Journal of Animal & Plant Sciences, 35(1): 2025, Page: 36-48
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2025.1.0018
REVIEW ARTICLE

PREVALENCE OF EQUINE HERPESVIRUSES (EHVS) INFECTION IN EGYPT: SYSTEMATIC META-ANALYSIS

M. Marzok[1], A. Al-mubarak[2], M. Elgioushy[3] and S. El-khodery[4]

[1]Department of Clinical Sciences, College of Veterinary Medicine, King Faisal University, Al-Ahsa, Saudi Arabia
[2]Department of Microbiology, College of Veterinary Medicine, King Faisal University, Al-Ahsa, Saudi Arabia
[3]Department of Animal Medicine, Faculty of Veterinary Medicine, Aswan University, Aswan 37916, Egypt.
[4]Department of Internal Medicine, Infectious Diseases and Fish Diseases, Faculty of Veterinary Medicine, Mansoura University, Manosura 35516, Egypt
Corresponding author's email: mmarzok@kfu.edu.sa ; marzok2000@hotmail.com

ABSTRACT

This report aimed to perform a meta-analysis on the occurrence of Equine herpesvirus (EHV) infection in Egypt. This systematic meta-analysis was performed in accordance with the PRISMA guidelines. Data were retrieved after a complete search, and eligible articles were identified. Data analysis with random-effects model was performed using a comprehensive meta-analysis software program. The results were presented as effect size, confidence intervals (CI), heterogeneity, and publication bias. A total of 1760 horses from 20 accepted studies were investigated for EHVs infection. Of these, 740 horses were found positive for EHVs, with a prevalence of 42%. The highest prevalence (100%) was during 2016 and 2020. EHV-1 was the most prevalent strain affecting horses in Egypt ($p \leq 0.05$). The prevalence of isolated strains was as follows: EHV-1 (492, 66.48 %), EHV-2 (151, 20.40 %), EHV-4 (105, 14.19 %), and EHV-5 (88, 11.89 %). The mixed EHV-1 and EHV-4 infections were predominant. However, the EHV-3 was not detected in any of these studies. At random effects, the Z-value was -1.539 (*p*-value = 0.124). The Q-value (373.103), I-squared (95.17), and p-value (0.000) were the final heterogeneity variables. The Egger's linear regression test did not imply a publication bias, and its outcomes were intercept (-3.66), and 95% confidence interval (-8.23 to -0.9). The results of the present meta-analysis indicated a high prevalence of EHV infection in Egypt, particularly EHV-1. Therefore, more attention should be paid to the prevention and control of this disease.

Keywords: Horse, Epidemiology, EHV, Systematic review

Published first online January 21, 2025 Published final February 18, 2025

INTRODUCTION

Equine herpesviruses (EHVs) are infectious agents that have deleterious effects on equine health (Lunn *et al*. 2009). They are large, enveloped, linear, double-stranded DNA viruses of the *Herpesviridae* family (Gatherer *et al*. 2021). Nine strains of herpesvirus have been recorded (Davison *et al*. 2009). EHV-1 and EHV-4 are considered the most important herpesviruses because of their high prevalence, ability to reactivate latent infections, and different clinical presentations (Pavulraj *et al*. 2021).

Clinical signs in infected animals vary depending on the type of EHV involved. Both EHV-1 and EHV-4 can cause severe respiratory syndromes. Horses infected with EHV-1 can show abortions in pregnant mares, neurological manifestations with high mortality rates in foals (Pavulraj *et al*. 2021; Slater *et al*. 2006). In addition to lymphadenopathy in foals, the most common clinical signs of EHV-2 in foals and adult horses include upper respiratory tract symptoms and keratoconjunctivitis (Borchers *et al*. 2006). The EHV-3 causes equine coital exanthema, an acute venereal mucocutaneous disease in mares and stallions (Vissani *et al*., 2021).

Equines can acquire EHV horizontally through direct contact with the nasal discharge of infected animals or EHV-1-positive aborted fetuses or indirectly through contact with contaminated fomites (Allen *et al*. 2004). Vertical transplacental transmission from infected mares to their offspring or through the venereal route via semen from an infected stallion has been identified as a method of transmission of EHV-3 (Negussie *et al*. 2016). The herpesviruses often remain latent in the host brain and lymphoid tissues after infection with no lytic viral replication (White *et al*. 2012). The compromised immune system of the host may cause the virus to reactivate, leading to viremia and shedding of the virus into the environment (Reese, 2016).

The clinical manifestations of EHV infections are not reliable tools for accurate diagnosis as they may mimic those of other infectious diseases. Therefore, EHVs are diagnosed using several laboratory serological tests for antibody detection, including enzyme-linked immunosorbent assay (ELISA), viral neutralization, and complement fixation (Bannai *et al*. 2013; Lang *et al*. 2013). Viral isolation is considered the standard diagnostic procedure for EHVs (Hartley *et al*. 2005). Recently, several molecular techniques have been used to detect the genomic materials of EHVs, including polymerase chain reaction (PCR) (Pusterla *et al*. 2009) and real-time PCR, which are considered the most sensitive molecular techniques for EHV detection (Smith *et al*. 2012).

The study population and presence of risk factors are determinants of the prevalence of infectious diseases (Buitrago-Garcia *et al*. 2022). Variables such as age and sex of the horses studied have been linked to a higher risk of EHV infection. Young foals are more likely to be infected with EHV-2/-5 than adult horses (Hue *et al*. 2014) while equids aged 3–8 years have a higher prevalence of EHV-1/-4 than those younger than 3 years (Worku *et al*. 2024). The gender differences have also been observed, with males being more likely to contract EHV-1 and-2 (Bolfa *et al*. 2017). However, several studies have recorded higher infection rate of EHV-1 and -4 among females than among males (de Souza *et al*. 2017; Negussie *et al*. 2016).

In Egypt, many epidemiological studies have investigated the prevalence of EHVs in horses, showing clinical signs indicative of EHV infection. The prevalence of EHV infection varies spatially and temporal variation (A Salib *et al*. 2016; Ata *et al*. 2020; Abdel-Rady *et al*. 2022; Ahdy *et al*. 2022; Khattab *et al*. 2022). Moreover, there was variation in the clinical findings and identified strains of EHV (A Salib *et al*. 2016; Azab *et al*. 2019**).** On the other hand, other studies could detect EHV in apparently healthy horses (Ata *et al*. 2020; Meselhy *et al*. 2019).

A meta-analysis is an epidemiological study designed to systematically assess the results of previous investigations to reach a conclusion about this research topic (Haidich 2010). It includes a combined and quantitative review of a large, frequently complex, and occasionally apparently conflicting body of literature (Moher *et al*. 2010b). Additionally, the results of the meta-analysis may provide a more accurate estimation of the effect of risk factors or treatment for specific diseases or other outcomes than any individual study participating in the pooled analysis (Moher *et al*. 2009). Thus, the objective of this investigation is to conduct a meta-analysis on the prevalence of EHV infection in Egypt.

MATERIALS AND METHODS

Ethical approval : Based on guidelines of PRISMA, this study was conducted. Consequently, it is not necessary to have approval from the ethical committee for animal use in scientific research.

Reference horses: The present meta-analysis included all articles focused on the prevalence of EHV infections in Egypt using different techniques. All horses examined, characterized by symptoms of respiratory, neurological, and abortion, were also included. However, the sample size of this study was not limited.

Selection criteria

Inclusion criteria

- Only acceptable papers those are in English language.
- All publications on Equine herpesviruses (EHVs) in Egypt
- A reputable journal publication
- Case-control and cross-sectional studies
- Studies on the seroprevalence of EHV were included.
- Studies imply the prevalence of EHV with any diagnostic technique used.

Exclusion criteria

- Techniques for identifying EHVs other than prevalence.
- Arabic-language publications or languages other than English.
- Preprint and review articles.

Study selection: The objective of this study was to search all publications that had been written about the prevalence of EHV infection in Egypt. We searched the PubMed, Web of Science, Sage, BESCO, Ovid, CABI, Scopus, database with a combination of the following search terms ("EGYPT" "EQUIN HERPESVIRUS") (title/ abstract) ("EQUINE HERPESVIRUS ") (title/ abstract) AND ("EGYPT") (title / abstract) AND ("PREVALANCE" "INCIDENCE") (title/ abstract) OR ("EGYPT") (title / abstract). Preliminary screening of the articles was based on the title and abstract from the earliest data available by May 2024. This procedure was supplemented by manual searching, Google Scholar searching, expert recommendations, and citation reviews. Database outputs were integrated using EndNote software. The standard identification, selection, and eligibility criteria of the selected studies are described (Figure 1**).**

Data extraction: The extracted data included the year of publication, study area, diagnostic method, sample size, EHV strain, and positive animals (Table 1).

