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Estimating Heterogeneity and Pooled Prevalence of Classical Swine Fever in Pigs in India: A Meta-analysis

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ABSTRACT

Background: Classical swine fever (CSF) is caused by small enveloped RNA virus that belongs to the Flaviviridae family and causes high morbidity and mortality events for pig farming. In India, it is highly prevalent but with varied distribution in various geographical areas resulting in substantial economic losses to farmers. The discrepancy in prevalence estimates across studies needs to be evaluated in order to strengthen the prevention and control strategies of CSF in pigs. The aim of the present study was to provide the pooled estimate of the prevalence of classical swine fever (CSF) in India and to examine the consistency of those estimates between published studies.

Methods: The data regarding prevalence of CSF in 7045 pigs were compiled from 22 published studies using comprehensive literature search for period from 1998 to 2018. The pooled prevalence of CSF was obtained under random effects model and heterogeneity between studies was determined using I^2 Index. Representation of meta-analysis was done using forest plot and followed by funnel plot, Baujat plot and radial plot.

Result: The result of Meta-analysis revealed that pooled estimate of prevalence of CSF under random effects model was 45% (95% confidence interval: 35, 55%) in India. The heterogeneity statistic (Q) was found to be significant ($p<0.001$) with I^2=98% which indicated that prevalence of CSF was inconsistent between the studies. Likewise, results of funnel plot and Radial plot indicated heterogeneity between studies. Most influential studies for overall heterogeneity were identified using Baujat and radical plots.

Key words: Classical swine fever, Heterogeneity, Meta-analysis, Pig, Prevalence.

INTRODUCTION

Classical swine fever (CSF), also known as 'Hog Cholera' is an OIE List A disease causing vast economic losses to pig farming all over the countries worldwide (Anonymous, 2020). It is caused by a small enveloped RNA virus which belongs to the family Flaviviridae and genus Pestivirus (Wengler *et al*., 1995). The transmission of virus happens through saliva, urine and faeces of infected animals (Depner *et al*., 1996). It affects animal with more severity and causing high mortality (Lalremruata *et al.,* 2015). Singh *et al.* (2016) estimated high annual economic losses (Rs. 4.3 billion) in pigs using sample survey data of India.

In India, the pig population is 9.06 million as per 20th national livestock census (2019) which decreased about 12% as compared to 19th livestock census (2012). The exotic/ crossbred pigs contribute about 21% of the total pig population, while 79% population belongs to indigenous/ non-descript category. The disease is endemic in India due to its high prevalence among pig population. The first appearance of CSF was reported in India in 1944 (Krishnamurty *et al.,* 1962). This disease shows acute, chronic or inapparent form (Rout *et al.,* 2015). Over the decades, several authors reported high incidences of disease in different states of India (Nandi *et al*., 2011; Deori *et al.,* 2012; Ahuja *et al.,* 2014; Choori *et al*., 2015; Mukherjee *et al*., 2018). The findings reported earlier showed discrepancies may be due to discrepancy between location, period and sample size of the studies.

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In order to reconcile these findings, systematic approach is of utmost necessity in order to provide a reliable estimate of the disease. Meta-analysis combines the results from multiple studies and offers generalize and more reliable conclusions (Walker *et al*., 2008). It also highlights the causes of variations present in studies, increases precision and provides insights for future hypotheses.

The purpose of the present study was to obtain pooled estimates of CSF prevalence in pigs by employing meta-analysis technique. Further, the heterogeneity amongst the studies was also to be examined.

MATERIALS AND METHODS

Literature search

Systematic review of prevalence of CSF in India was carried out by using published studies for a period of 21 years from 1998 to 2018 from various journals and online search engines like PubMed, Science Direct, Google Scholar, NCBI, J-Gate, Krishikosh, *etc*. All references in these studies were cross examined to find additional research papers not included in previous searches.

Data sources and study selection

A set inclusion criterion for selection of studies have been made on the basis of study objectives that required information such as author, year, location, period of study, total sample size and positive number per study. Studies regarding prevalence of CSF in India were extracted in Indian Scenario and flow diagram of selection of studies used in meta-analysis is presented in Fig 1. Out of total 73 studies, 39 studies were irrelevant as prevalence was not reported for India. Although the data of 44 studies were expected, however, 22 studies were inadequate due to lack of information on the prevalence of CSF. Finally, 22 studies were included in meta-analysis (Table 1).

