
SCL	P172	2020	Wound				F	25	Gyeongsangbuk-do			
SCL	P173	2020	Pus				F	62	Jeollanam-do			
SCL	P174	2020	Pus				F	42	Chungcheongbuk-do			
SCL	P175	2020	Fluid				F	86	Gyeongsangnam-do			
SCL	P176	2020	Wound				M	58	Chungcheongbuk-do			
SCL	P177	2020	Pus				F	79	Gyeongsangnam-do			
SCL	P178	2020	Wound				F	84	Chungcheongbuk-do			
SCL	P180	2020	Pus				F	59	Gyeongsangbuk-do			
SCL	P181	2020	Pus				F	78	Gyeongsangnam-do			
SCL	P182	2020	Pus				F	84	Chungcheongbuk-do			
SCL	P184	2020	Pus				F	74	Gyeongsangnam-do			
SCL	P185	2020	Wound				F	38	Gyeongsangbuk-do			
SCL	P186	2020	Pus				M	53	Chungcheongbuk-do			
SCL	P187	2020	Wound				M	77	Gyeongsangbuk-do			
SCL	P188	2020	Wound				M	61	Chungcheongbuk-do			
SCL	P189	2020	Pus				M	57	Gyeongsangbuk-do			
SCL	P190	2020	Wound				F	61	Jeollabuk-do			
SCL	P191	2020	Blood				F	80	Seoul			
SCL	P192	2020	Pus				M	43	Gyeonggi-do			
SCL	P193	2020	Wound				M	59	Gyeongsangbuk-do			
SCL	P194	2021	Pus				M	16	Gyeongsangnam-do			
SCL	P195	2021	Wound				F	73	Gyeongsangnam-do			
SCL	P196	2021	Pus				F	55	Jeollanam-do			
SCL	P197	2021	Pus				M	32	Gyeonggi-do			
SCL	P198	2021	Wound				F	82	Gyeongsangnam-do			
SCL	P199	2021	Wound				M	60	Jeollanam-do			
SCL	P200	2021	Other				M	72	Gyeonggi-do			
SCL	P201	2021	Other				M	35	Seoul			
SCL	P204	2021	Wound				F	52	Chungcheongbuk-do			
SCL	P205	2021	Wound				F	77	Gyeongsangnam-do			
SCL	P206	2021	Pus				M	58	Gyeongsangbuk-do			
SCL	P207	2021	Pus				F	45	Seoul			
SCL	P208	2021	Pus				F	30	Gyeongsangnam-do			
SCL	P209	2021	Wound				F	51	Gyeongsangbuk-do			
SCL	P211	2021	Pus				F	86	Chungcheongbuk-do			

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
SCL	P212	2021	Wound				M	39	Gyeongsangbuk-do			
SCL	P214	2021	Wound				F	51	Gyeongsangnam-do			
SCL	P215	2021	Other				M	67	Chungcheongbuk-do			
SCL	P216	2021	Pus				M	21	Jeollanam-do			
SCL	P217	2021	Wound				F	30	Incheon			
SCL	P218	2021	Pus				M	24	Gyeongsangnam-do			
SCL	P221	2021	Wound				F	71	Gyeongsangbuk-do			
SCL	P224	2021	Wound				F	27	Gyeongsangbuk-do			
SCL	P225	2021	Pus				F	46	Seoul			
SCL	P226	2021	Wound				F	27	Chungcheongbuk-do			
SCL	P227	2021	Wound				M	38	Gyeonggi-do			
SCL	P229	2021	Wound				F	52	Incheon			
SCL	P230	2021	Wound				F	54	Gyeongsangnam-do			
SCL	P231	2021	Pus				F	51	Gyeongsangbuk-do			
SCL	P232	2021	Pus				F	54	Gyeonggi-do			
SCL	P233	2021	Pus				F	41	Gyeonggi-do			
SCL	P234	2021	Pus				F	71	Jeollanam-do			
SCL	P235	2021	Wound				F	55	Gyeongsangbuk-do			
SCL	P236	2021	Wound				F	52	Chungcheongbuk-do			
SCL	P237	2021	Wound				F	55	Chungcheongbuk-do			
SCL	P238	2021	Pus				M	49	Gyeongsangnam-do			
SCL	P239	2021	Pus				F	24	Gyeongsangnam-do			
SCL	P240	2021	Pus				M	55	Gyeongsangnam-do			
SCL	P241	2021	Wound				F	89	Jeollanam-do			
SCL	P242	2021	Pus				F	60	Gyeongsangnam-do			
SCL	P243	2021	Wound				F	82	Gyeongsangbuk-do			
SCL	P244	2021	Pus				F	38	Jeollanam-do			
SCL	P246	2021	Other				F	67	Chungcheongbuk-do			
SCL	P247	2021	Pus				F	82	Gyeongsangnam-do			
SCL	P248	2021	Wound				F	55	Chungcheongbuk-do			
SCL	P249	2021	Pus				F	19	Seoul			
SCL	P250	2022	Wound				F	41	Gyeongsangbuk-do			
SCL	P251	2022	Wound				M	51	Gyeongsangnam-do			
SCL	P252	2022	Pus				M	63	Gyeongsangnam-do			
SCL	P253	2022	Wound				M	54	Gyeonggi-do			
SCL	P254	2022	Wound				F	75	Gyeongsangnam-do			
SCL	P255	2022	Wound				M	79	Gyeongsangbuk-do			
SCL	P256	2022	Wound				F	86	Gyeonggi-do			
SCL	P257	2022	Wound				F	79	Gyeongsangbuk-do			
SCL	P258	2022	Wound				M	73	Jeollanam-do			
SCL	P259	2022	Pus				M	63	Gyeongsangbuk-do			
SCL	P260	2022	Pus				F	72	Jeju			
SCL	P261	2022	Wound				F	46	Gyeongsangbuk-do			
SCL	P263	2022	Pus				F	43	Seoul			
SCL	P264	2022	Pus				F	44	Gyeongsangbuk-do			
SCL	P265	2022	Pus				F	48	Gyeongsangnam-do			
SCL	P266	2022	Pus				F	30	Gyeongsangnam-do			
SCL	P269	2022	Pus				F	34	Seoul			

