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Elephant tourism: An analysis and recommendations for public health, safety, and animal welfare

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Abstract

Background: Elephants are exploited for public entertainment tourism throughout Asia and Africa. Areas of concern include public health and safety and animal welfare.

Materials and Methods: We examined over 500 scientific publications with respect to our primary objectives, as well as non-peer-reviewed materials relating to other relevant subject matters (e.g., tourism promotional websites and YouTube films) for background purposes, although these additional materials were not included in this review.

Results: We identified at least 12 confirmed or potential zoonotic and other transmissible infections relevant to the elephant tourism sector, and at least 13 areas of animal welfare concern.

Conclusion: Infection and injury risks between humans and captive elephants cannot be safely controlled where close contact experiences are involved, arguably creating an unredeemable and indefensible public health and safety situation. Elephant welfare within some sectors of the close contact interactive tourism industry continues to involve significant mistreatment and abuse. To alleviate key One Health concerns outlined in this study, we recommend several types of regulation, monitoring, and control regarding interactions at the human-captive elephant interface. These include legal bans on the promotion and performance of close contact experiences, combined with strong enforcement protocols; new policies toward discouraging elephant tourism; 24/7 surveillance of captive elephants; and the adoption of independent scientific positive list systems for tourism promoters or providers regarding public observation of free-ranging elephants within national parks and protected areas.

Keywords: animal welfare, elephant tourism, One Health, public health, safety, zoonoses.

Introduction

Elephants are exploited for public entertainment tourism throughout Asia (*Elephas maximus*) [1] and Africa (*Loxodonta africana* and *Loxodonta cyclotis*) [2]. In Asia, notably Thailand and India, elephant tourism involves various human-elephant interactions and degrees thereof [1, 3–7]. These interactions may essentially be characterized as: observational (e.g., elephants viewed only whether or not manifesting any particular activity); low-level interactions (e.g., elephant feeding and trunk touching); or high-level interactions (e.g., elephant riding, assisted skin scrubbing, and assisted bathing). While members of the public may be able to experience some or all of these events, elephant managers or "mahouts," regularly experience all such events [1, 3–7]. In Africa, elephant tourism is relatively limited to ecotourism, where the public observe free-ranging animals, or experience either guided rides within national parks or interactive experiences at rescue and rehabilitation centers [1, 4, 7–9]. The frequent and brutal illegal killing of African elephants for the ivory market has been blamed for negatively affecting ecotourism by dramatically reducing or eliminating wild populations, and thus the viability of the sector [2, 10]. More recently, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)/Coronavirus disease 2019 (COVID-19) pandemic also reduced human-elephant tourism and consequently impacted the sector [6].

While both Asian and African contexts involve observational, low-level interactive, and high-level interactive events, there are different emphases between the two regions. In Asia, elephant tourism is substantively associated with direct and indirect elephant-centered interactive entertainment – attracting primarily animal welfare and public health and safety concerns, but also species conservation concerns [6, 10, 11]. In Africa, elephant tourism is substantively associated with free-range elephant ecotours, killing of elephants for related bioproducts and linked to substantial economic losses from population declines affecting tourism, and increasing species conservation threats [2, 10]; and to perhaps a lesser extent, at least within the literature, animal welfare and public health and safety concerns. Threats to species conservation arising from killing and habitat loss affecting both Asian and African elephants are increasingly noted [2, 10, 11]. This article is broadly relevant to situations affecting both Asian and African elephants in the captive animal tourism sector.

Public health issues and concerns are endemic to elephant tourism. Numerous elephant-to-human zoonoses (notably tuberculosis [TB]) and other transmissible infectious agents are documented as confirmed or potential threats to public health [12–41]. Elephants are also susceptible to reverse human zoonoses – infections transmissible from humans to elephants, notably TB [42–44], with varying degrees from low to high morbidities and mortalities affecting both elephants and humans.

The term "zoonoses" is commonly used to describe diseases that are transmissible between animals and people. There are over 200 zoonoses that range widely across pathogen classes, including bacteria, viruses, fungi, parasites, and prions [45–47]. Approximately 61% of human diseases are considered to be potentially zoonotic in origin [48]. Of the global emerging human diseases, around 75% generally have links to wild animals [49]. Accordingly, the association between pathogens occurring in wildlife and those in, or merging with, humans is well established. In addition, numerous captive elephant-to-human injuries and fatalities are also increasingly documented [50–54]. These injuries are mostly reported in the general media rather than within scientific documents and require a dedicated study of formalized public records, which was beyond the scope of the present article; thus, this issue is minimally discussed.

Although public health issues form the focus of this study, animal welfare is or should be, a powerful driver of any policy where humans have managemental responsibility over other species [55–57]. Both the treatment and well-being of elephants for tourism are increasingly raised as issues of concern [1, 5, 6, 10, 58, 59]. Audiovisual materials have been presented by the animal welfare campaigning sector regarding human-to-elephant physical and mental abuse in tourism, such as injurious handling, forced confinement, and social deprivation [60–62]. These campaigns broadly call for action to prohibit high-level interactive entertainment and limit tourism to the low-level observational engagement of free-living elephants. The scientific community has also provided numerous studies that similarly report and broadly justify the concerns of animal welfare campaigners [1, 4, 7, 63].

Psychobehavioral damage to elephants from abuse or transmission of elephant-associated human pathogens and disease (which may be exacerbated by stress-related immunosuppression in animals) is a relevant consideration potentially affecting public health and safety. As for other captive animals, elephants that are subjected to poor or stress-inducing treatment may present increased risks to public health and safety within somewhat circular causes and effects. Such implications in disease transmission emphasize the importance of the one health paradigm, which considers the environment, animals, and people interconnectedly [64–67].

Elephants are held captive in several world regions, for example, in zoos – which are arguably also confined for tourism reasons. However, within Western nations, greater frameworks exist that offer some foundation for protecting public health and safety and animal welfare compared with Asia and Africa [68–71]. Accordingly, for this study, elephant tourism refers primarily to *in situ* human-elephant contact or informational experiences as entertainment that occur in captivity or related managed conditions and involve such activities as rides, photo opportunities, petting experiences, and feeding sessions in Asia and Africa [72, 73].

This study aims to review information regarding captive elephants used for tourism, with regard to key public health issues, as well as associated animal welfare considerations relevant to a one health context, and offers recommendations for alleviating key concerns.

Materials and Methods

Ethical approval

Ethical approval was not needed for this study.

Databases search criteria

The literature was systematically searched using Google Scholar and PubMed for studies published from 2000 to 2023 (Box-1 & Figure-1).

Inclusion and exclusion criteria

Items were included based on search terms and subsequently screened for relevance (Box-1 & Figure-1). Further articles were supplemented from the authors' libraries. Studies were excluded based on low relevance, for example, where focused on subjects such as pathogen serotyping methodologies, highly specific veterinary treatment protocols, individual animal and small number case studies with no apparently relevant content, general discussions on human-wildlife conflicts, narrow welfare remits, and older reviews for which contents are repeated in more recent papers, and studies regarding zoo elephants.

