A scoping review of occupational biological exposures among horse grooms: a neglected group of workers in a thriving horse-racing industry

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ABSTRACT

Introduction: In addition to grooming, horse grooms' tasks include live breeding, foaling, night watch duty, raising and training horses, mucking stalls, landscaping, and horse maintenance. Horse stables are reported to have high organic dust levels, which pose a risk to horse grooms. Studies have reported an association between working with horses and an increased risk of respiratory symptoms and/or organic dust toxic syndrome. Some studies demonstrated that horses were exposed to high levels of endotoxin as well as (1,3)-β-D-glucan in horse stables.

Objective: To describe occupational biological exposures and associated respiratory diseases among horse grooms, shedding light on their working and living conditions.

Methods: A scoping review was undertaken using the PRISMA extension for scoping reviews (PRISMA-ScR) checklist. Data were extracted using key questions and eligibility criteria as a starting point. The keywords and phrases, occupational health, infectious diseases, workplace exposure, coronavirus disease 2019 (COVID-19), *Mycobacterium tuberculosis*, (1,3)-β-D-glucan, endotoxin, and horse grooms were used to search PubMed, Google Scholar, and ScienceDirect.

Results: Forty-six papers were selected for final review from the 94 identified for potential inclusion. These papers highlighted possible biological exposure in horse grooms' day-to-day tasks. Hostel living conditions, similar to those in the mining industry, were identified as a source of biological exposures. Due to overcrowding, the spread of tuberculosis was highlighted as a major concern.

Conclusion: More research on horse grooms is necessary, considering the paucity of occupational health information in this sector, especially in South Africa. Future studies should focus on environmental conditions, hostel living conditions, health outcomes among horse grooms, and prevention strategies.

INTRODUCTION

Horses played a crucial role in the agricultural, mining, and transport sectors in the growing economy towards the end of the nineteenth century and early in the twentieth century.[1] Currently, horses in South Africa are used in various activities, such as racing, competitive and leisure riding, policing, and military purposes.[1] The sport enjoys a long and rich history in South Africa that can be traced back to 1795.[2] The first recorded race club meeting of the National Horse Racing Authority took place in 1802.[2] Racing in South Africa is currently controlled by two bodies: 1) 4Racing (Eastern Cape, Gauteng, Free State, and Northern Cape provinces) and 2) Gold Circle (KwaZulu-Natal and Western Cape provinces).[2,3] The horse-racing industry is divided into different categories, such as the thoroughbred breeders' association, which focuses on horse breeding, sales, and purchases; the owners' association, which buys and owns these horses; the trainers' association, which trains the horses; and the jockeys' association, whose members ride horses during races.[4] These entities collectively report to the National Horseracing Authority.[4] Often overlooked is the South African Grooms Association (SAGA), representing horse grooms in the country, who lack adequate representation and voice within the industry.[5]

The South African horse-racing industry contributed R2.71 billion annually to the country's gross domestic product from 2009 to 2018.[6] While horse racing can be a thrilling experience for sports fanatics, gamblers, and fashionistas, the glamour and glitz are not shared by all who work in the industry, such as the grooms who maintain the horses[7] and play an essential role in their training and overall wellbeing.[7] Their work in the thoroughbred horse industry includes preparing horses for sale, boarding, and breeding.[8] Typical tasks include live breeding, foaling, grooming, night watch duty, raising and training horses, cleaning horse stalls, and landscaping.[8] Grooms also hold down horses during treatment by farriers and veterinarians, and assist with preparations for shipping horses to shows or races.[7] Horse grooms in South Africa have been reported to work under appalling conditions,[9] and their plight has been highlighted by both the SAGA and the Department of Employment and Labour.[5]