Hospital	Identification	Year	Specimen	Site	Polymicrobial infection	Animal contact	Sex	Age	Region	Hospitalization	Used antibiotics	Outcome
SCL	P270	2022	Pus				F	46	Gyeongsangnam-do			
SCL	P271	2022	Pus				F	68	Jeollanam-do			
SCL	P272	2022	Pus				F	43	Gyeongsangbuk-do			
SCL	P273	2022	Other				F	43	Gyeongsangbuk-do			
SCL	P274	2022	Wound				F	65	Gyeongsangbuk-do			
SCL	P275	2022	Pus				F	50	Gyeongsangnam-do			
SCL	P276	2022	Wound				F	93	Gyeongsangnam-do			
SCL	P277	2022	Wound				M	36	Chungcheongbuk-do			
SCL	P278	2022	Pus				F	60	Gyeongsangbuk-do			
SCL	P281	2022	Wound				F	82	Incheon			
SCL	P282	2022	Pus				F	73	Incheon			
SCL	P283	2022	Wound				M	49	Jeollanam-do			
SCL	P284	2022	Wound				F	37	Gyeongsangbuk-do			
SCL	P285	2022	Wound				M	48	Gyeongsangnam-do			
SCL	P286	2022	Wound				M	66	Chungcheongbuk-do			
SCL	P287	2022	Wound				F	65	Gyeongsangnam-do			
SCL	P288	2022	Wound				F	85	Gyeongsangnam-do			
SCL	P289	2022	Wound				F	19	Gyeongsangbuk-do			
SCL	P290	2022	Pus				F	70	Seoul			
SCL	P292	2022	Pus				F	27	Gyeonggi-do			
SCL	P293	2022	Wound				F	50	Gyeongsangnam-do			
SCL	P294	2022	Wound				F	55	Chungcheongbuk-do			
SCL	P295	2022	Wound				M	61	Chungcheongbuk-do			
SCL	P296	2022	Wound				M	76	Chungcheongbuk-do			
SCL	P297	2022	Pus				F	13	Jeollabuk-do			
SCL	P298	2022	Wound				F	90	Gyeongsangbuk-do			
SCL	P299	2022	Pus				F	23	Gyeongsangnam-do			
SCL	P300	2022	Wound				F	62	Incheon			
SCL	P301	2022	Wound				F	38	Chungcheongbuk-do			
SCL	P302	2022	Wound				F	38	Seoul			
SCL	P303	2022	Pus				F	40	Gyeongsangnam-do			
SCL	P304	2022	Wound				M	85	Chungcheongbuk-do			
SCL	P305	2022	Wound				M	53	Jeollanam-do			
SCL	P307	2022	Wound				F	64	Jeollanam-do			
SCL	P308	2022	Wound				M	69	Gyeongsangbuk-do			
SCL	P309	2022	Pus				F	45	Gyeonggi-do			
SCL	P310	2022	Wound				F	26	Gyeongsangbuk-do			
SCL	P311	2022	Pus				M	50	Jeollanam-do			
SCL	P312	2022	Wound				F	54	Incheon			
SCL	P313	2022	Pus				M	22	Gyeongsangnam-do			
SCL	P314	2022	Pus				F	45	Gyeongsangnam-do			
SCL	P315	2022	Wound				F	51	Jeollanam-do			
SCL	P316	2022	Pus				F	29	Seoul			