Meta-analysis

Random effects model was employed to obtain pooled estimates of CSF prevalence (Higgins and Thompson, 2002; Borenstein, 2009). The Statistic Q was used to test the heterogeneity between studies (Cochran, 1954) and further, Higgins's I^2 Index was employed to quantify per cent heterogeneity (Higgins *et al.,* 2003).

Graphical representation of meta-analysis was done using forest plot. Further, funnel plot was used for bias or systematic heterogeneity, which provides funnel shaped distribution of studies in absence of bias (Light and Pillemer, 1984). Baujat plot and radical plots were also used to detect sources of heterogeneity in meta-analysis (Galbraith, 1988; Baujat *et al*., 2002). Baujat plot provides the influence of each study for the overall heterogeneity. Radical plot displays several estimates of the same quantity that have different standard error. Meta-analysis was performed by using "R" software (https://www.R-project.org/).

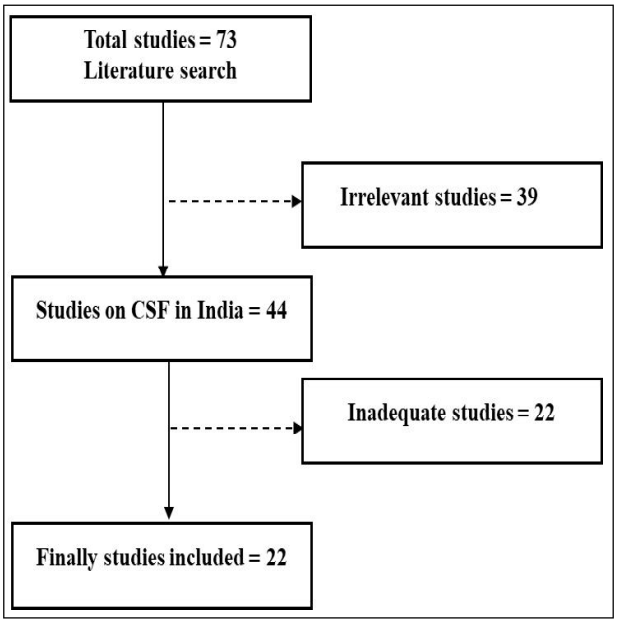

Fig 1: Flow diagram of study selection in the meta-analysis of CSF fever in India.

RESULTS AND DISCUSSION

Meta-analysis of CSF prevalence was carried out by using total 22 published studies of India comprising data of 7045 pigs. The details of studies included and the results of meta-analysis are shown on forest plot (Fig 2). The results showed pooled estimate of CSF was 45% (95%CI: 0.35; 0.54). Q statistics was found to be significant (Q=926.03; df=21, $p<0.001$) and it was concluded that there was significant heterogeneity between the studies. Between studies variance (tau-square) was 0.79. Heterogeneity across studies was quantified by I^2 Index (98%).

Funnel plot shows that there is little deviation from this shape which indicated that publication bias was less (Fig 3). Baujat plot showed that studies located in the upper right corner of the graph were most influential ones with the highest contribution to the overall heterogeneity (Fig 4). Among all studies used, Rout *et al*. (2012); Nandi *et al*., (2011); Kataria *et al*. (2010); Mukherjee *et al*. (2018) and Rajbongshi *et al*. (2015) studies had higher contribution to overall heterogeneity. Likewise, Radial plot showed that there was greater heterogeneity in the meta-analysis studies (Fig 5).

The present estimate of prevalence of CSF was lower than findings of Singh *et al*. (2016) who reported 61.58% in India. However, our estimate was higher than findings reported by Patil *et al*. (2018) who provided lower pooled estimate as 37% (95% confidence interval [CI]=0.24, 0.51) of CSF in pigs under meta-analysis using data of 5 years (2011-15). This discrepancy could be due to a higher sample size (7045 pigs) included in our meta-analysis as compared to sample size (6158 pigs) in meta-analysis of Patil *et al*. (2018). Further, the present estimate of prevalence of CSF was lower than estimate given by Li *et al*. (2018) in Tibetan pigs in Nyingchi, Tibet China.

Our meta-analysis was different from the previous meta-analysis performed by Patil *et al*. (2018) in a number of respects: (i) we used larger sample size in meta-analysis (ii) our study period was larger (iii) we used Baujat plot to identify influence of each study to inconsistency in results (iv) we used radial plot to estimate standardized scores.