The working environments of grooms expose them to bioaerosols that include allergens (Table 1), microorganisms, by-products of microbial agents such as endotoxins, (1,3)-β-D-glucans, and organic dust. Elevated endotoxin levels have been measured in horse stables,[10,11] affirming the presence of endotoxin and (1,3)-β-D-glucan in these environments.[12] Individuals who regularly work with horses, including jockeys, trainers, and horse grooms, experience long-term exposure, leading to allergic diseases.[12,13] The hostel living conditions of horse grooms are a cause for concern as several workers live in confined spaces similar to those in the mining industry.[14] Up to eight men may occupy a room, with minimal ventilation.[15] The risk of tuberculosis (TB) and severe acute respiratory coronavirus 2 (SARS-CoV-2) transmission have been highlighted,[16,17] particularly among those with comorbidities.[18]

Given the anecdotal information on poor working and living conditions, and the lack of scientific evidence for biological exposures and possible health outcomes among horse grooms in South Africa, further research is warranted. This scoping review sought to investigate potential occupational biological exposures and related respiratory diseases among horse grooms, associated with working and living conditions. The investigation encompassed respiratory diseases such as TB, coronavirus disease 2019 (COVID-19), asthma and allergies caused by *Mycobacterium tuberculosis*, SARS-CoV-2, endotoxin, (1,3)-β-D-glucan, and horse allergens in the horse industry.

METHODS

Search strategy

The search terms used were: (horse grooms OR horse stables) AND (horse allergens OR horse industry OR South African horse racing industry) AND (occupational health OR infectious diseases OR workplace exposure) AND (COVID-19 OR *Mycobacterium tuberculosis* OR endotoxin OR (1,3)-β-D-glucan) AND (workers living hostels OR TB AND COVID-19) in overcrowded areas. English language, peer-reviewed articles published from January 1990 to December 2021 were identified from PubMed, Google Scholar, and ScienceDirect. Information was also obtained from Horse Racing South Africa, the World Health Organization (WHO), 4Racing, and Gold Circle webpages. Figure 1 summarises the search strategy and the selection of articles. The 32-year period was chosen as it likely provided insights into more current conditions, excluding studies from the distant past.

Fifty-five publications (46 articles and nine reports) were included, comprising peer-reviewed journal articles, non-peer-reviewed articles, reports, and webpages. Due to the anticipated limited information on horse grooms, studies related to horse workers' living and working conditions were included. Bioaerosol exposure was confined to TB, COVID-19, endotoxin, (1,3)-β-D-glucan, and horse allergens in the horse industry.

Data extraction

The authors' names, year of publication, article title, country of study, study sample size, living conditions, biological agents, and health effects were extracted from identified articles (Table 2).

RESULTS

Ninety-four potential articles were identified (Figure 1); 10 were removed before screening, and 20 were excluded as the content was unrelated to the review, leaving 64 eligible articles. A further 17 articles were excluded as the full text was unavailable. Ultimately, 55 articles met the inclusion criteria, of which 46 related to the review topic (Table 2). Most articles (n = 46, 83.63%) were identified from databases; nine (16.3%) were obtained from websites and organisations but were only used to support the findings in the other 46 articles. Only five articles on working and living conditions for horse grooms were identified, highlighting the limited literature on this topic.

Occupational exposure to endotoxin and (1,3)-β-D-glucan

Eleven studies reported exposures to endotoxin and (1,3)-ß-D-glucan in the horse industry, including horse grooms and veterinary practitioners.[11,12,21-26] In a study by Hwang et al., 2020, the endotoxin concentration of inhalable particles (geometric mean (GM): 50.2–1,024 EU/m^3) was 50 times higher than that of respirable particles (GM: 1.72–19.0 EU/m^3).[25] They showed that cleaning tasks produced higher concentrations while horse care generated the lowest endotoxin concentrations.[25] Similar endotoxin levels were also shown by Samadi et al., 2009, with GM concentrations ranging from 608 EU/m^3 to 9 846 EU/m^3 in horse stables.[12] However, the measurements in the latter study were collected for a full work shift, while they were collected over a shorter period by Hwang et al., 2020.[25] Positive associations were found between endotoxin exposure and respiratory disorders, such as asthma-like symptoms, chronic airway obstruction, and bronchitis.[21,22] Some studies demonstrated an increased risk of respiratory symptoms, including organic dust toxic syndrome (ODTS), among workers exposed to horses.[23,24]