Appendix Table 5. Dataset of the global prevalence of infections caused by *Pasteurella* species for meta-analysis

Study ID	Detected total	Blood positive	Published year	Location
Athanasia et al. [2005]	13	3	Before 2010	Greece
Dernoncourt et al. [2022]	215	14	After 2010	Europe
Ebright et al. [2009]	179	14	Before 2010	USA
Escande et al. [1993]	958	102	Before 2010	Europe
Giordano et al. [2015]	44	8	After 2010	USA
Holst et al. [1992]	146	5	Before 2010	Denmark
Kormondi et al. [2018]	162	14	After 2010	Europe
Mahony et al. [2023]	190	22	After 2010	Australia
Nollet et al. [2016]	28	8	After 2010	Europe
Nseir et al. [2009]	77	25	Before 2010	Israel

Appendix Table 6. Characteristics of patients with *Pasteurella* species infection

Characteristics	Value*
Age	52.0 (40.0-66.0)
Sex	
Male	95 (33.6%)
Female	188 (66.4%)
Animal contact	
Yes	62 (88.6%)
No	8 (11.4%)
Polymicrobial	
Yes	18 (25.7%)
No	52 (74.3%)
Year	
2018	46 (16.3%)
2019	55 (19.4%)
2020	48 (17.0%)
2021	62 (21.9%)
2022	72 (25.4%)
Hospitalization	
In-patient	38 (54.3%)
Out-patient	32 (45.7%)

*Values are expressed as the median (1st to 3rd quartile range) or no. (%).

Appendix Table 7. Comparison of the characteristics of patients with *Pasteurella* species infections who were or were not hospitalized*

Characteristics	In-patient	Out-patient	Total	*P*-value
Age	47.5 (41.0–59.0)	54.0 (34.0–68.5)	51.0 (40.0–66.0)	0.443
Sex				0.848
Male	15 (39.5%)	11 (34.4%)	26 (37.1%)	
Female	23 (60.5%)	21 (65.6%)	44 (62.9%)	
Animal contact				0.383
Yes	32 (84.2%)	30 (93.8%)	62 (88.6%)	
No	6 (15.8%)	2 (6.2%)	8 (11.4%)	
Specimen				0.156
Blood	4 (10.5%)	1 (3.1%)	5 (7.1%)	
CAPD fluid	0 (0.0%)	2 (6.2%)	2 (2.9%)	
Wound	34 (89.5%)	29 (90.6%)	63 (90.0%)	
Polymicrobial				0.485
Yes	8 (21.1%)	10 (31.2%)	18 (25.7%)	
No	30 (78.9%)	22 (68.8%)	52 (74.3%)	
Year				0.152
2018	7 (18.4%)	9 (28.1%)	16 (22.9%)	
2019	12 (31.6%)	4 (12.5%)	16 (22.9%)	
2020	3 (7.9%)	7 (21.9%)	10 (14.3%)	
2021	8 (21.1%)	8 (25.0%)	16 (22.9%)	
2022	8 (21.1%)	4 (12.5%)	12 (17.1%)	
Bacteremia				0.464
Yes	4 (10.5%)	1 (3.1%)	5 (7.1%)	
No	34 (89.5%)	31 (96.9%)	65 (92.9%)	

*Values are expressed as median (1st to 3rd quartile range) or no. (%).

Appendix Table 8. Comparison of the characteristics of patients with *Pasteurella* infection with or without bacteremia*