Additional assessment

We used the zoonoplasticity algorithm [74] as an additional guidance tool to provide a basic assessment

Box-1: Search terms.

(Loxodonta OR Elephas) "public health"
(Loxodonta OR Elephas) tourist*
(Loxodonta OR Elephas) welfare
(Loxodonta OR Elephas) zoonos*
(Loxodonta OR Elephas) safety
(Loxodonta OR Elephas) "human injury"

(Loxodonta OR Elephas) (Leptospirosis OR anthrax OR tuberculosis OR Cowpox virus OR Cryptosporidiosis OR *Escherichia coli* infection OR Helminthiasis OR Pasteurellosis OR Plague OR Rabies or Salmonellosis OR Toxoplasmosis)

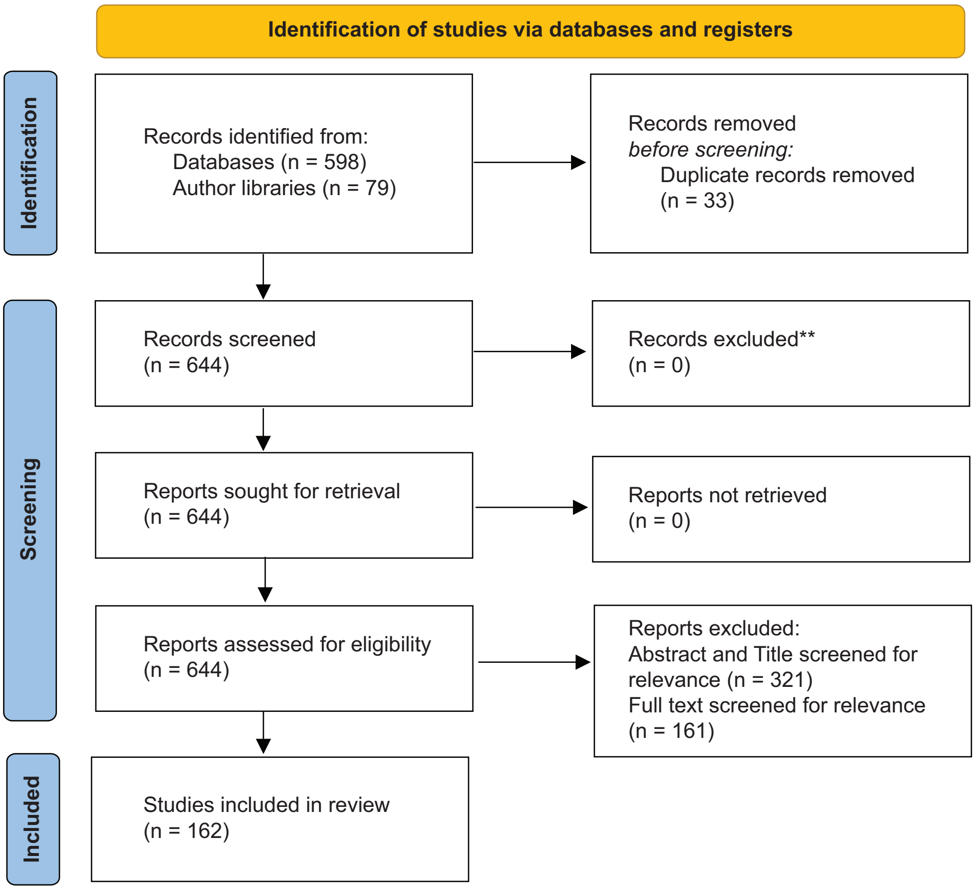

Figure-1: Search results based on PRISMA. Source: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. (2021) The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372(71). doi: 10.1136/bmj.n71

regarding the elephant-human interface and related potential pathogens and risk factors. The algorithm applies a two-tier assessment system: Tier 1 involves a species- and management-based questionnaire evaluation that provides a risk score (applicable range 10–35+ points) and rating (range Low, Moderate, High, and Very high); Tier 2 involves a pathogen- or disease-based questionnaire evaluation that provides risk score (applicable score range 10–50+ points) and rating (range Low, Moderate, High, and Very high).

Results

A total of 598 peer-reviewed studies were identified during the searches. Following the exclusion of studies, 83 publications were identified and included that involved primary associations with elephant tourism, public health and safety, and animal health and welfare. Of these publications, 43 were authored or coauthored by regional experts in Asia or Africa.

Public health and safety

Elephant-to-human zoonoses and other diseases

Based on the literature reviewed, Table-1 [12–36, 38–41, 44, 75–88] summarizes confirmed and potential elephant zoonoses and anthropozoonoses, or reverse zoonoses. These elements are ordered by pathogen class and then alphabetically by disease, based on reported associations between potential pathogens of elephants, humans, and other animals. While numerous confirmed and potential zoonotic and reverse-zoonotic pathogens have been established in the literature, there is a paucity of specific data regarding both the incidence and prevalence of, in particular, diseases shared at the elephant-human interface. Direct zoonotic associations (e.g., elephants infecting humans and *vice versa*) may not be recorded in the reviewed literature. All listed pathogens are confirmed zoonotic in mammals and, thus, involve a potential risk of elephant-to-human or human-to-elephant infection. Accordingly, we have adopted precautionary and preventative approaches in our analysis of pathogens and diseases.

Below are further descriptions relevant to potential pathogens and diseases listed in Table-1, which are sorted by pathogen class and then alphabetically by disease, rather than prevalence or importance.

Bacterial pathogens and diseases

Anthrax

Anthrax is a disease caused by the pathogen *Bacillus anthracis*. In humans, the infection results in cutaneous, pulmonary, flu-like, gastrointestinal signs or symptoms, fever, malaise, hemorrhage, meningitis, sepsis, or death. In elephants, infection is similar to other animals and results in hemorrhage, splenomegaly, swollen lymph nodes, edema, septicemia, and

Table-1: Confirmed and potential elephant zoonoses or anthropozoonosis (ordered by pathogen class and alphabetically by disease).