Limited data exist for (1,3)-β-D-glucan exposures, with only a few articles reporting airborne concentrations in different horse barns.[10, 25,27] Samadi et al. (2009) demonstrated personal exposure to (1,3)-β-D-glucan with a GM of 9.5 µg/m^3 (0.4–631 µg/m^3) in the horse stables.[12] Elfman et al. (2009) conducted a study in Sweden in summer and winter and found (1,3)-β-glucan levels ranging from 0.01 to 70 ng/m^3, with a mean of 20 ng/m^3.[28] Health effects from exposure to (1,3)-ß-D-glucan included cough, wheezing, chest tightness, shortness of breath, nasal irritation, throat and sinus trouble, ODTS, bronchitis, atopy, and asthma.[23,26,29-32,40]

Occupational exposures to horse allergens

Horse allergens are mainly acidic proteins, of which Equ c1 through c5 have been well characterised.[19] The 16 proteins identified from horses are located in skin dander, hairs, urine, and saliva.[19,20] There are different allergens of horses (*Equus caballus*) listed in the WHO and International Union of Immunological Society (WHO/IUIS) Allergen Nomenclature Database (Table 1).

Nine studies (Figure 1) reported exposures to horse allergens, including horse hair, dander, and allergens found in bedding materials and feed (Table 2).[13,19,20,23,24,28,33,34] Health effects included rhinitis, eczema, airway disease, urticaria, conjunctivitis, allergic sensitisation, bronchial inflammation, headache, throat irritation, nasal irritation, and dry productive cough, and chronic obstructive pulmonary disease (COPD) and asthma were also reported.[13,14,34,35] In a cross-sectional study among horse grooms in Istanbul, asthma was found in 14.4%,

Table 1. Allergenic proteins of *Equus caballus*

Major allergen	Biochemical name	Description
Equ c1	Lipocalin	A 25 kDa lipocalin, which is believed to be the major horse allergen; up to 76% of horse-allergic patients react to Equ c1
Equ c2	Lipocalin	A 17 kDa lipocalin that showed IgE binding, by immunoblotting, in horse-sensitised patients
Equ c3	Serum albumin	A 67 kDa horse serum albumin that showed IgE binding in 50% of patients tested
Equ c4	Latherin	A 17 (20.5) kDa protein with latherin function
Equ c6	-	15 kDa lysozyme, which seems to be both a food and dermal allergen
Horse allergen	-	mAb: 103, 14G4

IgE: immunoglobulin E, kDa: kilodalton, mAb: monoclonal antibodies

Sources: Mitlehner, et al., 2015; Victor, et al., 2019[19, 20]