Quality control: According to PRISMA (Moher *et al*. 2010a), the current meta-analysis was carried out. All available published publications on the assessment of the prevalence of EHV infection in Egypt based on blood sample collection from infected horses were included to reduce publication bias.

Data analysis: First, the prevalence of EHV was estimated and the Chi-square test was used to assess significant variation among infections with different strains of EHV (GraphPad Prism for Windows version 9, USA). The commercial meta-analysis software was used (Comprehensive Meta-Analysis software version 2, Biostat, Englewood, NJ, USA). At random effects model, effect size, 95% confidence intervals, variance, heterogeneity, relative weight, and publication bias were the main tests. To assess the significance of variation between strains of EHV, the chi square test was applied and at $p \leq 0.05$ the result was considered significant.

RESULTS

A total of 875 items were identified from database search. After applying the exclusion criteria, 20 acceptable studies were included in this meta-analysis (Table 1, Figure 1). A total of 1760 horses from 20 accepted studies were investigated for EHVs infection. Of these, 740 horses were found positive for EHVs, with a prevalence of 42%. EHV-1 was the most prevalent strain affecting horses in Egypt ($p \leq 0.05$).

There was a significant variation in the prevalence of different strains of EHV ($p \leq 0.01$). infection rate with EHV-1 was significantly higher than EHV-4 ($p \leq 0.001$, Odds ratio: 12.0), EHV-2 ($p \leq 0.001$, Odds ratio:7.73), and EHV-5 ($p \leq 0.001$, Odds ratio: 14.7). Moreover, the infection rate with EHV-2 was significantly higher than EHV-5 ($p \leq 0.05$, Odds ratio: 1.8)

The prevalence of isolated strains was as follows: EHV-1 (492, 66.48 %), EHV-2 (151, 20.40 %), EHV-4 (105, 14.19 %), and EHV-5 (88, 11.89 %). Mixed EHV-1 and EHV-4 infections were predominant. However, EHV-3 was not detected in any of these results.

Meta-analysis

The effect of size on the prevalence of EHVs infection at random effect model is presented in Table 2. At random effects, the Z-value was -1.539 (*p*-value = 0.124). To illustrate the degree of heterogeneity, a forest plot was constructed for random effect. The outcome of event rate with confidence interval of 95%, logit event rate, and relative weight are shown in figures 2-4. The Q-value (373.103), I-squared (95.17), and *p*-value (0.000) are the outcome of heterogenicity at fixed effect, but not at random effect. Results of publication bias were presented in Figure 5and 6. The funnel plot was asymmetric, and there was no indication of publication bias. The Egger's linear regression test did not imply a publication bias, and its outcomes were intercept (-3.66), 95% CI (-8.23 to -0.9), t-value (1.96), df = 17.00. The 1-tailed *p*-value was (0.05), and the 2-tailed *p*-value was 0.1. The result of Kendall's tau with continuity correction was -0.18, with a 1-tailed *p*-value of 0.13 and 2- tailed *p*-value of 0.26.

The classic fail-safe N proposed that 98000 missing studies are wanted to determine the significance of the results of this meta-analysis. In addition, Orwin's fail-safe N suggested a -0.47-event rate in observed studies and a 0.50 mean event rate in missing studies.

Table 1. Descriptive data regarding Equine herpesvirus (EHV) infection in horses in Egypt.

Author	Location	Samples	Positive	Technique	Virus type	Signs
Amer *et al*. (2011)	Cairo	93	34	Polyclonal antibody pool against EHV-1, 2, and 4	EHV-1 (n=3) EHV-2 (n=17) EHV-4 (n=7) EHV-1 and EHV-4 (n=1)	Abortion and respiratory signs
Kalad *et al*. (2013)	Cairo	21	9	Compliment fixation test	EHV-1	Respiratory and/or nervous manifestation and contact horses.
Al-Shammari *et al*. (2016)	Cairo	12	12	Nested-PCR	EHV-4	Abortion
A Salib *et al*. (2016)	Cairo, Giza, Kafr Elsheikh, Monofeia, Beni-Suef, El Sharkia and Behira Alexandria	182	9	Indirect ELISA	EHV-1	Abortions, respiratory diseases, fever and limb edema, Nervous manifestation
El Moghazy	Qalubiah	77	33	Indirect ELISA	EHV-1	No signs

et al. (2017)						
(Ghoniem *et al*. 2018)	Cairo	152	18	Multiplex real-time PCR	EHV-1 (n=12) EHV-4 (n=6)	Respiratory signs
Azab *et al*. (2019)	Cairo, Alexandria, Giza, Sharkia, Gharbia and Monufia	192	133	Virus-specific qPCR	EHV-1 (n=64) EHV-2 (n=63) EHV-4 (n=5) EHV-5 (n=37)	Abortion, respiratory diseases, fever and limb edema, and nervous manifestation
Meselhy *et al*. (2019)	Egypt	62	12	Nested PCR	EHV-1	No clinical signs mentioned
(Ali *et al*. 2020)	Cairo and Giza	4	4	PCR and cytopathic effect	EHV-1 (n=4)	Abortion and neonatal death
Ata *et al*. (2020)	Monufia	270	173	Indirect ELISA	EHV-1	N0 clinical signs
Hassanien *et al*. (2020)	Cairo and Giza	20	4	Consensus nested PCR	EHV-1 (n=3) EHV- 5 (n=1)	Abortion
Ahdy *et al*. (2022)	Cairo and Giza	66	25	Real-time PCR	EHV-1 (gB, ORF33)	Abortion (n=14) Stillbirth (n=3) Early neonatal deaths (n=2) Respiratory affections (n=5) Myeloencephalo pathy(n=1)
Khattab *et al*. (2022)	Cairo	20	16	Real-time PCR	EHV-4	Abortion
Emam *et al*. (2022b)	Giza	72	9	CPE (Cytopathic effect)	(EHV-1)	Abortion and respiratory affections
Abdel-Rady *et al*. (2022)	El-Menia, Assiut, Sohage and Luxor	115	92	Multiplex PCR	EHV-2 (n=71) EHV-5 (n=50) EHV-1 (n=23) EHV-4 (n=15)	Acute early febrile phase of respiratory infection
Mohammed *et al*. (2022)	Cairo and Giza	80	6	Real-time PCR	EHV-1 (n=1) EHV-4 (n=5)	abortion, respiratory illness and neurological signs
Emam *et al*. (2022a)	Giza	72	9	PCR	EHV-l	Abortion and respiratory manifestations
El-Zayat *et al*. (2023)	Cairo,Giza, Dakahlia, Sharkia, Gharbia	120	63	PCR	EHV-1 (n=48) EHV-4 (n=15) Mixed infection (5)	Respiratory manifestations and abortion
Ali *et al*. (2024b)	Cairo, Dakahlyia and Qalyubia	80	53	Consensus PCR	EHV-1 (n=29) EHV-4 (n=24) Mixed infection (5)	No
Ali *et al*. (2024a)	Cairo, Dakahlyia and Qalyubia	50	26	Consensus PCR	EHV-1	Abortion

Table 2. Final Meta-analysis results of the effect of size and test of null (2-tail) for 19 studies on the prevalence of Equine herpesvirus in Egypt.

