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Review Article

The socioeconomic impact of equine epizootic lymphangitis in working equids in low and middle-income countries: A scoping review

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ABSTRACT

Equine epizootic lymphangitis (EEL) is a very infectious and contagious fungal disease that, with its ocular, respiratory and skin forms, causes severe effects on the health and welfare of working equids. Treatment is expensive and rarely available in low and middle-income countries (LMICs). Epidemiological data is lacking in most countries where the disease is known to exist. The purpose of this scoping review is to identify the current knowledge on the socioeconomic impact of EEL in working equids in LMICs, to highlight knowledge gaps and provide recommendations for future research. Seven eligible papers were obtained from the search of four databases and backward citation searching. The review showed that the available research on this subject is very scarce and restricted to Ethiopia. From the results it emerged that EEL causes detrimental socioeconomic effects on working equids' owners, compromising their health and livelihood. Its economic consequences were attributed to the reduced working capacity and loss of sick animals. Among the social impacts, authors highlighted the stigma around sick equids and their owners. Further studies on the socioeconomic impact of EEL conducted in endemic areas are highly required. The integration of epidemiological data with socioeconomic impact studies from LMICs may promote funding allocation for the development of cost-effective treatments and vaccines and for implementing disease prevention and control programmes. Future research would gain from applying the One Health approach to better examine the multiplicity of the disease socioeconomic effects, therefore increasing the potential of research to orientate policy.

1. Introduction

There are around 116 million working equids in low and middle-income countries (LMICs) that provide draught power and transportation for livelihood and domestic activities [1,2,3]. Among the diseases affecting working equids, equine epizootic lymphangitis (EEL), also known as equine histoplasmosis, is a chronic and highly contagious fungal disease caused by *Histoplasma capsulatum* variety *farciminosum.* It is identified as an ulcerative and suppurative pyogranulomatous dermatitis and lymphangitis [4]. With its ocular, respiratory and skin forms, EEL causes very severe effects on equid health and welfare, leading to anorexia, emaciation and death [5,6,7]. Horses are the most critically affected, while mules are considered more resistant and develop milder lesions [6]. Nevertheless, high disease prevalence and severe lesions in mules have been described [8]. According to some authors, donkeys are rarely affected by EEL [9], although critical cases in donkeys have been recorded [10]. For this reason, Scantlebury and Reed [7] suggest that EEL in donkeys may be an emerging problem.

The cutaneous form is the most common in both horses [11] and mules [12]. Animals develop papules that evolve in suppurating nodules and ulcers that produce a bad odour [6]. The infection disseminates through lymphatic vessels to subcutaneous and deep tissues [9]. In terminal cases, lesions spread to the whole body, making animals uncapable of work [12]. For this reason, animals are abandoned by their owners since they are considered uncurable [12]. The skin lesions are often contaminated by secondary bacteria that aggravate the equid's condition [13]. The ocular form causes an ulcerative keratocongiunctivits [11]. In the respiratory form, purulent discharge and severe dyspnoea that is followed by the animal's death, are observed [7].

The disease agent can be found in the soil and infects animals by contaminating wounds and by being ingested and absorbed through stomach ulcers [9]. Wound-inflicting harness is a risk factor for contracting EEL [14]. The disease is also transmitted through direct contact with exudates from wounds of infected animals [5]. For this reason, the

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risk increases in areas with high equine populations [5] where animals from different origins mix in overcrowded stations and stables [15]. The spores of the fungus can be inhaled, causing the respiratory form [9]. It is assumed that transmission can occur indirectly through fomities such as infected harness or grooming and feeding equipment. However, the agent has not yet been isolated from fomities nor its survival length has been investigated on objects [5,7]. Flies have a mechanical role in disease transmission among nearby animals and in spreading the infection within the same animal [5]. Skin lesions caused by ticks increase the risk of developing the disease [6,12].

EEL is diagnosed through clinical observation combined with identification of the aetiological agent from smears of discharged material stained with Grams and Giemsa and histology of lesions [6]. Polymerase chain reaction has been recently demonstrated as effective to identify the infection in asymptomatic equids [16,17]. The treatment is expensive and available only in charity hospitals. Amphotericin B is an effective drug, but it is cost prohibitive [18]. Antibiotic treatment is recommended because of the secondary bacterial infections affecting the skin lesions [13]. Wound prevention and care, hygiene promotion and control of flies and ticks represent essential control measures [18] in addition to screening, early treatment, quarantine of sick cases and euthanasia of the most severe ones [8,12]. Culling of infected cases, that would reduce the disease spread and the environmental contamination, is unrealistic in LMICs in absence of compensation measures [4,7]. Live attenuated and killed vaccines have been tested in endemic contexts but they are unavailable commercially [4,19].

EEL has been eradicated in many parts of the world, but it remains endemic in some regions of Africa, Asia and Middle East [7,9]. EEL is highly prevalent in Ethiopia, due to the favourable climatic conditions of increased humidity, reduced rainfall, hot temperature and altitude between 1500 and 2300 metres [5,17,20]. It has also been reported in other LMICs like Egypt [21], Iraq [11,22], Nigeria [23,24], Sudan [25,26], Senegal and South Africa [27].