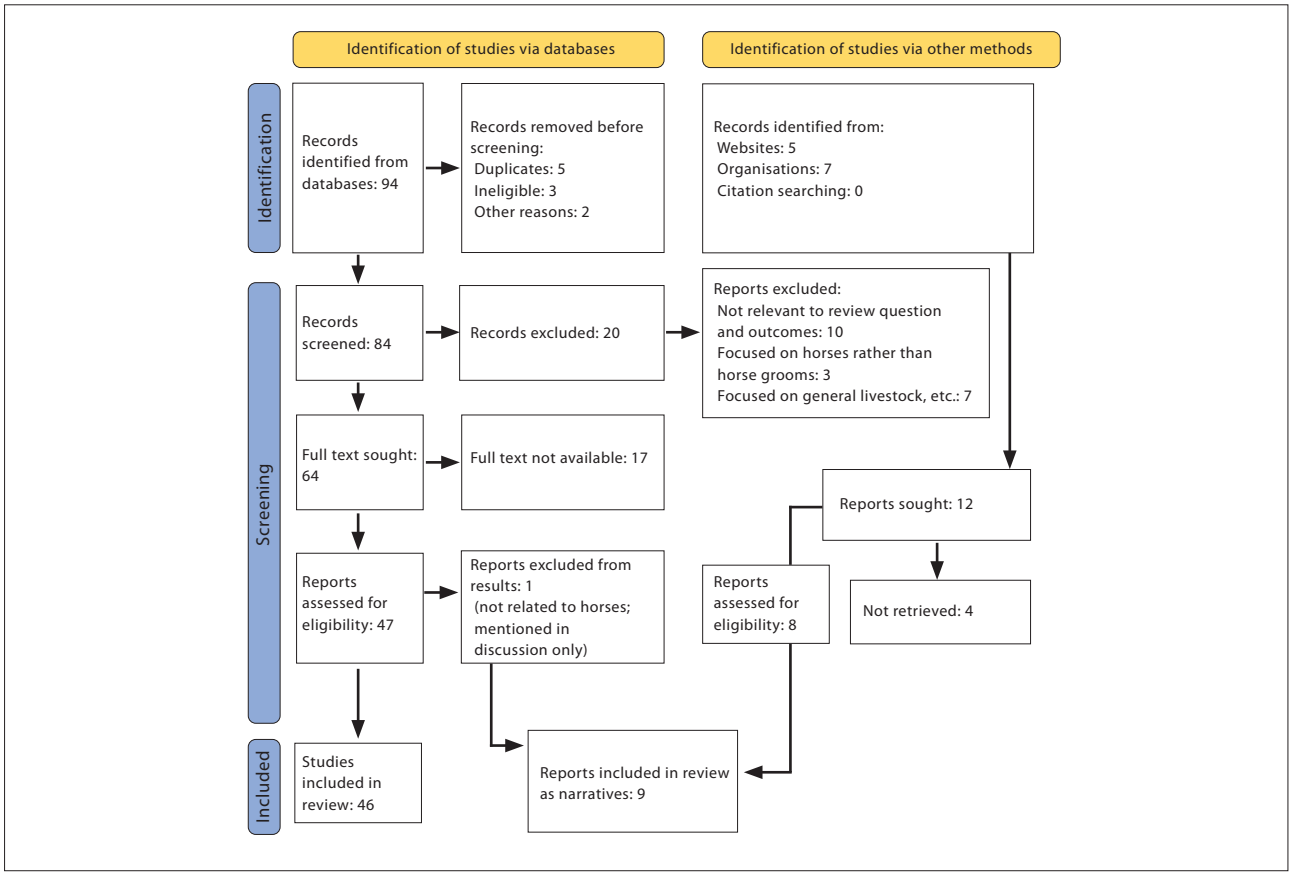

Figure 1. PRISMA flow diagram, summarising selection of articles

allergic rhinitis in 42.4%, allergic conjunctivitis in 35.2%, and allergic skin diseases in 32.8% of the grooms.[20] A 1.8-fold increased risk of allergic rhinitis, a 3.9-fold increased risk of allergic conjunctivitis, and a 3.25-fold increased risk of skin diseases were also reported.[20]

Mycobacterium tuberculosis in horse grooms' hostels

Only six of the studies included in the review related to *M. tuberculosis* exposure in agriculture and hostels.[36-40] According to one South African online news source, horse grooms live in single-sex hostels provided by horse owners or trainers.[9] Similar to the South African mining industry,[15] most are African male migrant labourers who leave their rural homes in South Africa and neighbouring countries to work at the horse-racing centres. According to a 2019 newspaper article, housing and living conditions of horse grooms are sub-standard and have been associated with adverse health effects, reduced productivity, and poor social wellbeing.[9] It was reported that the horse grooms' toilets and showers are dirty, and that they sleep on steel beds with mattresses in confined rooms that accommodate four to eight people.[9, 16]