Pathogen type	Pathogen	Disease	Example signs and symptoms	Zoonoses/ reverse	References
Bacterial	*Bacillus anthracis* (Asian and African elephant species)	Anthrax	Cutaneous, pulmonary, flu-like, gastrointestinal, fever, malaise, hemorrhage, meningitis, sepsis, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[16, 17, 26, 29, 75]
	Clostridium spp.	Clostridium infection	Gastrointestinal, malaise, fever, muscle spasm, tetany, convulsions, respiratory paralysis, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[12, 24, 30]
	Escherichia coli (African elephant species)	*Escherichia coli* infection	Gastrointestinal, malaise, fever, death	E-H (potential) E-OA (potential OA-E (confirmed) H-E (potential)	[21, 30, 76]
	Aerococcus viridans (African elephant species)	Gaffkemia	Arthritis, bacteremia, endocarditis, malaise, meningitis, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[27, 36]
	Leptospira interrogans (Asian elephant species)	Leptospirosis	fever, anorexia, malaise, muscle pain, renal or liver failure, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[30, 31, 77]
	Pasteurella multocida (Asian and African elephant species)	Pasteurellosis/ hemorrhagic septicemia	Malaise, fever, anorexia, inflamed mucous membranes, swellings, pain, pneumonia, hemorrhage, septicemia, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[19, 78–81]
	Salmonella spp. (Asian and African elephant species)	Salmonellosis	Gastrointestinal, fever, anorexia, malaise, weight loss, pain, septicemia, meningitis, death	E-H (confirmed) E-OA (confirmed) OA-E (confirmed) *H-E* (potential)	[12, 30, 34]
	Mycobacterium tuberculosis (potentially *Mycobacterium bovis; Mycobacterium avium, Mycobacterium elephantis*) (Asian and African elephant species)	Tuberculosis	Respiratory, pneumonia, malaise, fever, systemic dispersed disease, pain, death	E-H (confirmed) E-OA (potential) OA-E (potential) H-E (confirmed)	[20, 22, 25, 35, 40, 41, 44]
Viral	*Orthopoxvirus* spp. (Asian and African elephant species)	Elephant pox virus infection	Dermal lesions, mucous membrane lesions, conjunctivitis, fever, systemic disease, death	E-H (confirmed) E-OA (potential) OA-E (confirmed) H-E (potential)	[12–15, 30, 38, 82]
Parasitic	*Cryptosporidium* spp. (Asian and African elephant species)	Cryptosporidiosis	Gastrointestinal, fever, weight loss, pain, anorexia, malaise, septicemia, meningitis, death	E-H (potential) E-OA (potential) OA-E (confirmed) H-E (potential)	[18, 33, 83]
	Oesophagostomum aculeatum (Asian and African elephant species)	Helminthiasis	Gastrointestinal, cardio-respiratory, malaise, anorexia, weight loss, pain, fever, systemic disease, death	E-H (potential) E-OA (confirmed) OA-E (confirmed) H-E (potential)	[30, 84–86]
	Toxoplasma gondii (Asian and African elephant species)	Toxoplasmosis	Gastrointestinal, malaise, anorexia, weight loss, pain, fever, systemic disease, death	E-H (potential) E-OA (potential) OA-E (potential) H-E (potential)	[23, 28, 32, 39, 88]

E-H=Elephant-to-human, E-OA=Elephant-to-other animal, OA-E=Other animal-to-elephant, H-E=Human-to-elephant

death, although some animals may be asymptomatic before death. Non-specific symptoms in elephants may also include subcutaneous swellings, excessive bloating, incomplete rigor mortis, and rapid decomposition of carcasses [16, 17]. Infection may be spread in particular through contact with open skin lesions, and to a lesser extent by the ingestion of spore-contaminated vegetation or soil, the inhalation of airborne particulate matter, such as moisture droplets and dust (although the risk from dust, e.g., associated with dust bathing animals may be minimal) [26, 75], and the consumption of bushmeat [17]. Despite having a long history with both wildlife and human diseases, much is unknown about the incidence or prevalence of anthrax generally and specifically regarding the elephant-human interface [17]. However, large outbreaks of anthrax have been reported involving 10,000 people in Zimbabwe and many cases elsewhere, for example, in Bangladesh [89–91]. Globally, the case incidence of human anthrax is estimated at 20,000–100,000 [92].

Clostridium infection

Clostridium infection is a major global disease caused by *Clostridium difficile*. In humans, the infection results in gastrointestinal signs and symptoms, malaise, fever, muscle spasm, tetany, convulsions, respiratory paralysis, or death and is transmitted through fomite, direct contact and ingestion of contaminated food, and fecal-oral routes [24, 30, 93, 94]. In elephants, the infection results in gastrointestinal signs that may proceed to fatal enterocolitis, and typical post-mortem findings in elephants include necrohemorrhagic and ulcerative enteritis [95]. The emergence of this frequently commensal organism as a major pathogen may stem in part from antimicrobial overuse, agricultural practices, and other factors, giving rise to subsequent resistant proliferation [24]. Little is known regarding the prevalence or transmission of clostridium in elephants or at the elephant-human interface. However, elephants may harbor the organism, and the actual transmission between elephants and humans constitutes an occupational risk [12, 24].

Escherichia coli infection

Escherichia coli infection is caused by *E. coli*, a frequently occurring commensal gut microbe, and pathogenically opportunistic organism commonly found in soil and water [76]. One study found that 100% of elephants in human entertainment activities in Asia harbored the bacteria [96]. *Escherichia coli* is often transmitted through fomite, contaminated food, and fecal-oral routes. In humans, pathogenic infections result in gastrointestinal signs and symptoms, malaise, fever, and sometimes death [21, 30, 76]. In elephants, the infection results in gastrointestinal signs, septicemia, and sometimes death [21]. There is little documentation of the incidence or prevalence of *E. coli* infection between elephants and humans, although cross-infection is presumed [30].

Gaffkemia

Gaffkemia is an emerging yet rare disease caused by *Aerococcus viridian*. In humans, the infection results in genitourinary issues, arthritis, bacteremia, endocarditis, and meningitis [27, 36]. In elephants, the infection results in genitourinary signs [36]. Transmission is likely through fomite, contaminated food, and fecal-oral routes [27, 36]. Little is known regarding this pathogen and any direct association between elephants and humans, although both are susceptible to infection with the microorganism.

Leptospirosis

Leptospirosis is a globally important disease caused by *Leptospira interrogans*. In humans, the infection results in various signs and symptoms, including fever, anorexia, malaise, muscle pain, renal failure, hepatic failure, or death [77, 97]. In elephants, individuals are commonly asymptomatic, but they may act as carriers for transmission [31, 98]. A study of 11 elephants sampled for *L. interrogans* in Thailand found a prevalence rate of 57%, indicating frequent exposure of these animals to the potential pathogen [97]. While elephants may harbor *L. interrogans*, they are not clearly implicated in human disease [97]. However, a recent study of environments shared between elephants and humans in Thailand concluded that *L. interrogans* contamination may pose a potential risk to elephant camp tourists and workers [31]. Transmission is through contaminated urine, surface water, mud, and sewerage overspills, which may introduce the microorganism to its host through open dermal lesions, conjunctiva, genital tract, mucous membranes, lungs, or ingestion [77, 97].

Pasteurellosis (hemorrhagic fever)

Pasteurellosis is a globally important disease caused by *Pasteurella* spp. In humans, the infection results in malaise, fever, anorexia, inflamed mucous membranes, swellings, pain, pneumonia, hemorrhage, septicemia, or death [78, 99]. In elephants, the infection results in respiratory distress, frothy discharge from the trunk, shivering, fever, and sub-mandibular edema [19, 81]. One study showed hemorrhagic tracheitis, hemorrhages in the heart, and septicemia of the major organs [99]. *Pasteurella* spp. occur in diverse environments, including moist soil, and are frequently commensal to nasopharyngeal and other respiratory tract cavities in animals [78, 99]. Pathogens are transmitted through fomites and direct contact routes [78, 99]. While transmission of *Pasteurella* spp. from various animals to humans is well documented, very little is known regarding the elephant-to-human (or *vice versa*) relationship, although there are no strong grounds to presume that infection between elephants and people may not occur.