Due to their working environment such as overcrowded stations and their husbandry conditions characterised by the lack of hygiene, exchanges of harness and presence of harness-inflicting wounds, working equids are particularly at risk of contracting EEL [7,10,15,28]. Although they support the livelihoods of disadvantaged communities in LMICs [29], the socioeconomic role of working equids is under-recognised and they are excluded by governments and international organisations from animal health policy and interventions, meaning that working equids rarely have access to veterinary services with negative consequences on their health and welfare [1]. This is particularly detrimental when they are affected by diseases like EEL that, if untreated, can lead to animals' death [5]. Consequently, the livelihoods of families depending on working equids can be dramatically impacted [30].

Considering the severity of the disease, the multiplicity of risk factors for working equids to contract it and the role of working equids in supporting the livelihood of vulnerable communities, the aim of this review was to identify the socioeconomic effects of EEL in working equids in LMICs. A scoping review, structured according to the Extension for Scoping Reviews of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA-ScR) [31] was selected as the most suitable method to provide a resource for researchers to readily access data on animal health economics and recommendations for future research on the socioeconomic effects of EEL. The objectives of this scoping review were: 1) to identify the existing knowledge on the socioeconomic impact of EEL in LMICs, 2) to outline how research is conducted, 3) to identify knowledge gaps on the subject, 4) to provide guidance for future research [32,33].

2. Material and methods

2.1. Search strategy

The search strategy was identified through an iterative trial-and-error process that was performed on CAB Abstracts [34] and lead to a series of keywords that were combined by Boolean operators. Among the keywords, the list of LMICs was obtained from the filter issued by Cochrane [35]. Since the filter was created from the 2019 list of LMICs published by the World Bank for 2020 fiscal year [36], the 2020, 2021, 2022 LMICs lists were screened to exclude discrepancies within the filter. Regarding the disease keywords, both outdated and new nomenclatures of the pathogen were considered to ensure that all relevant publications were retrieved. In fact, according to the most recent classification, the causative agent of EEL is *Histoplasma capsulatum* variety *farciminosum*, while according to the former classification, the agent was named *Histoplasma farciminosum* as it used to be considered an independent species [37]. No limits were applied to the search to obtain as many papers as possible. The keywords are presented in Table 1 and the complete search strategy for all databases is provided in Supplementary material 1.

2.2. Information sources

Publications were obtained from four databases covering the subjects of human and animal health, veterinary medicine, rural development, animal husbandry and biomedical sciences: CAB Abstracts, EMBASE, Web of Science Core Collection and BIOSIS Citation Index. Databases from the same interface were searched individually. A librarian from the University of Edinburgh peer-reviewed the search strategy and adapted it to the different platforms as recommended by Spry and Mierzwinski-Urban [38]. The syntax of the filter was also adjusted to the different interfaces. The most recent database search was conducted on 11th June 2023. Backward citation searching of eligible publications was also performed.

2.3. Inclusion and exclusion criteria

To be eligible for the review, publications had to include an in-depth analysis of the socioeconomic impact of EEL, with working equids such as horses, donkeys, mules and ponies as the study population. The review considered studies that took place in LMICs based on the classification provided by the World Bank at the time of the study [39]. It included full-text peer-reviewed articles and non-peer-reviewed papers such as proceedings and organisation reports structured as research studies, based on the recommendations from Benzies et al. [40] and Hartling et al. [41] on the relevance of grey literature in adding evidence to scientific research. Eligible publications had to be original research published in English, Italian, Spanish, Portuguese and French. Papers that referred to the socioeconomic impact of EEL to support the relevance of a study without expanding the topic further, were not considered for the review. As secondary research, literature reviews were also excluded.

Table 1
Search strategy developed for CAB Abstracts. The groups of keywords are combined through Boolean operator AND. Truncation (*) includes both singular and plural forms.

Socioeconomic keywords	household* OR communit* OR income OR livelihood OR socioeconomic OR econom* OR poverty
Disease keywords	'epizootic lymphangitis' OR 'histoplasma capsulatum variety farciminosum' OR 'histoplasma farciminosum' OR 'equine histoplasmosis'
Working equids keywords	((work*OR pack* OR plough* OR plow* OR draft* OR draught* OR transport* OR traction* OR cart*) ADJ3 (animal* OR equid* OR equine* OR livestock OR donkey* OR horse* OR mule* OR pon*)) OR carthorse* OR cart-horse*
Low and middle-income countries keywords	Filter by Cochrane [35]

2.4. Screening of sources of evidence

The publications obtained from the database searches were stored on EndNote, deduplicated and selected according to the inclusion criteria. The screening process was undertaken by the first author in three stages. Titles were examined at first, followed by abstracts and full texts. Publications that met all the eligibility criteria were downloaded from an online source or acquired through the digitalisation and inter-library loan services of the University of Edinburgh.

2.5. Data extraction and data items

The following data were extracted from eligible publications through a data collection form in Microsoft Word [42], then entered in Microsoft Excel [43] and synthetised: publication details (peer reviewed/non-peer reviewed paper, publication source, year of publication, language), study details (main focus, species, method to appraise the socioeconomic impact of the disease, main findings including economic and social effects of the disease and recommendations), study setting, authors' affiliation and location.