Potential SARS-CoV-2 in horse grooms' living hostels

Seven studies were related to exposure to SARS-CoV-2.[17,18,41-45] Poorly ventilated and crowded spaces, such as hostels where grooms reside, may increase the risk of viral transmission and adverse health outcomes, including acute respiratory distress syndrome (ARDS).[17,41-43,45]

COVID-19 disease spreads in poorly ventilated and/or crowded indoor settings, where people tend to spend longer periods.[43,46] Two SARS-CoV-2 outbreaks have been associated with poor ventilation.[47] These outbreaks strongly suggest that many secondary infections may occur in a confined, crowded, and poorly ventilated environment.[47,45] Like refugees and migrant workers,[44] horse grooms live in individual and communal accommodations in horse-racing centres. They face similar health threats from COVID-19 as refugees and migrant workers.[44]

DISCUSSION

This scoping review was conducted to describe the occupational biological exposures and related respiratory diseases associated with working and living conditions among horse grooms in the horse industry. The limited literature on horse grooms suggests that they are an under-researched occupational group, particularly regarding exposures. Studies from similar agricultural settings were included in the review to provide context regarding potential biological exposures and health risks. Working conditions involved significant exposure to bioaerosols, including endotoxin and (1,3)-β-D-glucan, which are linked to respiratory diseases such as asthma, bronchitis, and ODTS. Routine activities such as cleaning and caring for horses contribute to these exposures.[7,19]

The high concentrations of endotoxins reported in the various studies indicate that horse grooms are at risk of developing respiratory symptoms while performing their daily tasks, particularly cleaning activities.[20] Additionally, the limited data on (1,3)-ß-D-glucan exposure highlights the need for further research to assess its impact on workers' health.[2,12,22,25] Horse grooms are particularly susceptible to respiratory conditions, infections, and allergic reactions directly linked to prolonged exposure to bioaerosols and microorganisms in the stable environment. These findings emphasise the importance of assessing and managing exposure to endotoxin and (1,3)-ß-D-glucan to mitigate respiratory health risks.

The presence of allergens in horse hair, dander, and feed contributes to allergic reactions among workers, including asthma and eczema.[13,14] Horse grooms face an increased risk of allergic diseases,[13,14] underscoring the need for preventive measures to reduce allergen exposure.

Horse grooms' poor living conditions, which resemble those of other high-risk groups such as migrant workers and miners, increase the risk of communicable diseases such as TB and COVID-19.[9,16] Overcrowding and poor ventilation are key factors in the transmission of these diseases.[36]

Table 2. Summary of articles included in the scoping review (N = 46)