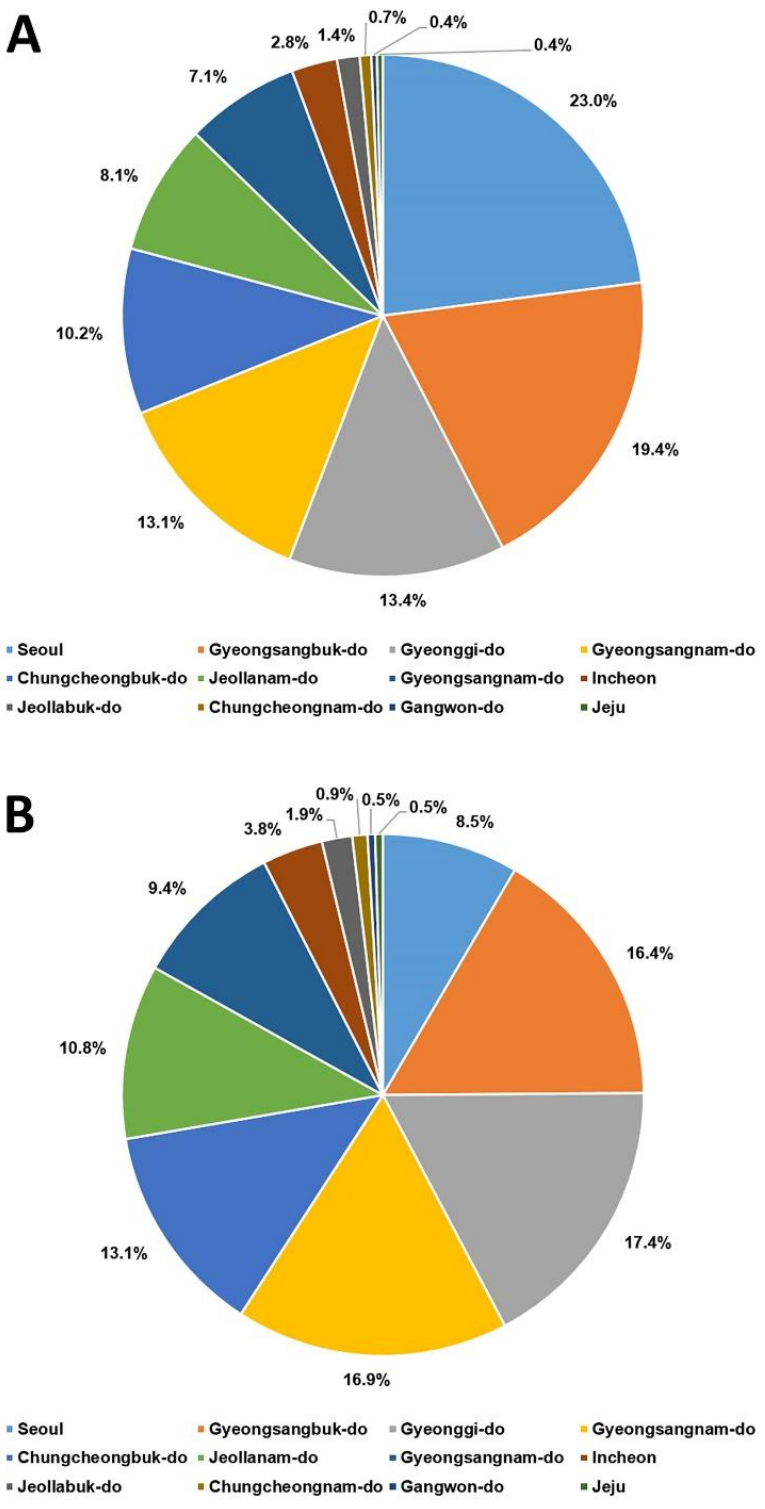
Characteristics	Bacteremia	Non-bacteremia	*P*-value
Age, years	68.5 (54.5-82.0)	52.0 (39.5-65.5)	0.021
Sex			1.000
Male	3 (37.5%)	92 (33.5%)	

Characteristics	Bacteremia	Non-bacteremia	*P*-value
Female	5 (62.5%)	183 (66.5%)	
Animal contact			<0.001
Yes	0 (0.0%)	62 (95.4%)	
No	5 (100.0%)	3 (4.6%)	
Polymicrobial			1.000
Yes	1 (20.0%)	17 (26.2%)	
No	4 (80.0%)	48 (73.8%)	
Year			0.271
2018	3 (37.5%)	43 (15.6%)	
2019	2 (25.0%)	53 (19.3%)	
2020	2 (25.0%)	46 (16.7%)	
2021	1 (12.5%)	61 (22.2%)	
2022	0 (0.0%)	72 (26.2%)	
Hospitalization			0.464
In-patient	4 (80.0%)	34 (52.3%)	
Out-patient	1 (20.0%)	31 (47.7%)	