3. Results

3.1. Selection of sources of evidence

A total of 39 articles were obtained from the initial search of the four databases. Once duplicates had been removed using EndNote, 29 original articles remained. Four papers were subsequently removed through

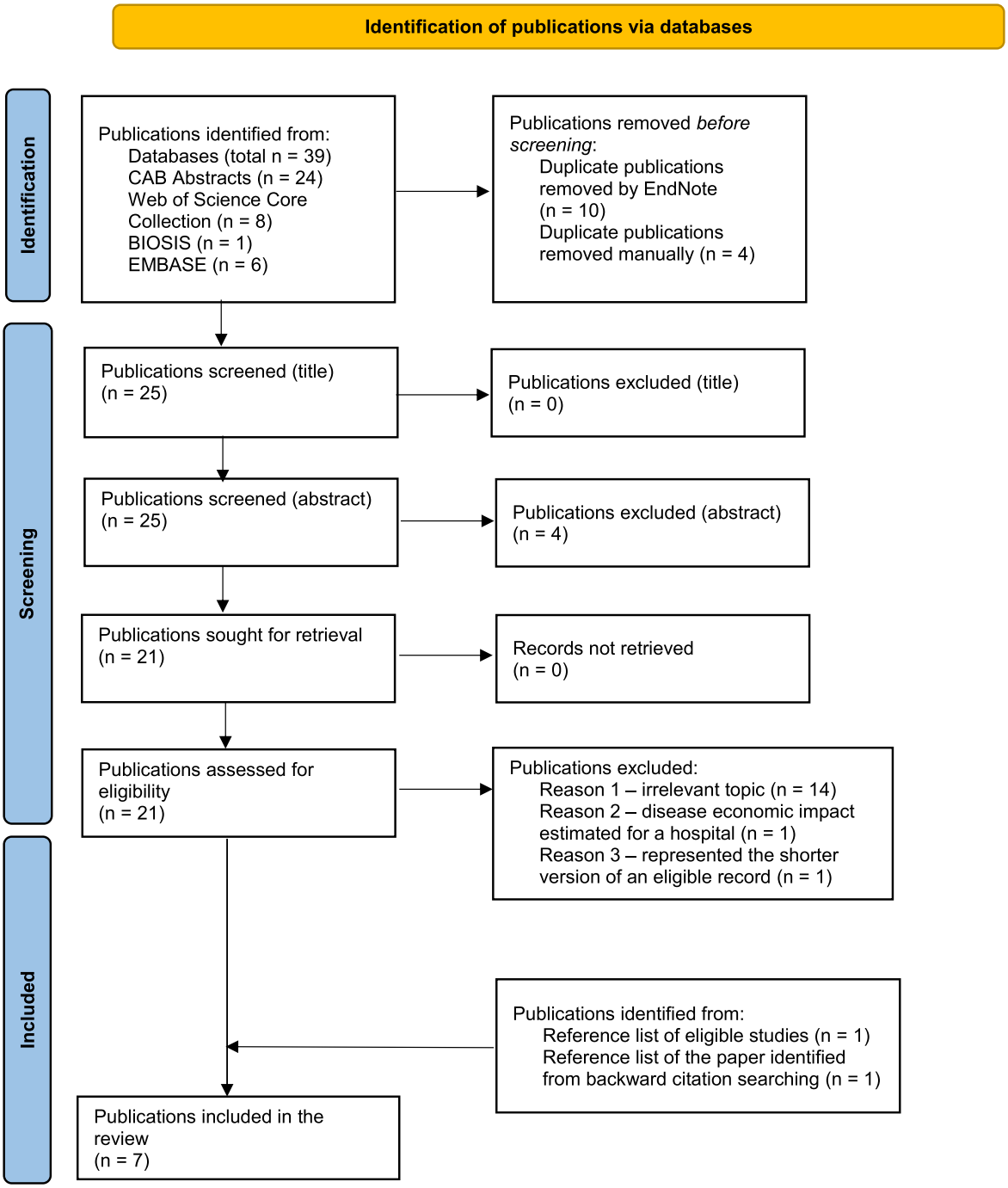

Fig. 1. PRISMA 2020 flow diagram for systematic reviews adapted from Page et al. [44].

manual deduplication. No papers were eliminated after the title screening. After the analysis of the abstracts, four articles were excluded because of irrelevant topic. The remaining 21 papers were considered for full-text evaluation. Fifteen publications did not meet the selection criteria, including one publication that determined the disease socio-economic impact for a charity hospital. One publication was excluded because it was the shorter version of another eligible paper. Following the full-text analysis, five eligible articles were identified. One additional relevant paper was obtained from backward citation searching of the five primarily included publications. Its references were also analysed and one more eligible article was identified. A total of seven papers were therefore included in the review (the reference list can be found in Supplementary material 2). The phases of the identification of eligible publications are reported in Fig. 1.

3.2. Features of the sources of evidence

An outline of the main aspects of eligible publications including publication details, study details, study setting and authors' affiliation is presented in Table 2.

3.3. Synthesis of results

Among the seven eligible publications, only two were not peer-reviewed as they belonged to conference proceedings, while five were peer-reviewed journal articles. Six papers were issued between 2014 and 2021 and one was published in 2010. All articles were written in English. Only one paper did not focus solely on the socioeconomic impact of EEL. In this paper, the socioeconomic effects of the disease were provided within the description of a community-based intervention to control and prevent EEL [46]. The majority of publications targeted individual species including horses (three papers) [47,48,50] and mules (two papers) [45,46]. Overall, considering the articles that covered multiple species, horses were the most represented species as they were studied in five publications [47,48,49,50,51], followed by mules, that were targeted by three publications [45,46,49]. Donkeys were mentioned only in one publication although their specificities in relation to the disease effects were not discussed [51].