No.	Authors	Country	Study design	Year of data collection	Outcome of interest	Population type	Sample size	Measure and findings	Health effect
Studies with exposure to endotoxins and/or (1,3)-ß-D-glucan									
1	Mendy et al., 2019[22]	USA	Cross-sectional	2005–2006	Increased emergency visits	General population	6 488	Co-exposure to endotoxin and PM2.5 synergistically associated with outcome, increasing odds fivefold (OR 5.01, 95% CI 2.54– 9.87)	Emergency room visits for asthma
2	Hwang and Park, 2018[25]	South Korea	Cross-sectional	2017	Variation of airborne endotoxin levels over one year	Microbiology laboratory workers	174	GM endotoxin levels: 0.240 EU/m^3 Environmental factors affecting endotoxin levels were temperature (R^2 = -0.388, p < 0.001) and illumination (R^2 = -0.370, p < 0.001)	Respiratory airway irritation
3	Gioffrè et al., 2018[29]	Italy	Cross-sectional	2010–2014	Concentration of airborne endotoxin	Greenhouse workers	30	Significant association (p = 0.01) between plant type and number of greenhouses exceeding 100 EU/m^3	Occupational lung diseases, including non-allergic asthma and ODTS
4	Kozajda et al., 2017[30]	Poland	Cross-sectional	2017	Concentrations of inhalable dust, endotoxins, and (1–3)-β-d-glucans	Waste sorting plant workers	42	GM concentrations: inhalable dust:1.3 mg/m^3 endotoxin: 13.7 ng/m^3 (1,3)-β-D-glucans: 51.8 ng/m^3	Bronchial asthma, ODTS and acute form of byssinosis
5	Samadi et al., 2013[31]	Netherlands	Systematic literature review	2013	Levels of bio-aerosols, e.g. as endotoxins, (1,3)-β-D-glucan, and some specific animal allergens	Equine veterinary medicine students	x	Prevalence of sensitisation increased over time Years 3–5: OR 2.4, 95% CI 0.4–15 Year 6: OR 4.7, 95% CI 0.4–49	Prolonged years of exposure to horses as a possible determinant of sensitisation
6	Berndt et al., 2010[10]	USA	Cross-sectional	2010	Endotoxin levels in stables	Horses	x	Endotoxin exposure significantly higher (~ 8-fold) in stables than in pasture	-
7	Samadi et al., 2009[12]	Netherlands	Cross-sectional	2009	Inhalable dust, endotoxins, β(1,3)-glucans	x	90	GMs of personal exposure to dust, endotoxin, and β(1,3)-glucan: 1.4 mg/m3, 608 EU/m^3, and 9.5 µg/m^3, respectively	Asthma, chronic bronchitis, and ODTS
8	Pirie et al., 2009[48]	UK	Experimental	2002	Inhaled endotoxin	x	30	x	Airway inflammation and dysfunction among horses
9	Douwes et al., 2003[49]	Netherlands	Reviewed article	2003	Exposure to bioaerosols	Workers	x	x	Respiratory diseases, infectious diseases, acute toxic effects, mycotoxin, allergies, cancer
10	McGorium et al., 1998[11]	UK	Cross-sectional	1997	Airborne endotoxin concentrations	Equine management systems	x	Pooled data: airborne endotoxin concentration of each environment was significantly correlated with its dust concentration (Spearman's rank coefficient = 0.865; p < 0.01)	Airway inflammation and dysfunction, broncho-constriction
11	Mackiewicz et al., 1996[50]	Poland	Cross-sectional	1996	ODTS	Workers on purebred horse farms	31	Mean concentration of endotoxin: 3.44 g/m^3	ODTS