Salmonellosis

Salmonellosis is a disease caused by microbial organisms of the genus *Salmonella*. In humans, the infection typically results in relatively limited gastrointestinal signs and symptoms, anorexia, malaise, weight loss, and pain, but in serious cases also may also cause severe systemic disease, septicemia, meningitis, or death [12, 30, 100, 101]. In elephants, the infection results in lethargy, loss of appetite, hemorrhagic diarrhea, colic, and suspected abdominal discomfort/pain [34]. *Salmonella* spp. is a very large and diverse family of highly durable microorganisms, commonly found in many environments in soil, water, aerosolized particles, and animals [100, 101]. As for other species, *Salmonella* is a common commensal microbe, and one study found that 8% of elephants in human entertainment activities in Asia harbored the bacteria [96], which can also be regarded as an opportunistic pathogen [12, 30, 34]. Another study found a low prevalence of *Salmonella* in the feces of healthy elephants [102]. The microbe is transmitted diversely through fomite transfer, direct contact with open lesions, and ingestion. *Salmonella* zoonoses can be considered a reasonably ubiquitous yet mostly mild to moderate cross-species risk.

Mycobacteriosis (TB)

Mycobacteriosis, or TB, is the current primary disease of concern regarding the elephant-human relationship and is one of the world's most significant diseases. Tuberculosis is caused by microbial organisms of the genus *Mycobacterium* spp. and includes two common types, *Mycobacterium tuberculosis* – the typical human infectious agent, and *Mycobacterium bovis* – the typical bovine infectious agent. However, whereas *M. tuberculosis* is classically associated with human TB, both types may infect humans. Tuberculosis occurs in both wild and captive Asian and African elephants, has a complex transmission modality and several elements remain unclear [43, 103]. Tuberculosis is typically transmissible from one individual to another through airborne droplets following expulsions, for example, sneezing, coughing, close contact respiration, or vocalization [103–105].

In humans, signs and symptoms of TB include fever, coughing, sneezing, pneumonia, breathlessness, malaise, fever, loss of body condition, systemic disease, pain, or death [104, 105]. Pathological findings may include localized focal or dispersed granulomas of sterile or non-sterile nature, diffuse exudate, and necrosis [103]. Although the disease usually invades the lungs, various body areas may be affected. The disease can be treated and cured using antibiotics and other therapies in the early stages, but chronic infection may result in treatable yet incurable states involving persistent or recurrent illness due to often slow onset, and cyclic active and inactive stages of the disease [106]. At later stages, treatment may necessarily be radical and involve major surgery, with varying degrees of success. Tuberculosis can affect all age groups, although people with underlying diseases, such as human immunodeficiency virus infection and other immune conditions and extant respiratory problems, as well as the elderly, are at increased susceptibility to infection and symptomology [103, 106]. Globally, approximately 10 million people become ill with TB annually, and approximately 1.5–1.8 million die from the disease, a mortality rate of 15–18% [106, 107]. Accounting for novel, persistent, and recurrent cases, approximately 1.8–2 billion people harbor the infection worldwide [105]. Bovine-to-human TB infections are relatively small, accounting for <2% of all TB cases [103, 108]. Essentially, TB is a predominantly human disease and the leading cause of global human infection-related mortality.

Tuberculosis and elephants

Although captive elephants in zoos, circuses, and tourism are frequently associated with TB [46, 109], as well as free-ranging Asian and African elephants [43, 110], the presence of TB in these animals may result from original human-to-elephant contamination [37, 109, 111]. In elephants, as in humans, signs of TB include fever, coughing, sneezing, pneumonia, breathlessness, malaise, fever, loss of body condition, systemic disease, pain, or death [104, 105]. TB among captive elephant populations is investigated using several methodologies, for example, blood serum sampling and lateral flow serological testing [112] and/or collection of material through trunk washing, culture, and PCR testing [113]. However, current methodologies are limited, and infection rates in populations are difficult to quantify conclusively [114, 115]. One study, using blood serum sampling of approximately 600 captive Asian elephants found a positive TB prevalence rate of 16% [112], and another study, also using serology, found 23% in a captive population [22]. Trunk wash testing of captive Malaysian elephants found a 20% prevalence rate [116]. Despite data limitations, such prevalence rates indicate the importance of TB among elephant populations, not only for their own health but also as a reservoir of potential human and wild elephant epidemics with implications for species conservation in the latter.

Viral pathogens and diseases

Elephant pox virus

Elephant pox virus is a disease caused by a group of orthopoxviruses that are similarly responsible for smallpox, cowpox, monkeypox, and other infections [12, 14, 15, 38, 82, 117, 118]. In humans, the infection results in dermal and mucous membranous signs and symptoms, fever, systemic disease, or death [12, 15, 30]. In elephants, the infection results in disseminated dermal ulceration, mucosal membrane lesions, tongue lesions, debilitation, or death [82]. Transmission can occur through bites, direct contact, and aerosolized particle routes [12, 15, 30]. Little is known regarding the prevalence of the pox virus in elephants. However, the diversity, geographic distribution, and adaptability of orthopoxviruses in general and the range of animal species involved lead them to be considered one of the world's most significant potential epidemic and pandemic threats to both animals and people [38]. The latest pandemic concern monkeypox [119] exemplifies the nature of orthopoxviruses and has been declared as a public health emergency of international concern [120].

Parasitic pathogens and diseases

Cryptosporidiosis

Cryptosporidiosis is a disease caused by a range of *Cryptosporidium* spp. microparasites. In humans, the infection results in gastrointestinal signs and symptoms, fever, malaise, anorexia, weight loss, pain, septicemia, meningitis, or death [121, 122]. There is little information regarding the disease in elephants, but signs of infection might be presumed to reflect those observed in humans and other animals. *Cryptosporidium* spp. is commonly found in many environments, including soil, water, and animals [121, 122], and over 25% of African elephants may harbor the organism [123]; thus, individuals may be asymptomatic carriers. Transmission occurs through ingestion of contaminated water, fomite transfer, and fecal-oral ingestion [121, 122]. The parasites are widely present across various species, including elephants and humans, and geographical regions [18, 83]. Cryptosporidiosis is an emerging zoonotic infection, increasingly reported across species and regions [33].

Helminthiasis

Helminthiasis refers to several pathogenic parasitic infections or infestations caused by a wide range of invasive macroscopic worms [86, 124]. The infection results in widely varied signs and symptoms in humans, including gastrointestinal, cardio-respiratory, malaise, anorexia, weight loss, fever, systemic disease, or death [30, 85, 86]. In elephants, individuals may be asymptomatic carriers, but infection results in debilitating gastrointestinal conditions [86]. Helminth parasites are extremely common in wild and captive animals, with 96% prevalence being found in some African elephant populations [86]. Many helminths have complex lifecycles, meaning that diverse transmission routes may be involved, although frequently these include fomite, fecal-oral, food, water, and soil [30, 85, 86].