Only one publication [42] applied a mixed method while four publications [47,48,49,50] were cross-sectional studies and two were participatory studies [46,51]. All studies were conducted in Ethiopia, a low-income country according to the World Bank classification [39]. The majority of papers (five) were written by researchers based in Ethiopia [45,47,48,49,50], while the remaining two publications had a mix of authors based in Ethiopia and in the United Kingdom [46,51]. Most of the publications (four) were written by authors belonging to Ethiopian academic institutions [47,48,49,50], two by authors belonging to a working equid charity [45,46] and one was published by a mixed team of academics and employees of a working equid charity [51].

3.4. Results of individual sources of evidence: the socioeconomic impact of equine epizootic lymphangitis

The eligible publications reported a series of factors that determined economic and social effects of EEL on working equid owners and their families, as summarised in Tables 3 and 4 respectively. Recommendations for research, policy and interventions provided by relevant publications are reported in Table 5.

4. Discussion

The results of this review show that, although there is a wide range of research reporting the severe effects of EEL on animal health and welfare [6,7,9,11,12], the socioeconomic impact of the disease in working equids in LMICs has been studied to a very limited extent. In fact, with exception of Ethiopia, where all the eligible studies were set and where the subject has been investigated to some degree, there is a complete lack of attention towards the consequences of EEL on the livelihoods and social assets of working equids' owners in other contexts where the disease is present.

4.1. Considerations on species targeted by eligible publications

Among the publications included in this review, horses were the most represented species. This may be linked to the perception that horses are the most severely affected by EEL compared to other equid species [6]. It also likely explains why mules were targeted by a more limited number of publications. However, this finding is in opposition to the high economic and social value attributed to mules in Ethiopia [30]. Similarly, also epidemiological studies published in Ethiopia initially privileged horses [5,14] above mules [12]. Attention towards the disease epidemiology in mules has arisen in recent years [8,53]. In contrast with what has been reported by Ameni [6], who believes that mules develop a lighter form of the disease and can survive longer after the symptoms appear, Bekele et al. [45] and Duguma et al. [46] reported that mules were affected by a very severe form of EEL with detrimental socioeconomic effects on the mules' owners. A study conducted by Molla et al. [49], that targeted both horses and mules, did not mention any species-specific differences in terms of disease severity and

Table 2
Main characteristics of the publications included in the review.

Publication details			Study details		Study setting and authors	
Author (year)	Publication source	Main focus	Species	Method used to appraise the socioeconomic impact of the disease	Country	Authors' affiliation
Bekele et al. (2014) [45]	Proceedings	Disease socioeconomic impact	Mule	Cross-sectional study; participatory method	Ethiopia	The Donkey Sanctuary
Duguma et al. (2021) [46]	Journal	Description of a community-based intervention	Mule	Participatory method	Ethiopia	The Donkey Sanctuary
Jagema and Jarso (2016) [47]	Journal	Disease epidemiology and socioeconomic impact	Horse	Cross-sectional study	Ethiopia	Addis Ababa University
Mitku et al. (2018) [48]	Journal	Disease epidemiology and socioeconomic impact	Horse	Cross-sectional study	Ethiopia	University of Gondar
Molla et al. (2021) [49]	Journal	Evaluation of owners' knowledge and management of a disease and its socioeconomic impact	Horse Mule	Cross-sectional study	Ethiopia	Mekidela Amba University; University of Gondar
Nigatu and Abebaw (2010) [50]	Proceedings	Disease socioeconomic impact	Horse	Cross-sectional study	Ethiopia	University of Addis Ababa
Scantlebury et al. (2015) [51]	Journal	Disease socioeconomic impact	Horse Donkey	Participatory method	Ethiopia	University of Liverpool; SPANA

Table 3
Determining factors of the economic impact of equine epizootic lymphangitis according to eligible publications[a].