Model	Effect size and 95% Confidence Interval				Test of null (2-Tail)	
	Number of studies	Point estimate	Lower limit	Upper limit	Z-value	P-value
Random	20	-0.445	-0.11	0.122	-1.539	0.124

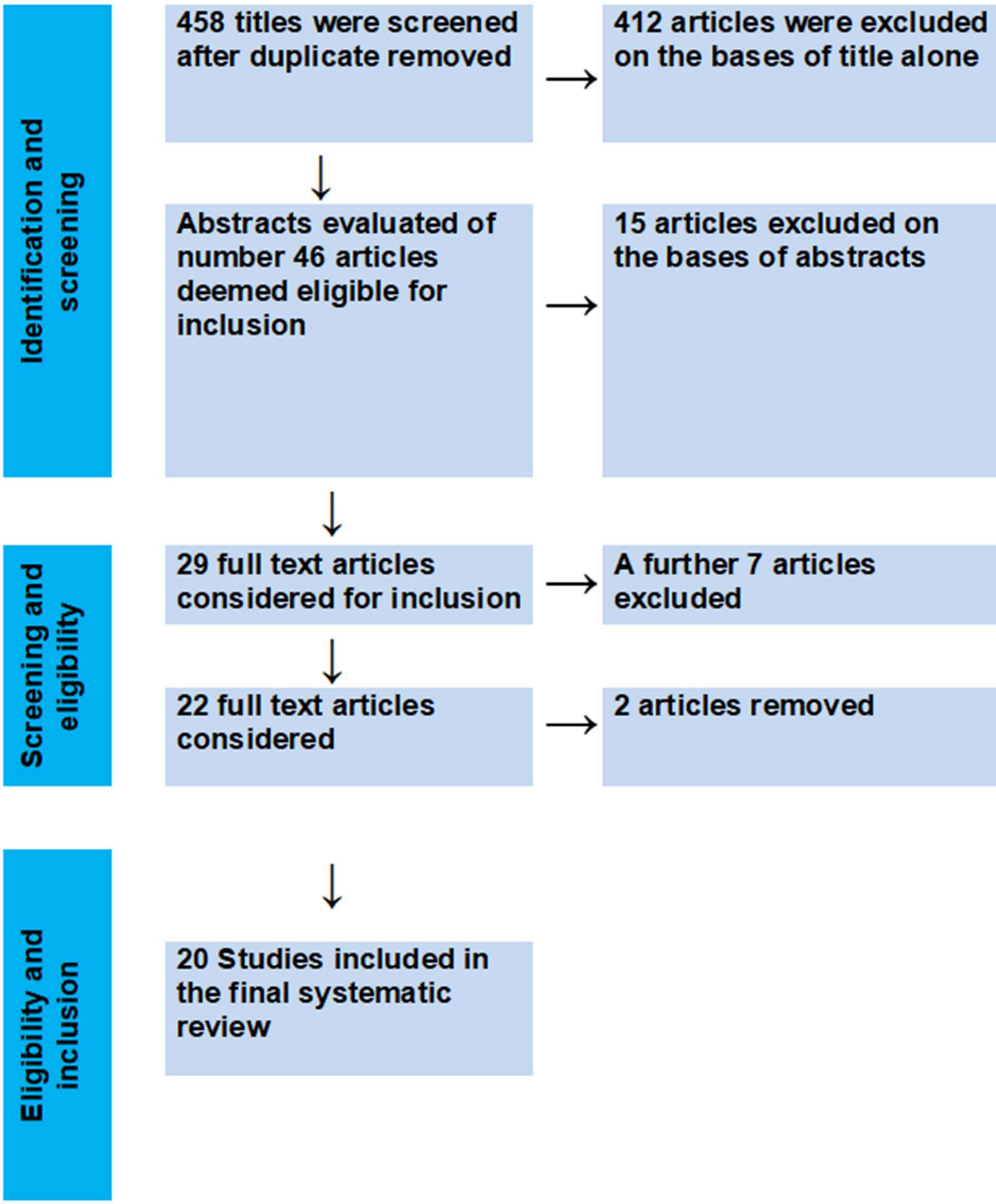

Figure 1. Results of the literature search and inclusion regarding prevalence of Equine herpesvirus (EHV) infection in Egypt.

Model	Study name	Event rate	Lower limit	Upper limit	Z-Value	p-Value
	Amer et al. (2011)	0.366	0.274	0.468	-2.560	0.010
	Kalad et al. (2013)	0.429	0.240	0.640	-0.652	0.514
	Al-Shammari et al. (2016)	0.962	0.597	0.998	2.232	0.026
	A Salib et al. (2016)	0.049	0.026	0.092	-8.646	0.000
	El Moghazy et al. (2017)	0.429	0.323	0.541	-1.249	0.212
	Ghoniem et al. (2018)	0.118	0.076	0.180	-7.997	0.000
	Azab et al. (2019)	0.693	0.624	0.754	5.196	0.000
	Meselhy et al. (2019)	0.194	0.113	0.311	-4.440	0.000
	Ali et al. (2020)	0.900	0.326	0.994	1.474	0.140
	Ata et al. (2020)	0.641	0.582	0.696	4.561	0.000
	Hassanien et al. (2020)	0.200	0.077	0.428	-2.480	0.013
	Ahdy et al. (2022)	0.379	0.271	0.501	-1.950	0.051
	Khattab et al. (2022)	0.800	0.572	0.923	2.480	0.013
	Emam et al. (2022b)	0.125	0.066	0.223	-5.461	0.000
	Abdel-Rady et al. (2022)	0.800	0.717	0.863	5.947	0.000
	Mohammed et al. (2022)	0.075	0.034	0.157	-5.919	0.000
	Emam et al. (2022a)	0.125	0.066	0.223	-5.461	0.000
	El-Zayat et al. (2023)	0.525	0.436	0.613	0.547	0.584
	Ali et al. (2024b)	0.663	0.553	0.757	2.853	0.004
	Ali et al. (2024a)	0.520	0.383	0.654	0.283	0.777
Fixed		0.477	0.449	0.505	-1.644	0.100
Random		0.392	0.274	0.523	-1.622	0.105

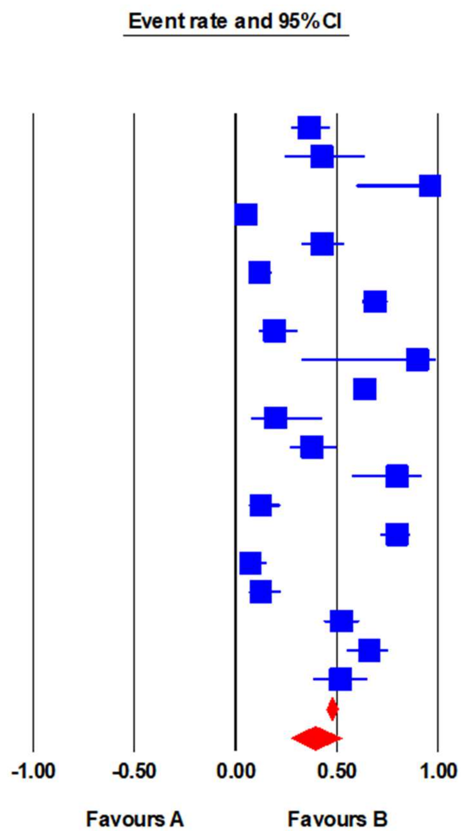

Figure 2. Forest Plot on the prevalence of EHV infection shows the event rate, 95% confidence interval, Z- value, P- value, and relative weight of 20 observed studies.

Model	Study name	Logit event rate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Amer et al. (2011)	-0.551	0.215	0.046	-0.973	-0.129	-2.560	0.010
	Kalad et al. (2013)	-0.288	0.441	0.194	-1.152	0.577	-0.652	0.514
	Al-Shammari et al. (2016)	3.219	1.442	2.080	0.392	6.046	2.232	0.026
	A Salib et al. (2016)	-2.956	0.342	0.117	-3.626	-2.286	-8.646	0.000
	El Moghazy et al. (2017)	-0.288	0.230	0.053	-0.739	0.164	-1.249	0.212
	Ghoniem et al. (2018)	-2.007	0.251	0.063	-2.499	-1.515	-7.997	0.000
	Azab et al. (2019)	0.813	0.156	0.024	0.506	1.119	5.196	0.000
	Meselhy et al. (2019)	-1.427	0.321	0.103	-2.057	-0.797	-4.440	0.000
	Ali et al. (2020)	2.197	1.491	2.222	-0.725	5.119	1.474	0.140
	Ata et al. (2020)	0.579	0.127	0.016	0.330	0.827	4.561	0.000
	Hassanien et al. (2020)	-1.386	0.559	0.313	-2.482	-0.291	-2.480	0.013
	Ahdy et al. (2022)	-0.495	0.254	0.064	-0.992	0.003	-1.950	0.051
	Khattab et al. (2022)	1.386	0.559	0.313	0.291	2.482	2.480	0.013
	Emam et al. (2022b)	-1.946	0.356	0.127	-2.644	-1.247	-5.461	0.000
	Abdel-Rady et al. (2022)	1.386	0.233	0.054	0.929	1.843	5.947	0.000
	Mohammed et al. (2022)	-2.512	0.424	0.180	-3.344	-1.680	-5.919	0.000
	Emam et al. (2022a)	-1.946	0.356	0.127	-2.644	-1.247	-5.461	0.000
	El-Zayat et al. (2023)	0.100	0.183	0.033	-0.258	0.458	0.547	0.584
	Ali et al. (2024b)	0.674	0.236	0.056	0.211	1.138	2.853	0.004
	Ali et al. (2024a)	0.080	0.283	0.080	-0.475	0.635	0.283	0.777
Fixed		-0.094	0.057	0.003	-0.206	0.018	-1.644	0.100
Random		-0.441	0.272	0.074	-0.973	0.092	-1.622	0.105