Toxoplasmosis

Toxoplasmosis is a disease caused by *Toxoplasma gondii* and occurs widely in animals and humans [28, 39, 87, 88]. In humans, the infection results in a range of signs and symptoms, including gastrointestinal, malaise, anorexia, weight loss, pain, fever, systemic disease, or death, and transmission is characteristically fecal-oral, through contaminated soil, or fomites [28, 39, 87, 88]. In elephants, individuals may be asymptomatic carriers, but infection may result in debilitating gastrointestinal and systemic disease conditions [125]. Relatively little is known regarding disease incidence or prevalence [23, 32], although one study found antibodies in 45.5% of Asian elephants, indicating that animals had, at some point, been exposed to the pathogen [125]. Another study also showed widespread exposure but with no determination regarding the source of infection [39].

Public health and safety summary

Because detailed data on public health at the elephant-human interface in tourism are lacking, an evaluation of risk was conducted both for elephants as a species as well as the 12 pathogens/diseases cited in Table-1 using the zoonoplasticity intuitive risk algorithm [74]. The zoonoplasticity algorithm for elephant species provided a public health and safety risk factor score of 22–27 points and a rating of "High." The five-point range arises due to the addition of five points where vulnerable human groups (e.g., under 5 years, immunocompromised, elderly, pregnant) may be involved. The zoonoplasticity intuitive risk algorithm test results for the 12 pathogens or diseases from Table-1 are provided in Table-2 and are intended to offer a "ball park" analysis of possible risk.

Elephant welfare

Reported concerns regarding elephant welfare span physical and mental abuse during training and general husbandry, injury, and disease (Table-3 [1, 4, 7, 63, 126–132] for summary), often related to misperceptions that elephants are domesticated rather than wild animals. A study [133] of 3129 veterinary treatments (involving 1386 elephants mostly at tourist camps) undertaken by the Mobile Elephant Clinic in Thailand between 2005 and 2008, recorded: 19.1% wounds; 17.6% poor body condition; 14.9% ectoparasites; 14.1% eye problems; 9.8% musculoskeletal problems; 7.8% gastrointestinal issues; 4.1% tusk problems; 3.6% dermatology issues; 3.5% reproductive issues, and 3.1% foot problems.

A visual health assessment of 81 Asian elephants at ten facilities found that 43% exhibited hyperkeratosis, 84% had foot fissures or toe cracks, 8.5% had eye-related problems, 16% had physical wounds, 12% had abscesses, and 41% displayed signs of edema and concluded that elephant welfare at tourist camps and temples was poor compared with zoos and forest camps [126]. Another study collated information on elephants in private ownership in India and found 63% had leg/foot injuries; 16% eye problems; 14% other health issues such as gastrointestinal, urinary, respiratory, and parasitic problems; and 7% wounds and abscesses [134]. In addition, 89% of elephants were not allowed to free roam, 35% were confined with spiked chains or hobbled by forelegs, and the mean duration of chaining was 15.8 h [134].

A 2019 study involving 638 observations of 122 elephants in 15 tourist camps in Thailand, recorded 61% nail cracks (mostly minor), and 23% wounds (mostly abrasions related to hook use) [1]. The authors' assessment of a high wound score decreased by 70% when hooks were not used. Among observations of elephants for riding, 5% included ulcers on the back and chest associated with saddle use [1]. A 2015 study concluded that of 1422 captive elephants at 88 venues in Thailand, 86% were kept on short chains when not being used for tourist activities, 25.6% on a concrete floor, and 34.2% were not allowed direct social contact with other elephants [135].

The majority of Asian elephants in temple and private captive environments were kept in solitary

Table-2: Zoonoplasticity intuitive risk assessment score (Tier 2) for confirmed and potential elephant-to-human-pathogen or disease.

Pathogen	Disease	Score (Range 1–50+points) (preweighted score=10)	Rating (Low, Moderate, High, Very high
Bacillus anthracis	Anthrax	38	High
Clostridium spp.	Clostridium infection	33	High
Escherichia coli	*Escherichia coli* infection	30	Moderate
Aerococcus viridans	Gaffkemia	10	Low
Leptospira interrogans	Leptospirosis	25	Moderate
Pasteurella multocida	Pasteurellosis/ hemorrhagic septicemia	21	Moderate
Salmonella spp.	Salmonellosis	21	Moderate
Mycobacterium spp.	Tuberculosis	47	Very high
Orthopoxvirus spp.	Elephant pox virus infection	26	Moderate
Cryptosporidium spp.	Cryptosporidiosis	27	Moderate
Oesophagostomum spp.	Helminthiasis	12	Low
Toxoplasma gondii	Toxoplasmosis	26	Moderate

Worked scores for Tier 2 questionnaire (Qs 1–6 of zoonoplasticity algorithm, see [74]) in above examples are as follows: anthrax 3,3,1,10,6(15); clostridium infection 3,3,1,10,6(15); E. coli infection 6,3,3,10,3(5); gaffkemia 1,0,1,1,6(1); leptospirosis 1,0,1,10,3(10); pasteurellosis/hemorrhagic septicemia 1,0,1,3,6(10); salmonellosis 3,3,2,3,5(5); TB 6,6,6,10,4(15); elephant pox virus infection 1,4,3,4,4(10); cryptosporidiosis 6,5,2,3,6(5); helminthiasis 3,0,1,1,6(1); and toxoplasmosis 3,3,6,3,6(5). Where data are insufficient or absent, a minimal or medial estimate score has been applied for each evaluation question

Table-3: Physical and psychobehavioral welfare concerns for elephants in tourism.

Example types of abuse	References
Wild capture (capture trauma and long-term negative consequences for health and reproduction)	[1, 4, 7, 128, 129]
Breaking (forceful coercion and domination)	[63, 130, 131]
Psychological and physical torment (fear, verbal chastisement, invasive sounds, beating with steel bars, sticks with imbedded nails, ankuses, use of crushes or Phajaan ritual – forced psychobehavioral domination, food deprivations)	[1, 4, 7, 63, 130–132]
Maladaptation stereotypies (e.g., repetitive head rocking, bobbing or swaying)	[1, 4, 7, 63, 127]
Chaining (forced immobility using chains and other constraints)	[1, 4, 7, 63, 131]
Drugging (use of amphetamines to prolong working periods) to prepare animals for tourism	[63]
Entrapment (confinement in spatially highly restrictive and understimulating environments)	[63, 131]
Miscarriages (due to mistreatment trauma)	[63]
Premature weaning (separation of calves from parents)	[63]
Social deprivation (isolation, lack or prevention of normal contact with same species and groups, and social frustration)	[1, 4, 7, 63, 131]
Malsocialization (exposure to atypical and abuse behavioral interactions with humans)	[63]
Breakdown (post-traumatic stress disorder/c-PTSD)	[63, 130]
Injuries and disease (ocular trauma from flash photography, dermatitis, dermal abrasions, limb lesions, foot fissures, nail cracks, spinal problems from performing rides, wounds, infections, foot pad burns, stress, malnutrition, constipation, and endo and ectoparasites, death)	[1, 4, 7, 63, 126, 131]

confinement (95% and 82%, respectively) with a corresponding proportion of elephants exhibiting stereotypies (weaving, head bobbing, and pacing) – 49% in temples and 26% in private facilities [127]. A survey of 627 elephants at 33 camps in Northern Thailand, using mahout interviews to assess behavior, found that 25% of animals exhibited stereotypic repetitive movement activities, although the authors interpret that this is likely an underestimate [136]. Another study among observed elephants found that 40% exhibited stereotypic behavior [134]. A 2018 study found that of 53 Asian elephants previously used for riding, street begging, logging, and/or circus-type shows, 74% exhibited at least some symptoms of complex post-traumatic stress disorder, including cognitive symptoms, mood disturbances, and overdeveloped avoidance responses [63]. Post-traumatic stress disorder may account for the fact that wild-caught Asian female elephants are 28% less likely to ever reproduce than non-wild captive elephants [128]. Government figures estimate that the mortality rate for all wild capture methods of Asian elephants is between 5% and 30%, with most of these deaths occurring during the months following capture [128].