Studies with exposure to airborne dust									
12	Flunker, 2015[32]	USA	Cross-sectional	2014	Chronic exposure to dusty barn environments	Latino thoroughbred horse workers	80	Odds of abnormal pulmonary function increased by years of current horse farm employment (OR 6.3, 95% CI 1.15–34.35) and years living in the USA (OR 5.2, 95% CI 1.3–20.6)	Respiratory symptoms: cough wheezing, chest tightness, shortness of breath, nasal irritation, throat and sinus
13	Clements and Pirie, 2007[26]	UK	Cross-sectional	2006	Respirable dust concentrations	Equine stables	60	Mean respirable dust concentrations significantly reduced ($p < 0.05$) in equine stables by changing the environment from hay feed and straw bedding to haylage feed and wood shavings bedding (reduction in mean from 0.087mg/m^3 to 0.026mg/m^3; reduction in maximum -4.076mg/m^3 to 0.218mg/m^3	x
14	Gallagher et al., 2007[23]	New Zealand	Cross-sectional	1999–2000	Occupational respiratory health	Horse trainers	659	Chronic bronchitis: OR 6.8, 95% CI 2.2–21.4; ODTS: OR 3.5, 95% CI:1.8–6.8	ODTS, bronchitis, atopy, asthma
15	Rosenthal et al., 2006[32]	USA	Cross-sectional	2006	Airborne particulate levels (RP and TP)	Horse barn workers	50	Mean ratio of RP:TP was 0.63 in summer, 0.34 in winter, and 0.50 for pooled measurements	Respiratory effects
16	Woods, 1993[27]	England	Cross-sectional	1993	Airborne dust and aeroallergen concentration	Horse stable management systems	40	GM concentrations higher in stables with hay feed than in those with wood shavings	Respiratory effects
Studies with exposure to SARS-CoV-2									
17	Song et al., 2021[17]	China	Cohort study	2020	Impact of comorbidity (asthma and COPD) on COVID-19	COVID-19 patients	961	COPD patients had higher risk of developing severe illness (OR 23.433, 95% CI 1.525–360.135; $p < 0.01$) and ARDS (OR 19.762; 95% CI 1.461–267.369; $p = 0.025$) than asthmatics	COVID-19, asthma, hypertension, diabetes, cardiovascular disease, malignancy, COPD
18	Azuma et al., 2020[44]	Japan	Review article	2020	Indoor environmental quality	General population	x	x	COVID-19 transmission
19	Guo et al., 2020[41]	South Africa	Review article	2020	Clinical therapies for COVID-19	COVID-19 patients	x	x	Fever, cough, fatigue, gastrointestinal infection, ARDS
20	Li et al., 2020[45]	China	Cross-sectional	2020	Evidence for aerosol transmission	COVID-19 infected persons	10	Ethane concentration positively associated with risk of acquiring COVID-19 (OR associated with 1% increase in concentration: 1.115; 95% CI: 1.008–1.233; $p = 0.035$)	COVID-19 transmission
21	Morawska and Cao, 2020[42]	China and Australia	Review article	2020	Viral airborne transmission	General population	x	x	COVID-19 transmission
22	Somsen et al., 2020[43]	Netherlands	Review article	2020	Transmission in poorly ventilated spaces	General population	x	x	COVID-19 transmission
23	Wang et al., 2020[18]	China	Retrospective study	2020	Clinical characteristics	Hospitalised patients	138	NCIP suspected in 41% of patients; 26% of patients received ICU care, mortality was 4.3%	COVID-19, COPD, asthma
***Studies with exposure to* Mycobacterium tuberculosis**									
24	Almekhlef et al., 2016[37]	Syria	Cross-sectional	2015–2016	Risk of latent tuberculosis infection	Internally displaced people	419	Positivity of tuberculin skin test associated with close contact (87/161, 54%) vs no close contact (32/244, 15%), OR 10.36; 95% CI = 5.969–17.997; $p < 0.001$	TB latent infection
25	Carruth et al., 2016[40]	Africa	Letter to the editor	2016	Zoonotic tuberculosis challenges	General population	x	x	Zoonotic TB
26	Hlokwe et al., 2016[39]	South Africa	Case report	2005	Molecular characterisation of *M. bovis*	x	x	x	Bovine TB
27	Narasimhan et al., 2013[36]	Australia	Systematic literature review	2013	Risk factors for TB	General population	x	x	TB
28	Kulchavenya et al., 2012[38]	Russia	Review	2012	Male genital TB	Patients with UGTB	310	x	UGTB