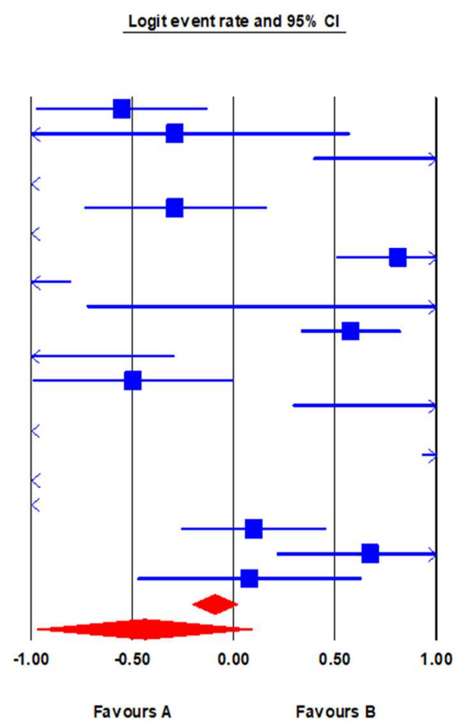

Figure 3. Forest Plot of the prevalence of EHV infection shows the logit event rate, 95% C, standard error, and variance on the random effect model of 20 observed studies.

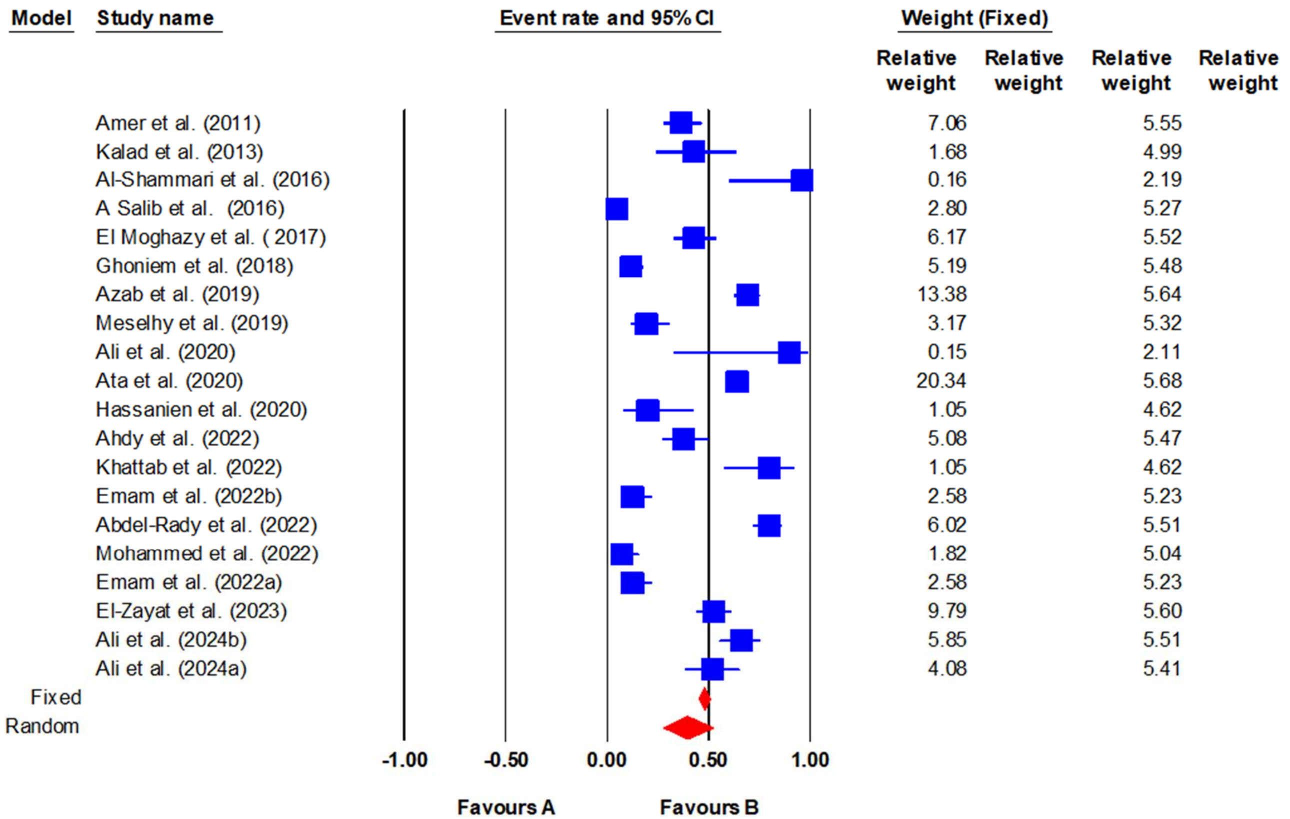

Figure 4. Forest Plot of the prevalence of EHV infection shows the weight on the random effect model of 20 observed studies.

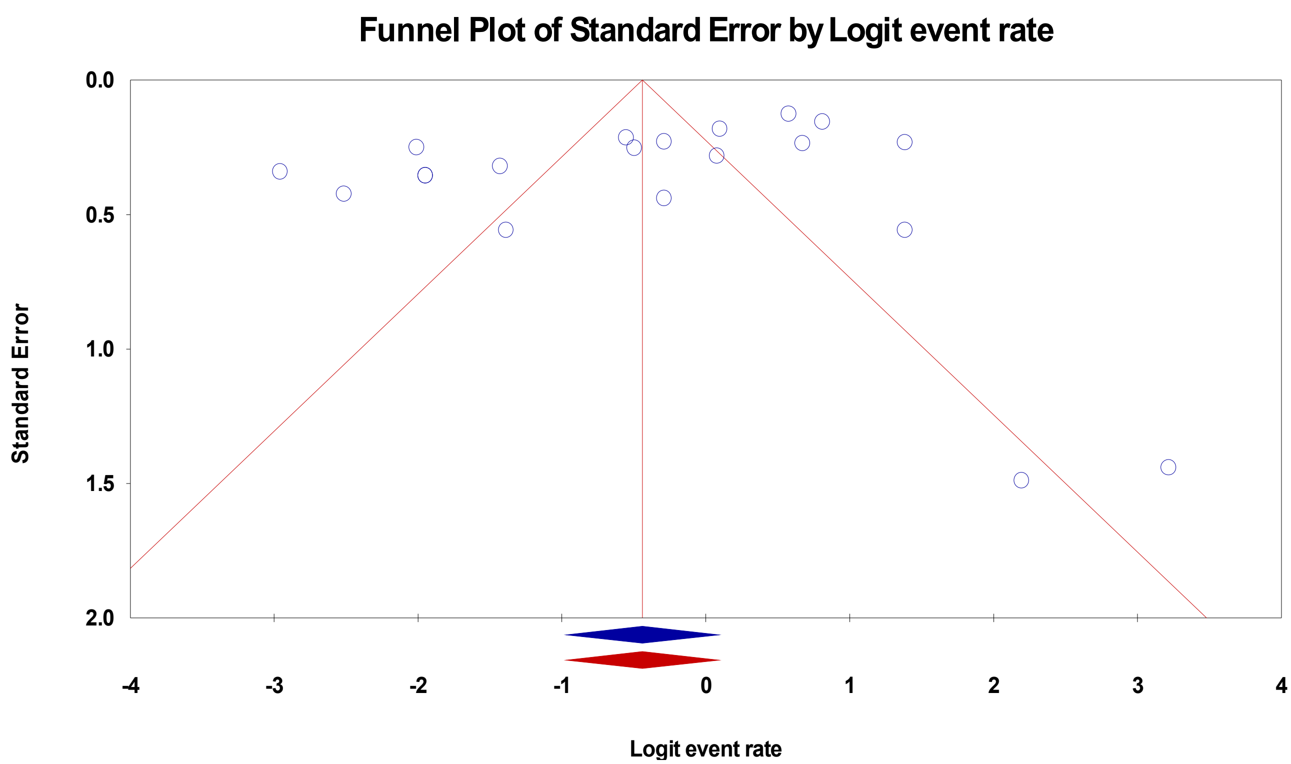

Figure 5. Funnel plot of the prevalence of EHV infection shows standard error by logit event rate on the random effect model of 20 observed and imputed studies.