Discussion

One health, one welfare

The term "one health" represents an enduring paradigm in which the environment, animals, and people are considered interconnected [137–139], and elephant-human disease prevention and control has been specifically highlighted within this concept [110]; meaning that threats to health between elephants and people may be exacerbated by negative one health factors. Similarly, the paradigm of "one welfare" considers the relationship between animal welfare, human well-being, and the physical and social environment [140]; meaning that the health and welfare dynamics of the elephant-human relationship are largely inseparable and may impact coactors, and poor health is associated with increased risk of pathogen shedding. Collectively, these paradigms infer that the reduction or resolution of animal-public health and welfare issues invites multidisciplinary involvement and effort [137, 138, 140]. Furthermore, concerns exist as to whether psychologically and behaviorally damaged elephants and other animals may negatively impact the mental states of their observers [63]. Accordingly, negative factors within the one health, one welfare, and paradigms can reasonably be extrapolated to elevate potential risks from zoonoses and their transmissibility. Anthropogenic pressures, including shrinking natural habitat, and concentration of species into novel, atypical, and potentially unstable ecologies may create conditions for both exacerbation of established infectious diseases, re-emergence of diseases, and emergence of novel threats from pathogens and diseases [141, 142], including at the elephant-human interface [29].

Public health and safety

Elephant-human zoonoses and other diseases

There is a paucity of data regarding both the incidence and prevalence of pathogens and diseases relevant to the elephant-human interface. However, this information deficit does not infer a lack of zoonotic potential or importance because relevant species- and interspecies-specific susceptibilities toward health risks between elephants and humans are well understood. Where data or our understanding of zoonotic threats are minimal, the reasonable tendency is to heighten scientific concerns regarding pathogens, their transmission cycles, and disease with the aim of alleviating public health risks [141].

Where a potential pathogen is known to affect both elephants and humans and has the capacity to transfer laterally between these species, then the precautionary principle implies that even in situations of little available data, epidemics and pandemics may be "preemergent." Preemergent epidemics and pandemics may depend on subtle yet critical co-initiators such as minor anthropogenic ecological disturbances or greater encroachment into already pressurized elephant or other animal habitats [46, 141].

It is entirely possible that with or without anthropogenic or natural "gamechangers" in the relationships between potential pathogens, and elephants and humans, no significant health threats are elevated or emerge. However, despite long-standing scientific advocation toward adoption of the precautionary principle to avoid emergent epidemics and pandemics, little acknowledgment has been given to this inferred wisdom, at least not before SARS-CoV-2/COVID-19, which exemplified the value of a cautious approach.

Established, emergent, and preemergent pathogens and diseases

The pathogens and diseases cited in Table-1 and elsewhere include both established and emerging issues in the elephant-human relationship. Preemergent issues are those that invite speculation based on hypothetical scenarios, which may or may not hold merit, but are worthy of some considerations. For example, although not included in Table-1 due to their highly hypothetical nature, pathogens and diseases such as SARS-CoV-2/COVID-19 understandably raised concern regarding potential infectivity and elephants [143]. Thus far, no data appear available to confirm any significant links between the SARS-CoV-2 virus and risks to elephants or *vice versa*, and early worries may largely have been alleviated.

Our rationale of concern is reasonable in that in nature, many pathogenic agents, including a range of coronaviruses, are widespread, and many animal species harbor strong potential for hosting their cross-contamination by numerous transmission routes [144, 145]. Already, certain species, notably Asian bats, and pangolins are implicated as carriers of SARS-CoV-2 [144]. Several other species, including lions, cats, dogs, mink, ferrets, and rabbits have been identified as susceptible to the virus and have experienced morbidities and mortalities, and some species appear potential sufferers, transmitters, or carriers of coronaviruses; mice and hamsters have also been artificially infected with the virus [145]. Disease risks associated with wildlife may involve discrete transmission routes and pathogen-host-species interfaces. For example, while snakes may present a low direct risk to humans from viral agents, they nevertheless possess the potential to act as vectors for such pathogens through the dissemination of contaminated feces (including SARS-CoV-2) from ingestion of carrier or infected prey (e.g., bats) [146].

Viruses require some degree of infection to facilitate particle replication; thus, unless an elephant becomes subclinically or clinically infected, multiplication of virus is contained and dispersal limited to, for example, respiratory recirculation of contaminated air. Whether or not elephants are susceptible to novel coronaviruses and other emergent infections and diseases, they are capable of inhaling large volumes of surrounding air, holding it in their respiratory tracts (including trunks), and then expelling that air and aerosolized droplets along with potential pathogens over long distances [40], and enclosed spaces present notable hazards [111]. It is probably reasonable to presume that elephant respiratory tracts offer environments that may at least be conducive to relevant survival periods for various bacteria, viruses (including coronavirus), and other microbes and disperse these liberally. Even relatively large indoor spaces and limited-scale outdoor areas and conditions, such as (potentially) within tens of meters range of elephant respiratory expirations or riding on elephants, are all relevant. However, while the routes of transmission and infection of diverse potential pathogenic agents and subsequent diseases between elephants and humans are clear, based on available evidence, elephant-to-human SARS-CoV-2 disease risks appear to be low.

Elephant-to-human injuries

For centuries, humans have used elephants for diverse reasons including military combat, hauling, traditional religious festivals, entertainment in zoos, circuses and parades, and increasingly wildlife tourism [50]. There are also many incidents of captive elephants that deliberately or, more often, accidentally injure keepers and public members, sometimes fatally, at zoos and circuses worldwide [54]. However, research papers that discuss captive elephant-to-human attacks in Asia and Africa frequently do not distinguish between elephants being used for tourism or other purposes (such as traditional keeping or logging); thus, data are difficult to interpret. An investigation of 34 incidents of aggressive or out-of-control elephants in Kerala, South India, was conducted (where elephants are used commonly in festivals) and recorded 15 human deaths and 21 injuries over a 2-year period [147]. A survey conducted on 200 mahouts, also in Kerala, found that over 90% had been attacked by their elephants at some point in time [148]. Over three decades, 352 human fatalities (94% mahouts) were caused by elephants used in festivals and processions in Kerala, and elephant stress levels were implicated in the attacks [149]. However, it is unclear to what extent local habits or tourism are involved. Another survey of 135 elephants in Tamil Nadu, South India, reported 11 human deaths and 27 injuries throughout the time the elephants were at the facility [150].