Publication	Species	Determining factors	Economic impact
Bekele et al. (2014) [45]	Mule	- Decreased work productivity of affected animals - Reduced working hours - Decreased load capacity - Inability to work during latest stages of the disease - Animal death, abandonment and disease relapse due to ineffective and costly treatment	- Daily income reduced from 100 ETBs to 60 ETBs or income completely lost - Losses for treatment cost between 60 ETBs and 200 ETBs - Increased livelihood precarity
Duguma et al. (2021) [44]	Mule	- High treatment cost - Lack of effective treatment - High disease prevalence - Highly transmissible disease - High mortality	- Treatment losses reported as 1000 ETBs equal to 10% of the animal economic value - Animal loss (whole economic value)
Jagema and Jarso (2016) [47]	Horse	- Reduced working efficiency - Cost-ineffective feeding - Horse death - Abandonment of uncurable cases	- Animal loss equal to 1600 ETBs - Daily loss of 40 ETBs
Mitku et al. (2018) [48]	Horse	- Reduced working hours - Reduced traction power - Cost-ineffective feeding - Reduced clients' uptake due to visibly sick horses - High treatment cost and ineffective treatment - Inability to work with consequent animal abandonment - Animal death	- Decreased daily income by more than 50% - Animal loss (whole economic value)
Molla et al. (2021) [49]	Horse Mule	- Animal death - Loss of traction capacity due to decreased number of days worked - Costly treatment	- Average yearly loss per affected cart-owner: 9835.04 ETB (3304.32 ETB lost in traction power, 5081.22 ETBs lost for mortality, 1449.51 spent in treatment) - Daily income decreased by 67% - Transport expenses to search for veterinary assistance that can be also translated in losses for time off-work - Expenses for hiring replacement work force
Nigatu and Abebaw (2010) [50]	Horse	- Reduced work output - Loss of worked days - Reduced number of clients - High veterinary costs - Replacement of sick animals - Animal death	- Daily income nearly halved (46.1%), reduced from 55.30 ETBs to 29.80 ETBs - Weekly income more than halved, reduced from 337.30 ETBs to 131.10 ETBs - Estimated loss for 336 horses owned by study participants for 6.8 years based on time worked: 628,373.88 ETBs - Estimated loss for dead or euthanised animals: 279,568 ETBs - 200 ETBs charged for treatment
Scantlebury et al. (2015) [51]	Horse Donkey	- Decreased working capacity - Reduced hours worked - Reduced distance that the animal can walk - Decreased load capacity - Lowered number of clients because of animals' clinical status, bad smell and for welfare reasons - Animal abandonment - Unavailability of treatment	- Halved income - Livelihood is compromised - Animal loss and replacement cost

[a] The economic losses are expressed in Ethiopian birrs (ETBs). Difference in losses among years should take into account inflation [49]. According to the official exchange rate of the World Bank for 2020, 1 United States Dollar (USD) was equal to 34.93 ETBs [52].

socioeconomic impact. This may suggest that the disease affects both horses and mules to the same level. On the other hand, the absence of reflections on species-specificities represents a study limitation.

Considering the report from Powell et al. [10] on the severity of the disease in donkeys, the epidemiology and socioeconomic impact of EEL should be investigated in depth in this species. This would be particularly relevant in contexts with high populations of donkeys such as Ethiopia [54]. The only article by Scantlebury et al. [51] that included donkeys among the targeted population did not outline any specificities on the disease socioeconomic impact in donkeys, representing a limitation of this study. More research on the disease manifestations and socioeconomic impact in donkeys is needed also to make clarity on the different clinical and epidemiological reports previously made on the disease in donkeys. For example, in contrast with the severe cases

Table 4
Determining factors of the social impact of equine epizootic lymphangitis according to eligible publications.

Publication	Species	Determining factors	Social impact
Bekele et al. (2014) [45]	Mule	- Infectious nature of the disease - Poor animal's appearance - Bad smell of the skin - Economic losses	Owners' stigmatisation - Deterioration of living conditions
Duguma et al. (2021) [46]	Mule	- Presence of stray animals and their dead bodies on the streets	- Deterioration of city image - Increased number of road traffic accidents - Difficulties in waste removal
Jagema and Jarso (2016) [47]	Horse	Economic losses	Poverty
Mitku et al. (2018) [48]	Horse	Economic losses	Poverty and unemployment
Molla et al. (2021) [49]	Horse Mule	Not reported	Not reported
Nigatu and Abebaw (2010) [50]	Horse	Not reported	Not reported
Scantlebury et el. (2015) [51]	Horse Donkey	Economic losses	Poverty

Table 5
Recommendations provided by authors of eligible publications.

Publication	Recommendations for research	Recommendations for policy and interventions
Bekele et al. (2014) [45]	- Sustainable and affordable treatment - Preventive measures	Application of a participatory approach to prevention and control interventions
Duguma et al. (2021) [46]	- Epidemiological and socioeconomic studies to inform interventions - Gender-based research	- Participatory interventions to control the disease - Involvement of all relevant stakeholders within interventions - Multidisciplinary team to conduct interventions - Early project planning - Establishment of compensation or insurance measures to enforce culling - Education on animal welfare of government personnel involved in the transport sector - Incorporation of animal traction within governmental regulations for transport
Jagema and Jarso (2016) [47]	- Epidemiological studies - Vaccine development	- Government's involvement in disease control - Owners' education - Sensitisation of owners on euthanasia of advanced cases
Mitku et al. (2018) [48]	- Epidemiological studies - Ethnoveterinary medicine - Diagnostic tests - Cost-effective and easy-to-find treatment - Disease impact on animal welfare	- Coordination among stakeholders in control plans - Owners' education - Culling of infected animals
Molla et al. (2021) [49]	Not reported	- Development of disease control plans involving all concerned stakeholders - Education of owners - Support to extension services for owners' education
Nigatu and Abebaw (2010) [50]	Not reported	- Owners' education - Facilitated access to cost-effective treatment for private clinics and government vets - Coordination among stakeholders for the development of vaccines and control plans
Scantlebury et el. (2015) [51]	- Epidemiological studies - Participatory research to understand social context and owners' habits - Gender balance within participatory groups	- Owners' education - Application of the participatory approach to education and veterinary interventions

described by Powell et al. [10], Pal [55] observed a very mild disease in donkeys. On the other hand, a paper by Chaburte et al. [56] on the health and welfare issues of donkeys and horses in a region of Ethiopia reported no cases of EEL.