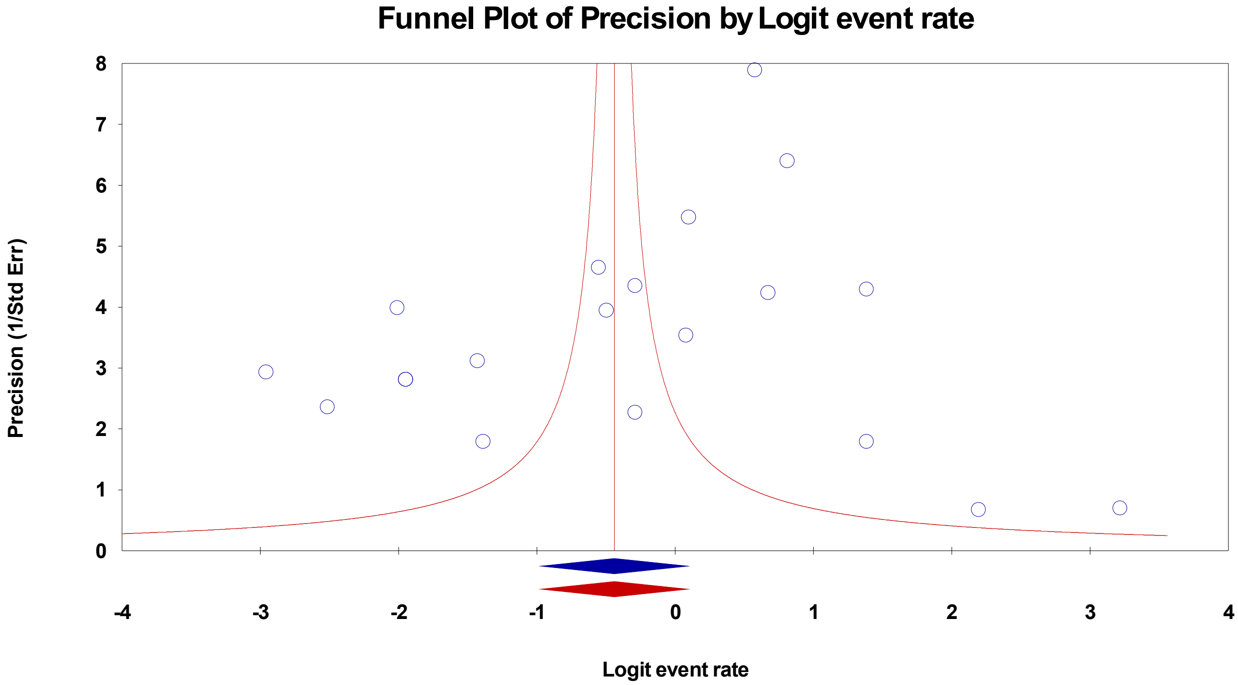

Figure 6. Funnel plot of the prevalence of EHV infection shows precision by logit event rate on the random effect model of 20 observed and imputed studies.

DISCUSSION

Egypt is one of the most famous countries and centers for breeding and exportation of pure Arabian horses (Kalad *et al.* 2013). In the absence of any previous systematic meta-analysis on the prevalence of EHV infection in Egypt, we conducted this study. This meta-analysis provides the results of electronic and print sources of peer-reviewed publications without restrictions on the publication date. Conference proceedings, technical reports, and other grey literature were not included in this meta-analysis.

Twenty studies fulfilled the selection criteria for the present study. In these studies. A total of 1683 horses were tested for EHV infection with prevalence of 42%. The prevalence of EHV infection varied widely among selected studies. This finding may be attributed to the used diagnostic test, age and gender of tested horses. The high prevalence reflects the importance of the EHV infection to cause multiple clinical manifestations, especially respiratory signs and abortion. Similar prevalence has been recorded in Tunesia (Badr *et al.* 2022). In the present study, the prevalence varied among studies even with using the same diagnostic technique. The prevalence of EHV-1 was the highest among the Arabian horses (Abdel-Rady *et al.* 2022; Ahdy *et al.* 2022). This finding is supported by findings of outbreaks caused by EHV-1 (El-Hage *et al.* 2021).

The study population and presence of risk factors are determinants of the prevalence of infectious diseases (Buitrago-Garcia *et al.* 2022). Variables such as age and sex of the horses studied have been linked to a higher risk of EHV infection. Young foals are more likely to be infected with EHV-2/-5 than adult horses (Hue *et al.* 2014), whereas equids aged 3–8 years have a higher prevalence of EHV-1/-4 than those younger than 3 years (Worku *et al.* 2024). Gender differences have also been observed, with males more likely to contract EHV-1-2 (Bolfa *et al.* 2017). On the other hand, many researchers have reported higher rates of EHV-1 and -4 among females than among males (de Souza *et al.* 2017; Negussie *et al.* 2016).

Clinically, 16 out of 20 eligible studies detected EHV in horses with various respiratory manifestations, abortion, and myeloencephalopathy. Similar findings have been reported globally (Kapoor *et al.* 2014; Sutton *et al.* 1998; Van Maanen 2002). The EHV-1 infection is a cause for upper respiratory tract signs in young horses and abortion in mares (Smith *et al.* 2004). However, myeloencephalopathy in adults and placental damage without abortion during early gestation have been also demonstrated (Allen *et al.* 1999). The EHV-4 also induces mainly respiratory infections in young and rarely causes abortion (Reed and Toribio 2004). The signs of respiratory disease associated with EHV infection are difficult to detect but may be observed as an outbreak (Reed and Toribio 2004). However, the genotype of EHV-1 did not affect clinical signs (Pusterla *et al.* 2020).

The present meta-analysis included 20 studies, of which 14 used molecular techniques were used for the diagnosis of EHV. However, the remaining studies used only screening tests. This finding may reflect the potential of studies using this technique. The multiplex real-time PCR is a convenient and rapid tool for investigating the clinical relevance of EHV-2 and EHV-5 (Fürer *et al*. 2022). Meanwhile**,** Other techniques were found to be reliable for detecting different strains of EHV (Lang *et al*. 2013; Nordengrahn *et al*. 2001).

Based on the results of meta-analysis, the study of Ata *et al*. (2020) provided a relative weight of 20.34 %, whereas the small studies by Al-Shammari *et al*. (2016) and Ali *et al*. (2020) are given approximately 0.16 % and 0.15% of the relative weight, respectively. It is known that the common effect is well assessed by larger studies but not by small studies. Studies with small sample size had a negligible effect on the total value. Consequently, larger studies with smaller standard errors have greater weight than those of smaller studies with large standard errors. The present meta-analysis provided Z-values of -1.377 (p = 0.168) and -1.539 (p = 0.124). The Z-value here does not add to the results, as it is not the effect size, but only indicates the data distribution (Hak *et al*. 2016).

Regarding heterogeneity, the Q-statistic and I^2 for the prevalence of EHV were 373.103 and 95.17, respectively (p-value $\leq$ 0.000). The Q-statistic includes the observed dispersion, while the null hypothesis for heterogeneity proposes that the studies assign a common effect size. Consequently, it is assumed that the degrees of freedom are equal to the Q-statistic (Thompson 1994). However, if Q-statistic provides no effect size dispersion, I^2 and tau-squared can provide alternative good interpretation (Schulz *et al*. 1995).

The I^2 concludes that the definite differences in effect sizes for 99 % of the variance among the studies, and only 1% of the observed variation can be predicted by means of random error. The tau-squared value for EHV infection was 1.383, which is the variance among studies and is utilized to calculate the weights. It has been stated that the I^2 can be used to measure the level of heterogeneity in meta-analysis, but the eyeball test is a less formal substitute to measure the heterogeneity (Huedo-Medina *et al*. 2006).