While elephant tourism in South Africa has been predominantly focused on observational safaris involving free-living elephants, it is becoming increasingly popular to add in more interactive experiences with captive "trained" elephants [151]. For example, reported high profits from elephant riding have led tour operators to use inadequately trained elephants and mahouts, resulting in welfare concerns and injuries to both mahouts and tourists [151].

Elephant welfare

Strong concerns have been presented by numerous welfare campaigning organizations regarding the treatment and poor welfare of elephants for many tourism-associated activities [61, 62, 152, 153], and several scientific reports have also been produced that lend support to a number of these concerns [1, 4, 7, 63, 126, 127, 128–132, 154].

Reports from welfare assessments and surveys of sanctuaries describe physical injury-and disease-causing factors affecting elephants in tourism, including eye trauma and blindness from excessive flash photography, dermal and other infections from poor environmental conditions, foot burns from overexposure to high ground (e.g., concrete) temperatures, limb damage from chains and other ligatures, spinal damage from performing rides, and malnutrition [7, 63]. Contrary to certain perceptions, elephants are wild, non-domesticated, species [63]. Domesticated species, for example, dogs, develop positive associations with humans due to numerous specific genetic, affiliative behavioral, and other factors [155]. Accordingly, evolved innate drive states should be presumed to govern elephant biology, psychology, and behavior for life in the wild, which would normally involve them occupying vast home ranges and having complex social lives within highly affiliative groups.

Importantly, an animal's ability to voluntarily act on drive states to have control over its interactions with the environment is essential to homeostasis and survival [156, 157]. Lack or absence of such control can result in a raft of negative states, including stress, maladaptive stereotypies, sedentarism, learned helplessness, hyperactivity, increased exploratory and escape activities, immunosuppression, and disease [156, 157]. Unsurprisingly, psychological and behavioral factors affecting elephants in tourism reportedly do include fear, maladaptive stereotypies, self-injury, post-traumatic stress disorder, anxiety, aggression, social deprivation, malsocialization, drugging, food deprivation and chronic hunger, and long periods of labor [63].

It may be argued that the use of, for example, certain punitive measures (e.g., ankuses to control elephants), or performances (e.g., riding), do not necessarily infer abusive treatment; rather, their way of application may be problematic [136]. However, we would argue that all highly negative coercive methods and all unnatural performances for spurious purposes are inappropriate and contraindicated.

Data for prevalence regarding specific and general abusive treatments of elephants in tourism are incomplete. This paucity of information is perhaps partly due to most historical studies being somewhat narrowly focused, as well as possibly some abuses being covert. However, observation and documentation of abuses appear to be commonplace; individually, many of these welfare factors warrant concern, and collectively these concerns may be tantamount to severe cumulative and systematic abuses.

The association between poor animal welfare and increased risks to public health and safety is well understood, especially involving large and potentially dangerous animals. Stress, whether acute, chronic, subtle, or gross, is known to significantly impact immune competence in human and nonhuman species [158–160], with negative effects on susceptibility to infection and disease, as well as recovery from disease, and these issues directly relate to elephants and their increased ability to both experience and transmit diseases, for example, TB [161]. It is beyond reasonable question that the human management of elephants for tourism recreation frequently involves diverse stressors and, thus, resultantly a range of implied stress-related outcomes, one of which will be compromised immune condition. As indicated previously, compromised immune condition is relevant not only to the susceptibility, and therefore probability, of elephants acquiring and harboring infections, either from each other or from humans, but also to the likelihood of them asymptomatically or symptomatically shedding pathogens. There is no specific safe distance over which infection can be assuredly avoided, because airborne droplets may travel widely according to, for example, expulsion forces, quantity of droplets, air density, and local ventilation conditions. Pathogens such as *Mycobacterium* spp. (TB), in particular, involve a potential risk of elephant-to-human and human-to-elephant infection.

Current guidance on disease prevention and control and elephant welfare

Tourism industry guidance

Industry guidance encourages direct contact experiences between humans and elephants, recognizes that elephants are carriers of TB, and advises that clientele should be informed of risks [73]. Although guidance from the tourism advocacy sector to clientele regarding both public health and safety and animal welfare should be welcomed, such information may not be impartial or evidence-based and instead may harbor vested interest messaging that in effect increases relevant risks. For example, industry advice for avoiding elephant-associated human TB recommends handwashing to prevent infection [73]. However, given that TB pathogens are typically transmitted by air and inhalation and not by touch, such advice on handwashing constitutes grossly oversimplified and misleading guidance. In addition, industry public health guidance [73] presents only voluntary controls; thus, even if such information was scientifically sound (which it is not) then that information remains lacking in authority and enforcement. The importance of adherence to impartial, evidence-based, guidance independent of industrial influence is thus essential and emphasized.

Scientific and independent guidance

Relevant guidance within the scientific literature regarding zoonotic infections and risk prevention, as well as animal welfare, essentially consists of broad recommendations concerning increased knowledge pertaining to diseases, handwashing and other practical measures, occupational health education, screening of animals for infection, and training for mahouts [5, 6, 46, 103, 111, 162].

Detailed recommendations were proposed providing a six-step "Animal-Visitor Interaction Protocol" for the assessment and alleviation of animal welfare and elephant-human problems, and which focused on behavioral observations and analyses, physiological measures, risk assessment, visitor experience assessment, ethical analysis, and final assessment, along with training, with an overview of improving conditions for both elephants and their human interactors [9]. The same authors also proposed a five-stage "General control measures of zoonotic risk" protocol, which focused on biosecurity, veterinary control, environmental hygiene, design of exhibition areas, and control measures for risks of infection.

While all of these measures offer potentially valuable improvements, they all may also hold limited potential for disease prevention and control. Uptake of and adherence to information by the public is notoriously poor. Face masks to protect people from possible elephant-associated contaminants are probably valuable *ad hoc* barriers to infection, but their use and effectiveness is less than comprehensive, as demonstrated during the pandemic spread of SARS-CoV-2/COVID-19 [163–166]. Elephants in tourism are also exposed to substantial numbers of people of uncertain health status, and there are no rational grounds to presume that simple adoption of face masks by mahouts, other handlers, or public clientele would, in any event, be consistently complied with. Accordingly, air that is relevantly free of pathogens cannot be assured in either direction across the elephant-human interface, leaving both parties exposed.

In addition, many gaps exist regarding current knowledge of relevant diseases, their incidence, prevalence, transmission modes, infectivity, and other issues; consequently providing clear information of sufficient breadth for public health protection is challenging. Infections frequently involve an inactive or latent phase during which the re-emergence of the disease may be triggered by, for example, environmental factors, stressors, or concomitant disease. Screening for infection against the background of latency and disease lag phases may not merely erode confident assessment but also invite complacency. Furthermore, screening for the diversity of pathogens harbored by elephants is not feasible.