The present meta-analysis was undertaken in Indian scenario to obtain the pooled prevalence of CSF in pigs and we compared our results with some Indian authors who reported prevalence of CSF using published reports or studies. However, literature on CSF in exotic pigs lacks information on prevalence of CSF which hinders any comparison of our results with exotic pigs.

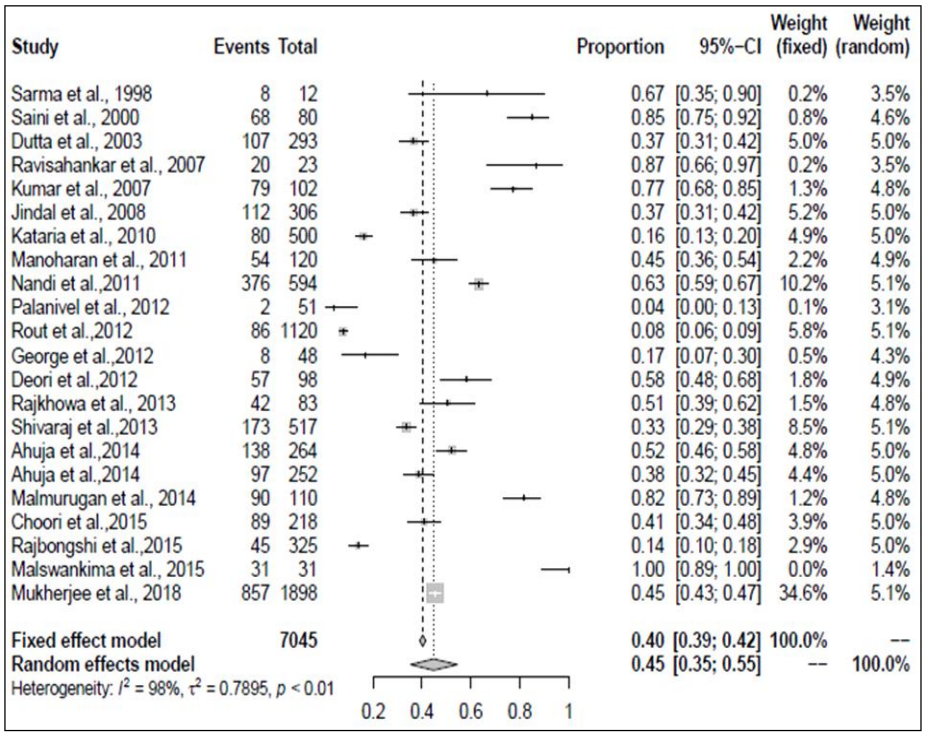

Fig 2: Forest plot showing meta-analysis of prevalence of CSF in India using total 22 published studies.

Table 1: List of 22 studies included in the meta-analysis.

Study	State	Total	Positive cases
Sarma *et al.* (1998)	Assam	12	8
Saini *et al.* (2000)	Punjab	80	68
Dutta *et al.* (2003)	Assam	293	107
Ravisahankar *et al.* (2007)	Kerala	23	20
Kumar *et al.* (2007)	Punjab	102	79
Jindal *et al.* (2008)	Haryana	306	112
Kataria *et al.* (2010)	Rajasthan	500	80
Manoharan *et al.* (2011)	Andhra Pradesh	120	54
Nandi *et al.* (2011)	West Bengal, Meghalaya, Nagaland	594	376
Palanivel *et al.* (2012)	Tamil Nadu	51	2
Rout *et al.* (2012)	Uttar Pradesh	1120	86
George *et al.* (2012)	Assam	48	8
Deori *et al.* (2012)	Assam	98	57
Rajkhowa *et al.* (2013)	Mizoram	83	42
Shivaraj *et al.* (2013)	Karnataka	517	173
Ahuja *et al.* (2014)	Meghalaya	264	138
Ahuja *et al.* (2014)	Manipur	252	97
Malmurugan *et al.* (2014)	Tamil Nadu	110	90
Choori *et al.* (2015)	Karnataka	218	89
Rajbongshi *et al.* (2015)	North Eastern Region	325	45
Malswankima *et al.* (2015)	Mizoram	31	31
Mukherjee *et al.* (2018)	Meghalaya	1898	857