Heterogeneity analysis usually proves how the effect width varies among studies. This statistical test explains the difference among studies due to differences between the studies or to sampling errors (Borenstein *et al*. 2021). Heterogeneity tests are performed to determine the conformity of the normal distribution of effect sizes. Considering heterogeneity, the null hypothesis is that the effect will be zero for both fixed and random effects. Hedges' g/standard error for the relevant model is usually used to determine the z-value, which is used to check the null hypothesis (Higgins JP 2019). It has also been stated that the p-value is not an effect size, and therefore, is not a measure of the magnitude of heterogeneity. In this case, a low p-value indicates that there is probably some (unidentified) degree of heterogeneity (Duffield *et al*. 2008).

Regarding publication bias, publication bias is evident in reports with small sample size (Joober *et al*. 2012). Thus, detecting bias is an important issue as it has determinantal effect on the conclusion of systematic meta-analyses (Sutton *et al*. 2000). Funnel plot, an indicator usually used to decide the evidence of bias. In this plot, the effect size is usually shown against standard errors or precision (Light and B. Pillemer 1986). In the present study, the funnel plot was asymmetric, and there was no indication of publication bias. Moreover, the Egger's test confirmed absence of publication bias (intercept: -3.66, 95% confidence interval: - 8.23 to - 0.9; t-value: 1.96; df: 17.00). From the statistical meta-analysis, lack of bias is identified by zero level of regression slope (Rothstein HR 2005). If the Begg test has strong correlation, this indicates presence of publication bias (Begg and Mazumdar 1994).

Trim and fill test evaluates the total effect size and tests publication bias (Duval and Tweedie 2000). A repeated technique was used to exclude small studies at the extreme ends of the positive end of the funnel plot. The trimming and filling processes were repeated until the funnel plot was symmetric (Duval 2005)**.** In the present result, the trim-and-fill finding appears as the closed dots indicating the missing studies (no studies trimmed), and the open dots indicate the observed studies (about 20 studies) imputed, which depend greatly on the selected estimator (R0, L0, or Q0) for imputing missing studies and its result in an adjusted correlation from -0.19 to 0.034 (95% CI).

The fail-safe test suggests that 980000 missing studies were required to conclude the result of study is significant (p = 0.000). Additionally, Orwin's fail-safe N suggests a 0.47 event rate in observed studies and a 0.50 mean event rate in missing studies. Even though they are usually used in meta-analysis, these publication bias assessments could have type I error rate and/or low power (Peters *et al*. 2006; Peters *et al*. 2007; Rücker *et al*. 2008; Sterne *et al*. 2000; Terrin *et al*. 2003).

Conclusion: The results of the present meta-analysis indicate a high prevalence of EHV infection in Egypt, particularly EHV-1. Therefore, more attention should be paid to prevention and control of this disease.

Conflict of interest: Authors declare that there is no conflict of interest.

Funding: This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (funding number: A304).

Data availability: Data are available on request.

Authors' contribution: Authors contributed equally to this paper.

REFERENCES

Salib, F.A., M.A.Kalad, H.M. Hassan, and S.F Said (2016). Using indirect ELISA and PCR for the diagnosis of equine herpes virus-1 (EHV-1) infection in Egypt. J. Vet. Med. Res., 23(1):117-124. doi.org/10.21608/jvmr.2016.43230

Abdel-Rady, A., I. Abd El-Rahim, R. Abd El SGE and S. Malek (2022). Clinical and Molecular epidemiological study on herpesviruses infection among equid populations in upper Egypt. J. Hellenic V. Med. Soc. 73(4):4689-4872 . doi.org/10.12681/jhvms.28144

Ahdy, A.M., B.M. Ahmed, M.A.Elgamal, M. Shaalan, I.M. Farag, E.R. Mahfouz, H.R. Darwish, M.Z. Sayed-Ahmed, M.A. Shalaby and A.A. El-Sanousi (2022). Detection of equid alphaherpesvirus 1 from arabian horses with different clinical presentations between 2016-2019 in Egypt. J. Equine Vet. Sci. 114:103960. doi.org/10.1016/j.jevs.2022.103960

Al-Shammari, Z., B. Ahmed, M. Haroun, A. Afify, A. Elsanousi and M. Shalaby (2016). A first molecular phylogeny of an Egyptian equine herpesvirus-4 strain derived from a fetal Arabian horse. J. Vet. Sci. Med. Diag. 5(1):2-4. doi.org/10.4172/2325-9590.1000186

Ali, A.A., F. Abdallah, O.A. Shemies, G. Kotb and M.R. Nafea (2024a). Isolation and identification of equine herpesvirus-1 (EHV-1) in Egypt during 2021-2022. J. Adv. Vet. Res. 14(3):531-536. doi.org/10.5455/OVJ.2024.v14.i1.48

Ali, A.A., F. Abdallah, O.A. Shemies, G. Kotb and M.R. Nafea (2024b). Molecular characterization of equine herpes viruses type 1 and 4 among Arabian horse populations in Egypt during the period between 2021 and 2022. Open V. J. 14(1):534 . doi.org/10.5455/OVJ.2024.v14.i1.48

Ali, A.A., N.A. Refat, N.A. Algabri and M.S. Sobh (2020). Fetal lesions of EHV-1 in equine. Anais da Academia Brasileira de Ciencias 92:e20180837. doi.org/10.1590/0001-3765202020180837

Allen, G., J. Kydd, J. Slater and K. Smith (1999). Advances in understanding of the pathogenesis, epidemiology and immunological control of equine herpesvirus abortion. In: Wernery, U., Wade, J.F., Mumford, J.A. and Kaaden, O.R., Eds., Equine Infectious Diseases VIII. Proceedings of the 8th International Conference, R and W Publications, Newmarket, 129-146.

Allen, G., J. Kydd, J. Slater and K. Smith (2004). Equid herpesvirus 1 and equid herpesvirus 4 infections. Equid Herpesvirus 1 and Equid Herpes virus Infections, Infectious Diseases of Livestock, (ed.) Jaw Coestzar and RC Taustin. Oxford Press (Cape Town, Chapter 76, pp;929-859.

Amer, H.M., A.K. Shaltout, I.M. El-Sabagh, A.A. El-Sanousi and M.A.Shalaby (2011). Prevalence of equine herpes viruses 1, 2 and 4 in Arabian horse population in Egypt. African J. Mocrobiol. Res. 5(27):4805-4811. doi.org/10.5897/AJMR11.421

Ata, E.B., A. Salama, A. Zaghawa, A. Ghazy, A. Elsify, M. Nayel, Y. Hegazy, E. Abdel-Rahman and S. Warda (2020). Seroprevalence of equine herpes virus-1 in endemic area of Egypt with risk factors assessment. Bulgarian J. Ve. Med. 23(1). doi.org/10.15547/bjvm.2168

Azab, W., S. Bedair, A. Abdelgawad, K. Eschke, C.K. Farag, A. Abdel-Raheim, A.D. Greenwood, N. Osterrieder and A.A. Ali (2019). Detection of equid herpesviruses among different Arabian horse populations in Egypt. Vet. Med. Sci. 5(3):361-371. doi.org/10.1002/vms3.176

Badr, C., O. Souiai, M. Arbi, I. El Behi, M.S. Essaied, I. Khosrof, A. Benkahla, A. Chabchoub and A. Ghram (2022). Epidemiological and phylogeographic study of equid herpesviruses in Tunisia. Pathogens 11. doi.org/10.3390/pathogens11091016

Bannai, H., M. Nemoto, K. Tsujimura, T. Yamanaka, T. Kondo and T. Matsumura (2013). Improving a complement-fixation test for equine herpesvirus type-1 by pretreating sera with potassium periodate to reduce non-specific hemolysis. J. Equine Sci. 24(4):71-74. doi.org/10.1294/jes.24.71

Begg, C.B. and M. Mazumdar (1994). Operating characteristics of a rank correlation test for publication bias. Biom. 50(4):1088-101. doi.org/10.2307/2533446

Bolfa, P., I. Jeon, A. Loftis, T. Leslie, S. Marchi, F. Sithole, C. Beck, S. Lecollinet, S. Zientara and A. Hans (2017). Detection of West Nile virus and other common equine viruses in three locations from the Leeward Islands, West Indies. Acta Trop. 174:24-28. doi.org/10.1016/j.actatropica.2017.06.023

Borchers K., M. Ebert, A. Fetsch, T. Hammond and A. Sterner-Kock (2006). Prevalence of equine herpesvirus type 2 (EHV-2) DNA in ocular swabs and its cell tropism in equine conjunctiva. Vet. Microbiol. 118(3-4):260-266. doi.org/10.1016/j.vetmic.2006.07.024

Borenstein, M., L.V. Hedges, J.P. Higgins and H.R. Rothstein (2021). Introduction to meta-analysis.