4.2. Ethiopia as the sole geographical setting

The geographical context presented in this review was biased against Ethiopia where all eligible papers were set. Research on the socioeconomic impact of EEL is particularly meaningful to the Ethiopian context where working equids are crucial to support people's livelihoods and the national economy [57,58]. In fact, a high disease prevalence has been recorded by several studies conducted in Ethiopia [5,8,12,14,15,53]. Moreover, although nearly all publications included in this review were published after 2014, the socioeconomic impact of EEL has been studied in Ethiopia since early 2000's in the unpublished theses by Siyoum [59], Zerfu [60], Abebaw [61] and Meles [62].

As an additional confirmation of the relevance of EEL in Ethiopia, the disease was rated by equid owners within the majority of publications as the most important and fatal disease affecting their animals, causing poverty and unemployment [46,47,50,51]. It should be highlighted that all the eligible publications were set in an urban context. Similarly, epidemiological data are mostly collected from urban settings [8,12,14,15,53]. This may be linked to the fact that in the urban environment working equids are often found in overcrowded stations where the transmission of the disease is facilitated [15]. However, data on disease epidemiology and socioeconomic impact from rural contexts should be collected to enable comparisons with urban settings.

4.3. Owners' knowledge on equine epizootic lymphangitis

Contrastingly to the owners' recognition of the relevance of EEL, the owners' knowledge on the disease reported within some of the eligible publications was lacking [51]. In fact, authors stated that it was not uncommon to observe sick and healthy horses stationing together and sharing harnesses [48], that is a favourable condition for the disease spread [5]. Moreover, a high disease prevalence was associated with harness-inflicted wounds and with the presence of flies [47], that are evidence of poor management practices. Similar findings on harness and flies were reported in epidemiological studies by Abdela et al. [20] and by Endebu and Roger [63] respectively. As opposed to the overall scarce knowledge of EEL recorded among eligible publications, 43% of owners interviewed by Mitku et al. [48] showed to be aware about the importance of early treatment. Nevertheless, Scantlebury et al. [51] reported a limited capacity of owners to identify EEL at its initial stages. Molla et al. [49] found a discrepancy between an overall acceptable understanding of risk factors and the high mortality rates. This was attributed to the limited application of good management practices for disease prevention because of economic constraints and challenges in isolating animals [49]. From these findings it emerges that there is an urgent need to improve owners' knowledge on EEL, especially in terms of disease prevention, and to allocate funds to promote good management practices that can reduce the disease spread [46,47,50].

4.4. The economic impact of equine epizootic lymphangitis

Although all publications were set in Ethiopia, the application of different calculation methods to determine the economic impact of EEL makes the comparison of quantitative data among publications unfeasible. This is also not possible because of discrepancies among years of publication and related inflation [49]. Because of these factors, intraspecific and interspecific considerations among publications related to the economic impact of EEL cannot be undertaken. Nevertheless, there is coherence between types of economic effects of EEL and their determining factors reported by authors as it can be seen in Table 3. In fact, in most cases economic losses were linked to animal death and reduced work performance of sick animals because of decreased number of hours worked and lowered load capacity. These conditions can be translated

into a lower income-generating ability, with detrimental effects on the living conditions of working equids' owners [45] and on their capacity to cover their basic needs like food consumption and access to health services. The situation is aggravated by the fact that other income-generating activities depending on working equids are affected, for example agricultural activities or transportation of items to sell at the market [1,64]. All these aspects compromise the survival capacity of the household and its ability to resist to future shocks since assets like livestock may be sold to guarantee access to cash for covering basic needs.

Duguma et al. [46] added that high disease prevalence and mortality and the infectious nature of EEL crucially contributed to its economic impact. Without referring to the quantitative figures, some general considerations on the level of losses determined by EEL can be undertaken. According to Bekele et al. [45], the average income generated by a sick animal was higher than half of the income generated by a healthy equid. This is in contrast with what has been found by the majority of authors of eligible publications, according to whom the income of a sick animal was less than half of the average income produced by a healthy animal [47,48,49,50]. These differences may be attributed to the availability of effective treatment in the area studied by Bekele et al. [45]. Nevertheless, in the same study 74% of owners reported disease relapse and 24% reported animal loss following treatment. Some authors observed that during the latest stages of the disease equids were totally unable to work [45,48], meaning that dependent households completely lost their income-generating capacity.

Expensive and ineffective treatments determined animal death, abandonment and disease reappearance [45,47,48], that induced owners to invest funds in replacing their animals [50]. According to Nigatu and Abebaw [50], only 30% of owners reported a positive outcome of treatment administered at local facilities. In a prevalence study on lameness in mules conducted by Ali et al. [65] it was estimated that the average cost of a mule was more than half of the average annual income in Ethiopia according to the World Bank. Even if such proportions may change over years, this information can give a general idea of the size of investment needed by a household in case of animal replacement. In some areas, owners have access to charity hospitals, where expensive and outsourced drugs are available for free [50]. However, the recovery depends on the disease stage at time of hospitalization [66,67]. Animal abandonment may promote the transmission of EEL [8] as stray animals walk freely around the streets with a multiplier effect on the economic consequences of the disease. Economic losses were also caused by the reluctancy of clients to hire sick animals [48]. This aspect had severe social implications on working equid owners [45].

4.5. The social impact of equine epizootic lymphangitis

The results of this review show that more attention is provided towards the disease economic effects than towards its social effects. Inclusion of social scientists within teams to undertake this type of research may facilitate understanding of the social impact of EEL and may provide in-depth reflections and additional perspectives on the subject. This is in line with what suggested by the authors of one eligible publication, according to whom future research could benefit from the engagement of multidisciplinary teams [46].