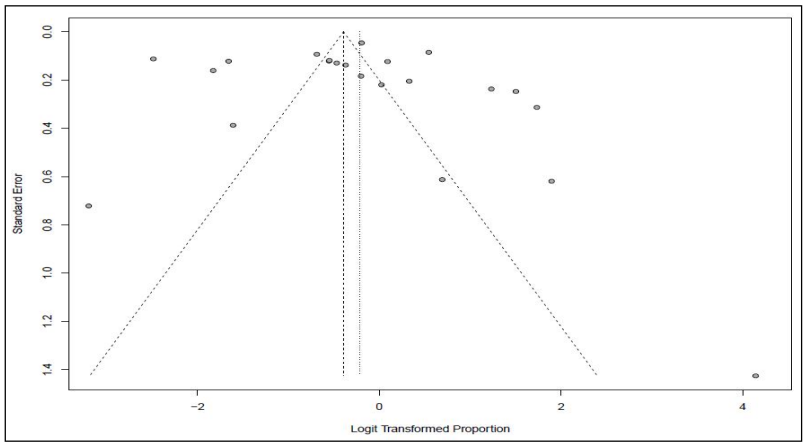

Fig 3: Funnel plot for prevalence of CSF in pigs in India using total 22 published studies.

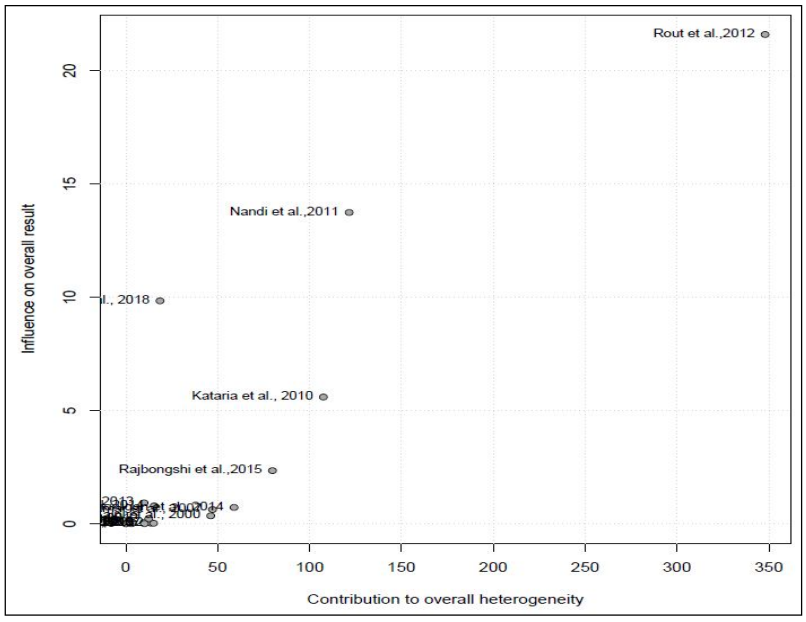

Fig 4: Baujat plot for prevalence of CSF in pigs in India using total 22 published studies.

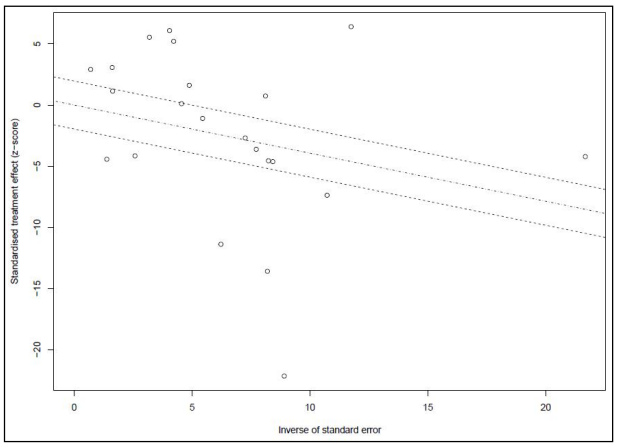

Fig 5: Radial plot for prevalence of CSF in pigs in India using total 22 published studies.

CONCLUSION

The present meta-analysis was undertaken estimate pooled CSF prevalence in pigs in India using 22 published studies over 21 years. The pooled prevalence was observed as 45%, which indicated that this disease is of high importance in studied population. We also found that there was high heterogeneity between studies and those with high contribution were identified.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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