Guidance regarding monitoring and improvement of elephant welfare in tourism is varied. For example, a behavioral assessment tool for elephant welfare has been developed using established indicators trialed at zoos [167], as well as a generalized dedicated welfare index trialed at zoos and sanctuaries [132]. Stakeholder education methods have been proposed to incentivize commerce, including against negative criticism [168, 169]. Much of the current guidance on elephant welfare is aimed at factors such as balancing commercialism, community economics, and sustainability through "practical" measures [7, 170–172], promoting environmental, psychological, and social enrichment [136], education, standard setting, and accreditation [154], and positive incentives for mahouts and related actors [170]. Thus, recommendations frequently presume the continuation of the elephant tourism industry with some prospective degrees of reduction rather than prioritizing animal welfare (or public health and safety) as overarching primary issues. However, captive elephants, whether in zoos or in tourism, share numerous commonalities of poor welfare related to their biological demands, nature of captivity, and associated husbandry challenges [136]. These issues raise the question that if elephant welfare cannot be assured even in the major regulated institutions (zoos), then the prospects for good welfare in lesser regulated conditions – that is, tourism – are worrying, and this conforms to the concept of controlled deprivation [173]. Some authors look beyond the theoretical reduction of welfare with elephant tourism and commerce, toward promoting observational tourism involving only free-ranging animals [131].

Conclusion

While much is known regarding public health issues between elephants and humans, much information, particularly epidemiological data, is lacking. These deficits should not be used to justify latency to act to curtail potential disease spread. Despite these data deficits, we believe that sufficient information is known regarding pathogens and their modes of transmission to warrant a precautionary approach to safeguarding animal and human health. Accordingly, this study has embraced the precautionary principle throughout. Increasing pressures on natural habitats and wildlife are key drivers of zoonotic problems, and even subtle ecological alterations may act as rapid trigger events to transform historically stable host-pathogen relationships into epidemics or pandemics. It was likely that SARS-CoV-2/COVID-19 emerged from just such a scenario, with globally devastating results.

Relatedly, potential pathogens can be difficult to detect and disease spread can manifest from highly insidious processes during which time affected individuals are asymptomatic yet destined to become sick perhaps months later. Such infection latency and disease lag phases may cause tourists and medical health professionals to fail to associate sick animals or people with their causative situations, resulting in the paradigm of epidemiological under-ascertainment [174].

Remote or non-proximal engagement between humans and elephants under entirely natural conditions likely represents very low zoonotic and reverse zoonotic infection risks; however, close contact between humans and elephants under artificial captive conditions should be avoided, due to known pathological concerns. Even within the most regulated and professional situations, such as during veterinary management, zoos, and highly credible rehabilitation centers, elephants and people continue to cross infect, regardless of high-level knowledge bases and comprehensive prevention and control protocols. Therefore, other close contact experiences between elephants and humans as part of lower regulated activities, such as those pertinent to the tourism industry, cannot be reasonably expected to manage infection risks well at the elephant-human interface, arguably creating an unredeemable and indefensible public health situation.

Elephant welfare within some sectors of the close contact interactive tourism industry manifestly has involved and continues to involve, significant abuse, both incidental deprivation and inhumane treatment, and deliberately brutal abuse. Such mistreatment and abuse constitute major standalone concerns but also have potential ramifications in causal links with public health and safety risks. Strong, evidence-based guidance for improved welfare is always welcome, but given the ongoing nature of abuses outlined previously, the essential welfare mindset required to conscientiously impose improvements would appear somewhat lacking. In addition, there are long-standing and somewhat complex and negatively evolving attitudes among mahouts toward elephants [6, 8], and such issues are probably traditionally ingrained and resistant to change.

It may be overly optimistic to anticipate real-world improvement in elephant welfare without strong incentives and consequences for violations. There may be no rapid resolution to elephant welfare issues in currently permissive systems, and long-term re-education of mahout handlers and others may be required where elephant tourism persists. Elephant welfare can feature strongly among tourists [168, 169], and in current scientific recommendations, which include regular monitoring of physical behavioral and psychological states for elephants and human-elephant interactions [9].

Comprehensive animal welfare strategies are essential, but while poor welfare exacerbates public health risks, good welfare does not imply a major reduction of such risks. However, pressure aimed at incentivizing welfare (or disincentivizing abuse) can be urgently applied by multiparty, cross-sector, actors adopting messaging that infers immediate financial loss for failures among those at any link in the chain of elephant tourism promotion or performance. For example, live-feed digital cameras have been successfully used to stream images for studying animal behavior 24/7 at zoos and universities [175], as well as to survey human handling, stunning, and slaughter of farmed animals in abattoirs [176]. Legal bans have been applied to many situations in which free-ranging wildlife is threatened by anthropogenic activities, and this approach remains the gold standard for effective control of all industries [177]. Therefore, bans combined with strong enforcement, offer the best protection for all unredeemable persistent problematic issues (e.g., close contact interactive settings, whether for proximal observation, feeding, trunk touching, assisted skin scrubbing, and assisted bathing or riding) arising from elephant tourism.

Where elephant tourism is redeemable without persistent or unmanageable problems (e.g., public observation of free-ranging animals within national parks), positive list systems can offer permissive frameworks for promoters or providers. Positive lists are permissive registers of, for example, activities that have been subject to independent evaluation methods, typically using objective scientific algorithms, intended to ensure that such activities are safe for people, animals, and the environment [178, 179]. Activities not surviving evaluation scrutiny for positive listing are by default not permitted. Relevantly, positive lists comprise the normal operational procedures securing health and safety standards for all major industrial sectors, including pharmaceuticals, veterinary and human medical practices and practitioners, aircrafts, marine vessels, cars, buildings, and many other sectors [178, 179].

Recommendations

Legal bans

Legal bans on promotion and performance of close contact interactive elephant-human experiences combined with strong enforcement protocols, should constitute the primary gold standard measures for prevention and control of public health, safety, and animal welfare risks within the tourism industry, and become the earliest goal of all regulatory authorities and other actors.

Consistent policies

Public health and safety, species conservation, and animal welfare organizations and programs within their communities should rapidly adopt consistently strong policies toward discouraging elephant tourism, based on messaging outlining established interrelationships between disease prevention and control, animal welfare, and species and ecological conservation.

Cease commercial promotion

Commercial promoters of tourism in which elephants are used in close contact interactive settings, whether for proximal observation, feeding, trunk touching, assisted skin scrubbing, and assisted bathing or riding, should not anticipate formal governmental interventions but rather rapidly and greatly strengthen guidance against all relevant activities, as well as cease their promotion. All information and guidance should be based on entirely independent scientific input.

24/7 surveillance of captive elephants

Providers of tourism should rapidly institute live-feed digital cameras that stream images to key public assess platforms ensuring that no areas where elephants have access are unavailable for independent 24/7 scrutiny to offer some animal welfare securities. Significant penalties should be applied for either accidental or deliberate interruptions in streaming losses to deter obfuscation.

Positive list systems for tourism promoters or providers

Where elephant tourism involves public observation of free-ranging animals within national parks, governments should seek to develop positive list systems for promoters or providers to clarify and ensure that such activities are legitimately differentiated from problematic captive scenarios.

Authors' Contributions

CW: Concept and design. RG, CW, and CS: Literature research. CW, AP, RG, and CS: Analysis and writing. All authors have read, reviewed, and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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