The social impact of the disease was determined by the stigmatisation of owners due to the contagious nature of EEL, the severe skin lesions, the emaciated appearance and bad smell of the animals [45]. Owners' isolation resulted in loss of motivation and mental health consequences [45]. The loss of economic assets may aggravate the mental wellbeing of equids' owners, as highlighted by a study on an outbreak of African horse sickness in South Africa [68]. Similarly, mental health consequences in farmers due to animal losses, especially in case of outbreaks of livestock diseases, have been described in Ghana [69]. These considerations show how the social impact of the disease, its economic effects and the health of working equid owners are highly interconnected.

Owners' stigmatisation related to animal diseases, and in particular diseases affecting working equids, has been given very limited attention within research compared to the social isolation determined by human diseases like HIV and Ebola that has been widely studied [70]. For example, stigmatisation has been reported in relation to working equids affected by equine infectious anaemia in Brazil [71]. The activities surrounding working equids, especially donkeys, and their owners are considered in many contexts as 'low status' [72]. The stigma determined by diseases such as EEL can aggravate the state of isolation of working equid owners, increasing their vulnerability. Because in the Ethiopian context it is difficult to change profession or to obtain a loan to replace animals, the livelihood of equids' owners become extremely precarious [45]. The situation initiates a poverty cycle that it is difficult to interrupt [47,51], making these communities even more isolated. For this reason, more attention should be given within research to the social implications of working equid diseases. Such research may have a positive impact on highlighting the importance to include measures to mitigate the social isolation of working equids' owners within interventions targeting working equids.

Other social implications affecting the community rather than individual owners that emerged from the review were linked to the presence of sick stray animals wandering on the streets. These animals were reported to damaging the image of cities, causing road traffic accidents especially overnight and creating difficulties for the waste collectors in removing animal carcasses [46]. These aspects may also have economic implications by affecting the Ethiopian tourism sector, that before the pandemic contributed to the 6.3% of the total economy [73]. The effects of the presence of stray animals on tourism should not be underestimated. A study conducted in Bhutan showed that the stray dog population affects the image that tourists gain about the country, causing potentially a negative impact on the tourism industry [74]. These considerations represent another example of the complex interconnections between the disease, the economy, the society and the environment where working equids and their owners live.

4.6. Recommendations for research

Authors of eligible publications recommended that research is undertaken to develop vaccines [47] and to identify affordable treatments that could be available in private and government clinics [45,48]. These recommendations are in line with those made by Ameni and Terefe [12], Ameni [5] and Pal [56]. A cost benefit analysis for vaccines like the one conducted for African horse sickness by Redmond et al. [75] could enhance sensitisation of donors in investing funds on research to develop an effective and affordable vaccine against EEL. Furthermore, Mitku et al. [48] highlighted the need to conduct research on ethnoveterinary treatments. This is also recommended by Abdisa [76] as a sustainable treatment option since traditional knowledge on plants is already available within communities. Some research has already demonstrated the potential of plants for the treatment of EEL [77,78,79] but the subject still needs to be further studied. Nevertheless, it should be highlighted that Scantlebury et al. [51] identified welfare-threatening traditional practices related to EEL such as firing nodules and application of kerosene as fly repellent, that were considered ineffective also by the community.

In terms of research, various authors recommended to conduct more epidemiological studies on EEL [46,47,48,51]. While these authors referred to the Ethiopian context, more studies are also needed to understand the epidemiology and the socioeconomic impact of EEL in other LMICs where the disease has been reported such as Iraq [22], Sudan [26], Senegal and South Africa [27]. However, the disease may be highly underreported in other contexts. For example, while various epidemiological studies were published in Ethiopia [17,20], no reports are displayed on the World Animal Health Information System [27], in

line with the widespread lack of surveillance of working equid diseases [80]. For this reason, favourable climatic conditions of increased humidity, reduced rainfall and warmer temperature [20] should be considered for targeting locations for future studies. Research on how climate change may affect the disease epidemiology should be undertaken.

According to Mitku et al. [48], the impact of EEL on animal welfare should be targeted by research. In fact, very concerning findings related to animal welfare emerged from eligible publications. These issues were directly linked to the economic impact of the disease and to the role of working equids as economic assets. According to Ameni [5], equids were exploited until they could no longer work. Moreover, they were abandoned since owners thought it was not cost-effective to feed or treat them [5,47,48]. Animal abandonment represents a severe threat to animal welfare since animals, especially in advanced stages, do not have access to food, veterinary care or to humane euthanasia [5]. Similar findings were reported by Meselu et al. [8] as 34% of the owners they interviewed did not provide rest to sick mules. According to these authors, this may result in a depleted immunity and aggravate the lesions.