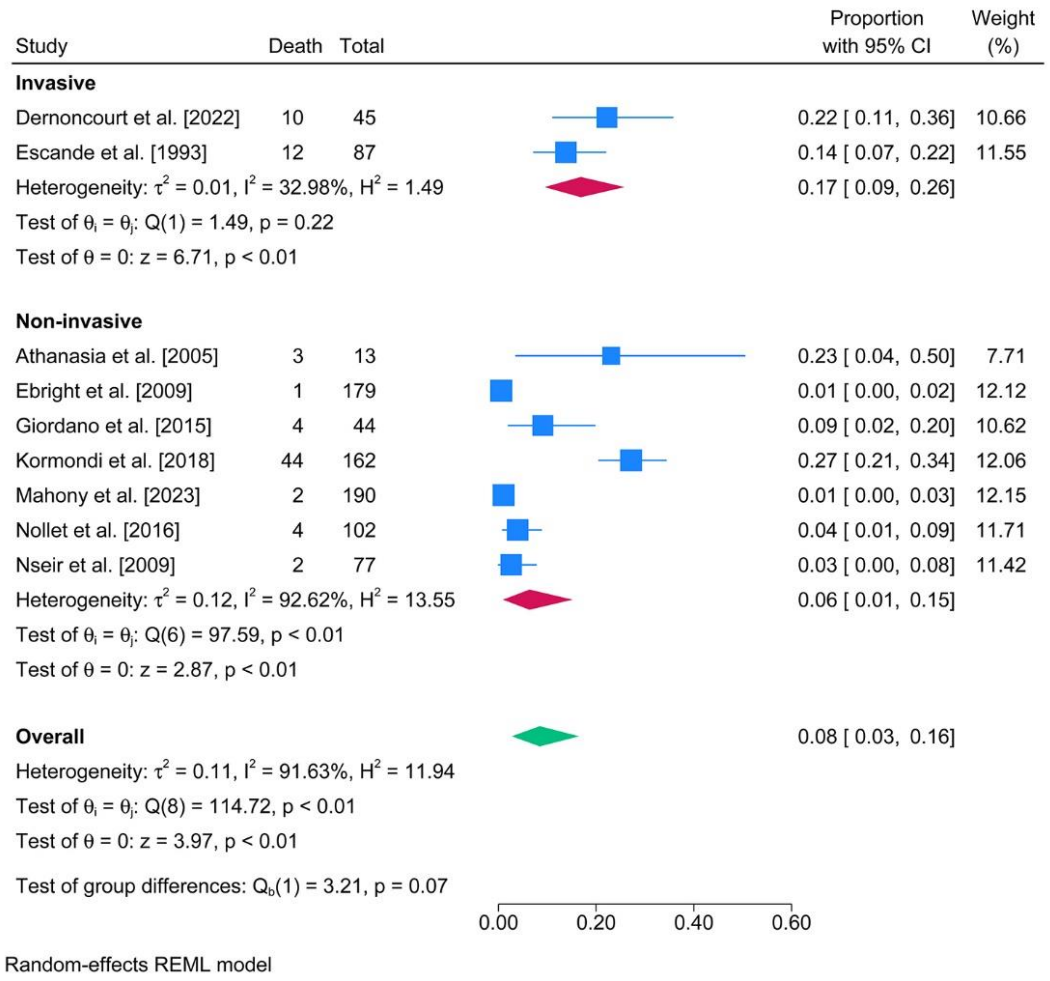
*****Values are expressed as the median (1st to 3rd quartile range) or number (%). For age, sex, and year, the number of bacteraemia and non-bacteraemia cases were 8 and 275 from all cases of hospitals and the reference laboratory, respectively.

Appendix Table 9. Sensitivity analyses of the included data for the prevalence of bacteremia caused by *Pasteurella* species

Omitted study	Estimated prevalence (%)	95% confidence interval (%)
Athanasia et al. [2005]	12.1	6.9–18.4
Dernoncourt et al. [2022]	13.4	7.6–20.4
Ebright et al. [2009]	13.2	7.3–20.3
Escande et al. [1993]	12.9	6.9–20.2
Giordano et al. [2015]	12.0	6.5–18.7
Holst et al. [1992]	13.8	8.4–20.2
Kormondi et al. [2018]	13.1	7.2–20.3
Mahony et al. [2023]	12.7	6.8–19.9
Nollet et al. [2016]	11.3	6.5–17.1
Nseir et al. [2009]	9.9	6.4–13.9



Appendix Figure 1. Distribution of *Pasteurella* infections stratified by regions. A) All 283 cases from hospitals and a reference laboratory. B) Only 213 cases from a reference laboratory.



Appendix Figure 2. Forest plots for the pooled death rates in patients with *Pasteurella* infections.

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