John Wiley and Sons. doi.org/10.1002/9781119558378

Buitrago-Garcia, D., G. Salanti and N. Low (2022). Studies of prevalence: how a basic epidemiology concept has gained recognition in the COVID-19 pandemic. BMJ open 12(10):e061497. doi.org/10.1136/bmjopen-2022-061497

Davison, A.J., R. Eberle, B. Ehlers, G.S. Hayward, D.J. McGeoch, A.C. Minson, P.E. Pellett, B. Roizman B, M.J. Studdert and E. Thiry (2009). The order herpesvirales. Arch. Virol. 154:171-177. doi.org/10.1007/s00705-008-0278-4

de Souza, M., H. Lara, E.Villalobos, E. Cunha, T.V. de OLIVEIRA, A.F. de Castro Nassar, L. Silva, L.H. Okuda, A. Romaldini and M.S. Cunha (2017). Occurrence of viral diseases in donkeys (Equus asinus) in São Paulo State, Brazil. Brazilian J. Vet. Res. Anim. Sci. 54(2):154-158. doi.org/10.11606/issn.1678-4456.bjvras.2017.121241

Duffield T.F., A.R. Rabiee and I.J. Lean (2008). A meta-analysis of the impact of monensin in lactating dairy cattle. Part 1. Metabolic effects. J. Dairy Sci. 91(4):1334-46 doi:10.3168/jds.2007-0607. doi.org/10.3168/jds.2007-0607

Duval, S. (2005). The trim and fill method publication bias in meta-analysis. Publication bias in meta-analysis: prevention, assessment and adjustments. eds. H. R. Rothstein, A.J. Sutton and M. Borenstein John Wiley and Sons, pp 127-144. doi.org/10.1002/0470870168.ch8

Duval, S. and R. Tweedie (2000). Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. Biom. 56(2):455-63 doi:10.1111/j.0006-341x.2000.00455.x. doi.org/10.1111/j.0006-341X.2000.00455.x

El-Hage, C., Z. Mekuria, K. Dynon, C. Hartley, K. McBride and J. Gilkerson (2021). Association of equine herpesvirus 5 with mild respiratory disease in a survey of EHV1, -2, -4 and -5 in 407 Australian Horses. Animals (Basel) 11. doi.org/10.3390/ani11123418

El-Zayat, M., O.A. Shemies, S.M. Mosad and S. Abd El Rahman (2023). Recent sequencing and phylogenetic analysis of equine herpesviruses 1 and 4 among different equine populations in Egypt. JAVAR 10(4):639. doi.org/10.5455/javar.2023.j719

El Moghazy, H.M., M.G. Abdelwahab, F.I. Hamouda, E.M. Ibrahim and S.M. Warda (2017) Seroprevalence of equine herpes virus type-1 In Horses And Donkeys In Qalubiah Governorate In Egypt. J. Biol. Sci. 3(12):01-18

Emam, H.S., Y.G. Abd-Elhafeiz, M.A. Abo-Elkhair, A.M. Hesham and A. Bazid (2022a). Detection of local isolates of equine herpes virus type 1 associated with abortion and respiratory manifestation in horses in Giza. JCVR 4(2):80-90. doi.org/10.21608/jcvr.2022.267516

Emam, H.S., I. Bazid, Y.G. Abd-Elhafeiz, M.A. Abo-Elkhair and A. Beshir (2022b). Isolation and molecular characterization of equine herpes virus-1 from horses localized in Giza Governorate, Egypt. J. App. Vet. Sci.7(3):50-58. doi.org/10.21608/javs.2022.134025.1145

Fürer, F., C. Fraefel and J. Lechmann (2022) Multiplex real-time PCR for the detection and differentiation of equid gammaherpesvirus 2 and 5. J. Virol. Methods 310:114615 doi:10.1016/j.jviromet.2022.114615. doi.org/10.1016/j.jviromet.2022.114615

Gatherer, D., D.P. Depledge, C.A. Hartley, M.L. Szpara, P.K. Vaz, M. Benkő, C.R. Brandt, N.A. Bryant, A. Dastjerdi and A. Doszpoly (2021). ICTV virus taxonomy profile: herpesviridae 2021. J. Gen. Virol. 102(10):001673. doi.org/10.1099/jgv.0.001673

Ghoniem, S.M., A.H. El Deeb, M.G. Aggour and H.A. Hussein (2018). Development and evaluation of a multiplex reverse-transcription real-time PCR assay for detection of equine respiratory disease viruses. J. Vet. Diagn. Invest. 30(6):924-928. doi.org/10.1177/1040638718799388

Haidich, A.B. (2010) Meta-analysis in medical research. Hippokratia 14(Suppl 1):29-37

Hak, T., H. van Rhee and R. Suurmond (2016). How to interpret results of meta-analysis. Available at SSRN 3241367. doi.org/10.2139/ssrn.3241367

Hartley, C.A., C.R.Wilks, M.J. Studdert and J.R. Gilkerson (2005). Comparison of antibody detection assays for the diagnosis of equine herpesvirus 1 and 4 infections in horses. Am. J. Vet. Res. 66(5):921-928. doi.org/10.2460/ajvr.2005.66.921

Hassanien, R.T., E.M. El-Nahas, N.A. Mahmoud and G.F. El-Bagoury (2020). Molecular characterization of equine herpesvirus-1 and asinine herpesvirus-5 isolated from aborted fetuses of Arabian horses. TJVM 50(3):397-403. doi.org/10.56808/2985-1130.3042

Higgins, T.J., J. Chandler, M. Cumpston, T. Li and M.J. Page (2019). Cochrane handbook for systematic reviews of interventions:. John Wiley & Sons. doi.org/10.1002/9781119536604

Hue, E.S., G.D. Fortier, C.I. Fortier, A.M. Leon, E.A. Richard, L.J. Legrand and S.L. Pronost (2014). Detection and quantitation of equid gammaherpesviruses (EHV-2, EHV-5) in nasal swabs using an accredited standardised quantitative PCR method. J. Virol. Methods

198:18-25. doi.org/10.1016/j.jviromet.2013.12.008

Huedo-Medina, T.B., J. Sánchez-Meca, F. Marín-Martínez and J. Botella (2006). Assessing heterogeneity in meta-analysis: Q statistic or I2 index? Psychol. methods 11(2):193-206 doi:10.1037/1082-989x.11.2.193. doi.org/10.1037/1082-989X.11.2.193

Joober, R., N. Schmitz, L. Annable and P. Boksa (2012). Publication bias: what are the challenges and can they be overcome? J. Psychiatry & neuroscience : JPN 37(3):149-52 doi:10.1503/jpn.120065. doi.org/10.1503/jpn.120065

Kalad, M., M. Hanafy, S. Warda, N. Saleh, N. Madkour, H. Elgharieb, S. Ebraheem and E. Ebied (2013). Prospective studies of equine herpes virus-1 myeloencephalopathy in Egypt 2012. Ippologia 24(3/4):25–31.