In 2006, Ameni [5] observed that, regardless of the availability of epidemiological data, the research results seem to have a poor uptake by veterinary services since their action against EEL was quite limited in Ethiopia at that time. Although since 2006 further research has been published in Ethiopia on epidemiology and health economics of EEL, the situation in terms of prevention and control does not seem to have changed. More attention should be given by concerned stakeholders to EEL [48]. For this reason, the application of the One Health approach to future research is recommended as it may enhance the translation of research into policy. The One Health approach is intended as a transdisciplinary method that highlights the interdependencies between the health of humans, animals and the environment [80]. To achieve an in-depth knowledge of such interconnections, the One Health approach promotes the integration of different disciplines, from social sciences to natural sciences and it incorporates non-academic knowledge such as indigenous knowledge [81,82]. This transdisciplinary approach may facilitate the clarification of the complex implications of EEL and the links between equid health and welfare and the livelihoods of vulnerable communities. The One Health approach may promote a better understanding of the impact of EEL on human health including mental health. In line with the transdisciplinary method, the integration of social scientists within research teams could improve the knowledge on the social effects of the disease.

A participatory approach to research is also recommended to ensure that the community viewpoint on EEL is acquired in detail [51]. This method has been effectively and widely used in LMICs to gain the communities' perspective on issues related to animal health [83]. Participatory research can improve the understanding of owners' knowledge on the disease and its management practices [51] including indigenous knowledge on ethnoveterinary medicine. This information could inform further research on natural remedies. Comprehension of owners' knowledge on EEL could enable to design more specific interventions aimed at addressing knowledge gaps related to the disease since many risk factors of EEL can be prevented by owners' education [48].

4.7. Recommendations for interventions

Regarding recommendations for interventions, the importance of education was underlined by several authors as presented in Table 5. Duguma et al. [46] suggested that education programmes should target both owners and stakeholders of the working equid sector. Sensitisation of owners on early hospital presentation, sustainable harness, disease transmission, animal welfare, fly control were highlighted as the most relevant topics for education projects [47,48]. Similar recommendations were provided in an epidemiological study conducted in Ethiopia by Meselu et al. [8].

Among the preventive measures, humane euthanasia of sick animals was recommended to reduce the spread of the infection and to prevent horse abandonment [47,48]. While Jones [66] believes that a culling policy would not be sustainable because of endemicity and economic constraints, Duguma et al. [46] recommended to establish a compensation system. Several authors indicated participatory interventions for sustainable disease control and prevention. The need for involvement of all stakeholders from non-governmental organisations, governments, communities and universities was a recurrent theme proposed by several authors [45,48,50,51]. Among effective participatory interventions, the one implemented by Duguma et al. [46] resulted in a considerable decrease in disease prevalence, with a positive outcome on both animal and human welfare. A participatory approach to the control of EEL was also implemented successfully in Ethiopia by Worku et al. [67].

4.8. Study limitations

Because of time limitations, non-peer reviewed literature was not systematically screened in any of the eligible languages. This process may have retrieved additional publications, especially from non-English speaking contexts [40]. National journals that are not indexed by international databases were not searched. Considering that two papers published by national journals were identified through backward citation searching, systematic screening of national journals from LMICs may have sourced additional relevant papers [84]. It is encouraged to screen national journals and non-peer reviewed literature within future studies. Unpublished theses on the socioeconomic impact of EEL that were identified through backward citation searching were not requested to their authors. This was partly due to lack of time, but also because of discordant views on the matter. While Paez [85] supports the contribution of theses in adding evidence to a review, Hartling et al. [41] do not recommend this practice.

5. Conclusions

This review shows that available research on the socioeconomic impact of EEL is scarce and focuses only on Ethiopia. From the eligible publications it emerges that EEL has very severe effects on animal welfare and on the livelihood and social inclusion of households who depend on working equids. In conclusion, up-to-date epidemiological information is highly needed to inform studies on the socioeconomic impact of EEL in contexts where the disease has been previously reported and where there are the optimal climatic conditions for the disease to be widespread. Information is also needed from contexts with high working equid populations. Considering previous reports on EEL in donkeys, data on epidemiology and symptoms of the disease in donkeys is needed, especially from Ethiopia, where the donkey population is the highest in the world [54]. This information also represents the basis to better understand the socioeconomic impact of EEL in donkeys. Gender-based research on the socioeconomic impact of the disease is required from settings where working equids - donkeys in particular - have a crucial role in reducing the work burden on women.

The application of the One Health approach to future research is recommended to highlight the implications of EEL on animal welfare, human health, livelihoods and the environment. The transdisciplinary approach can also improve the understanding of the social impact of the disease. By looking at the complex issue of EEL through the One Health lens, policymakers, especially within governments and international organisations in LMICs, may be positively influenced on the need to invest resources for improving disease surveillance, developing affordable treatments and vaccines and for implementing programmes to prevent and control EEL. Ethnoveterinary research should be promoted as it could provide cheap and readily available treatment options.

Participatory programmes with a strong education component are recommended to improve prevention and control of EEL as successful stories have been reported. These programmes should incorporate

mitigation measures to prevent the stigmatisation of owners whose animals are affected by EEL. Tackling the issue of EEL would improve dramatically health and welfare of working equids, besides securing the livelihoods of vulnerable communities. It would also have a positive impact on preserving the mental health of working equid owners and on preventing their social exclusion in addition to protecting the image of cities.

Ethical statement

The authors Marta Bonsi, Neil Euan Anderson and Gemma Carder declare that the manuscript does not contain clinical studies or patient data.

CRediT authorship contribution statement

Marta Bonsi: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Neil Euan Anderson:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Gemma Carder:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors Marta Bonsi, Neil Euan Anderson and Gemma Carder declare that they have no conflicts of interest.

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Supplementary materials

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