Kapoor, S., H. Sharma, M. Singh, P. Kumar, K. Ranjan, A. Kumari and R. Khirbat (2014). Equine herpesviruses: a brief review. Nine 2014:06-25. doi.org/10.14737/journal.aavs/2014/2.2s.46.54

Khattab, O., H.K. Abdelmegeed, H.N. Hamdy, A. Hamed, H. Fahmy, E. Ibrahim, M. Shahein and E. Ahmed (2022). Equine herpes virus 4 (EHV4) investigation in aborted Egyptian Mares; molecular detection, isolation, and phylogeny for viral glycoprotein B. Adv. Anim. Vet. Sci. 10(9):1907-1915. doi.org/10.17582/journal.aavs/2022/10.9.1907.1915

Lang, A., M. de Vries, S. Feineis, E. Müller, N. Osterrieder and A.M. Damiani (2013). Development of a peptide ELISA for discrimination between serological responses to equine herpesvirus type 1 and 4. J. Virol. Methods 193(2):667-673. doi.org/10.1016/j.jviromet.2013.07.044

Light, R. and D.B. Pillemer (1986). Summing Up: the Science of Reviewing Research Harvard University Press: Cambridge, MA, 1984, xiii+191 pp. Educ. Res. 15(8):16-17. doi.org/10.3102/0013189X015008016

Lunn, D., N. Davis-Poynter, M. Flaminio, D. Horohov, K. Osterrieder, N. Pusterla and H. Townsend (2009). Equine herpesvirus-1 consensus statement. JVIM 23(3):450-461. doi.org/10.1111/j.1939-1676.2009.0304.x

Meselhy, N.K., M. Abo El-khair, B.M. Ahmed, S.A. El-Soally, A. Fares, M.A. Nayel and H.A. Hussein (2019). Sequence analysis of seven equine herpes type 1 viruses circulating in non-vaccinated Arabian and foreign horses in Egypt. J Virol Sci 5:11-21

Mohammed, S.I., A.H.I. Bazid, M.A. Shahein and M.A. Abo-Elkhair (2022). Isolation and identification of Some viruses causing abortion in equine in Egypt. JCVR 4(2):68-79. doi.org/10.21608/jcvr.2022.267515

Moher, D., A. Liberati, J.Tetzlaff and D.G. Altman (2010a). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int. J. Surg. 8(5):336-41. doi.org/10.1016/j.ijsu.2010.02.007

Moher, D., A. Liberati, J. Tetzlaff , D.G. Altman and The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann. Intern. Med. 151(4):264-269. doi.org/10.7326/0003-4819-151-4-200908180-00135

Negussie, H., Y. Li, T.S. Tessema and H.J.Nauwynck (2016). Replication characteristics of equine herpesvirus 1 and equine herpesvirus 3: comparative analysis using ex vivo tissue cultures. Vet. Res. 47:1-11. doi.org/10.1186/s13567-016-0305-5

Nordengrahn, A., B. Klingeborn, A. Lindholm and M. Merza (2001). The use of a neutralizing monoclonal antibody to detect infections of equine herpesvirus type 2 (EHV-2). J. Vet. Diagn. Invest. 13(5):389-93. doi.org/10.1177/104063870101300504

Pavulraj, S., K. Eschke, J. Theisen, S. Westhoff, G. Reimers, S. Andreotti, N. Osterrieder and W. Azab (2021). Equine herpesvirus type 4 (EHV-4) outbreak in Germany: Virological, serological, and molecular investigations. Pathogens 10(7):810. doi.org/10.3390/pathogens10070810

Peters, J.L., A.J. Sutton, D.R. Jones, K.R. Abrams and L. Rushton (2006). Comparison of two methods to detect publication bias in meta-analysis. JAMA 295(6):676-680. doi.org/10.1001/jama.295.6.676

Peters, J.L., A.J.Sutton, D.R. Jones, K.R. Abrams and L. Rushton (2007). Performance of the trim and fill method in the presence of publication bias and between-study heterogeneity. Stat. Med. 26(25):4544-4562. doi.org/10.1002/sim.2889

Pusterla, N., K. Hatch, B. Crossley, C.Wademan, S. Barnum and K. Flynn (2020). Equine herpesvirus-1 genotype did not significantly affect clinical signs and disease outcome in 65 horses diagnosed with equine herpesvirus-1 myeloencephalopathy. Vet. J. 255:105407. doi.org/10.1016/j.tvjl.2019.105407

Pusterla, N., S.B.Hussey, S. Mapes, C.M. Leutenegger, J.E. Madigan, G.L. Ferraro, W.D. Wilson and D.P. Lunn (2009). Comparison of four methods to quantify Equid herpesvirus 1 load by real-time polymerase chain reaction in nasal secretions of experimentally and naturally infected horses. J. Vet. Diagn. Invest. 21(6):836-840. doi.org/10.1177/104063870902100611

Reed, S.M. and Toribio (2004). Equine herpesvirus 1 and 4. Vet. Clin. N. Am., Equine Pract. 20(3):631-642. doi.org/10.1016/j.cveq.2004.09.001

Reese, T.A. (2016) Coinfections: another variable in the herpesvirus latency-reactivation dynamic. J. Virol. 90(12):5534-5537. doi.org/10.1128/JVI.01865-15

Rothstein, H.R. and S.A. Borenstein (2005). Publication bias in meta-analysis. . Publication bias in meta-analysis: Prevention, assessment and adjustments. John Wiley & Sons, Ltd, PP1-7. doi.org/10.1002/0470870168.ch1

Rücker, G., G. Schwarzer and J. Carpenter (2008). Arcsine test for publication bias in meta-analyses with binary outcomes. Stat. Med. 27(5):746-763. doi.org/10.1002/sim.2971

Schulz, K.F., I. Chalmers, R.J. Hayes and D.J. Altman (1995). Empirical evidence of bias. dimensions of methodological quality associated with estimates of treatment effects in controlled trials. Jama 273(5):408-12 doi:10.1001/jama.273.5.408. doi.org/10.1001/jama.273.5.408

Slater, J., D. Lunn, D. Horohov, D. Antczak, L. Babiuk, C. Breathnach, Y-W. Chang, N. Davis-Poynter, N. Edington and S. Ellis (2006). Report of the equine herpesvirus-1 Havermeyer Workshop, San Gimignano, Tuscany, June 2004. Vet. immunol. immunopathol. 111(1-2):3-13. doi.org/10.1016/j.vetimm.2006.01.004

Smith, K., K.Whitwell, A. Blunden, M. Bestbier, T. Scase, R. Geraghty, J. Nugent, N. Davis-Poynter and J. Cardwell (2004). Equine herpesvirus-1 abortion: atypical cases with lesions largely or wholly restricted to the placenta. Equine Vet. J. 36(1):79-82. doi.org/10.2746/0425164044864732

Smith, K.L., Y. Li, P. Breheny, R.F. Cook, P.J. Henney, S. Sells, S. Pronost, Z. Lu, B.M. Crossley and P.J. Timoney (2012). New real-time PCR assay using allelic discrimination for detection and differentiation of equine herpesvirus-1 strains with A2254 and G2254 polymorphisms. J. Clin. Microbiol. 50(6):1981-1988. doi.org/10.1128/JCM.00135-12

Sterne, J.A., D. Gavaghan and M. Egger (2000). Publication and related bias in meta-analysis: power of statistical tests and prevalence in the literature. J. Clin. Epidemiol." 53(11):1119-1129. doi.org/10.1016/S0895-4356(00)00242-0

Sutton, A.J., S.J. Duval, R.L. Tweedie, K.R. Abrams and D.R. Jones (2000). Empirical assessment of effect of publication bias on meta-analyses. BMJ (Clinical research ed) 320(7249):1574-7 doi:10.1136/bmj.320.7249.1574. doi.org/10.1136/bmj.320.7249.1574

Sutton, G., L. Viel, P. Carman and B. Boag (1998). Pathogenesis and clinical signs of equine herpesvirus-1 in experimentally infected ponies in vivo. Canadian J. Veterinary Research 62(1):49

Terrin, N., C.H. Schmid, J. Lau and I. Olkin (2003) Adjusting for publication bias in the presence of heterogeneity. Stat. Med. 22(13):2113-2126. doi.org/10.1002/sim.1461

Thompson, S.G. (1994). Why sources of heterogeneity in meta-analysis should be investigated. BMJ (Clinical research ed) 309(6965):1351-5 doi:10.1136/bmj.309.6965.1351. doi.org/10.1136/bmj.309.6965.1351

Van Maanen, C. (2002). Equine herpesvirus 1 and 4 infections: an update. Vet. Q. 24(2):57-78. doi.org/10.1080/01652176.2002.9695126

Vissani, M.A., A.M.Damiani and M.E. Barrandeguy (2021). Equine coital exanthema: New insights on the knowledge and leading perspectives for treatment and prevention. Pathogens 10(8):1055. doi.org/10.3390/pathogens10081055

White, D.W., R. Suzanne Beard and E.S. Barton (2012). Immune modulation during latent herpesvirus infection. Immunol. Rev. 245(1):189-208. doi.org/10.1111/j.1600-065X.2011.01074.x

Worku, A., W. Molla, A. Kenubih, D. Gizaw, A. Muluneh, B. Admassu, M. Ejo, G.G. Dagnaw,A.B. Bitew and T. Fentahun (2024). Seroprevalence and associated risk factors of equine herpesvirus type-1/-4 in selected districts of Northwest Amhara, Ethiopia. Comp. Immunol. Microbiol. Infect. Dis. 107:102155. doi.org/10.1016/j.cimid.2024.102155