Studies with exposure to allergens									
29	Victor et al., 2019[20]	Sweden	Cross-sectional	2019	Allergen levels of Equ c4 in dander and saliva	Horse owners	170	GM values: Equ c4 in dander 639 U/µg protein (range 5–15 264), Equ c4 in saliva 39.5 (range 4–263)	Respiratory symptoms
30	Zahradnik et al., 2018[35]	Germany	Cross-sectional	2016	Allergen levels in horse breeds	Horse breeders	50	Mean allergen concentration of Equ c1 and Equ c4 in hair significantly related to breed and sex combined	x
31	Mitlehner et al., 2015[19]	Germany	Review	2015	Horse allergy in riders	Equestrian athletes	40	x	Rhinitis, asthma, eczema
32	Elfman et al., 2009[28]	Sweden	Review	2004–2005	Influence of horse stable environment	Stable personnel	13	Mean endotoxin and (1–3)-β-d-glucan transiently higher when stable doors closed: 31 and 362 ng/m^3, respectively; dropped to 5 and 85 ng/m^3, respectively, with doors open	Bronchial obstruction
33	Gawlik et al., 2009[14]	USA	Case report	x	Anaphylaxis from horse allergy	Horse owners	1	x	Anaphylaxis with specific IgE to horse dander (> 100 kU/l)
34	Mazan et al., 2009[24]	Czech Republic	Cross-sectional	2005–2006	Airway disease symptoms in barn personnel	Barn workers	82	x	Airway disease, asthma
35	Tutluoğlu et al., 2002[34]	Turkey	Cross-sectional	2002	Sensitisation to horse hair	Horse grooms	125	Association for sensitisation to horse hair with asthma: OR 4.5, 95% CI 1.5–13.3, allergic skin diseases: OR 2.4, 95% CI 0.6–9.8, allergic rhinitis: OR 1.5, 95% CI 0.4–5.1	Sensitisation to horse hair, asthma and allergic symptoms, lung function impairment
36	Roberts and Lack, 2000[13]	UK	Case report	2000	Horse allergy	Children	3	x	Allergic sensitisation, bronchial inflammation, asthma
37	Felix et al., 1996[33]	Sweden	Cross-sectional	1996	Allergenic composition of dander extracts	Breeders and patients with asthma	20	x	Asthma, rhino-conjunctivitis
Studies with exposure to respiratory and other agents									
38	Bulfin et al., 2019[51]	Ireland	Cross-sectional	2018	Equestrian worker's personal RCS and RD exposure; occupational exposures in equestrian centre	Equestrian workers	1	GM RD and RCS exposures: 0.12 mg/m3 and 0.02 mg/m^3, respectively	Lung cancer
39	Pelders and Nelson, 2019[15]	South Africa	Cross-sectional	2014	Living conditions of migrant workers	Migrant workers	875	x	Respirable communicable diseases
40	Wolny-Koładka, 2018[52]	Poland	Cross-sectional	2015–2017	Microbiological air quality in stables	x	x	x	x
41	Bush et al., 2018[53]	USA	Cross-sectional survey	2013–2014	Missed work due to occupational illness	Latino farmworkers	225	Workers with poor self-reported general health (PR 0.72, 95% CI 0.48–1.08), experiencing stress during a typical workday (PR 2.58, 95% CI 1.25–5.32), or spending less time with horses (PR 1.87, 95% CI 1.15–3.05) are significant predictors of missing work	Headache, throat irritation, nasal irritation, dry and productive cough
42	Nowakowicz et al., 2014[54]	Poland	Cross-sectional	2014	Level of exposure to air pollution in a stable	Horse caregivers	x	Total number of airborne bacteria in the stable exceeded allowable level of microbiological contamination in animal rooms and safe value for workers (3.2 x 105 cfu/m^3 in stable and 1.1 x 105 cfu/m^3 in social room)	Unfavourable health effects
43	Swanberg et al., 2013[8]	USA	Cross-sectional	2012–2013	Occupational injuries on thoroughbred farms	Latino workers	378	x	Occupational injuries
44	McShane and Swart, 2011[1]	South Africa	Systematic review	2011	Equine management	Equine breeders	x	x	x
45	Madsen, 2006[21]	Denmark	Cross-sectional	2006	Airborne endotoxin levels	General population	169	x	Airway inflammation and dysfunction
46	Curtis et al., 1996[55]	Canada	Cross-sectional	1996	Organic dust and ammonia in horse stalls	x	x	Mean concentration	Respiratory disorders

ARDS: acute respiratory distress syndrome, CI: confidence interval, CMAQ: community multi-scale air quality modelling system, COPD: chronic obstructive pulmonary disease; GM: geometric mean; ICU: intensive care unit; NCIP: novel coronavirus (2019-nCoV)-infected pneumonia, NO2: nitrogen dioxide, ODTS: organic dust toxic syndrome, OR: odds ratio, p: probability value, PR: probability, R: correlation coefficient, RCS: respirable crystalline silica, RD: respirable dust, RP: respirable particles, TB: tuberculosis, TP: total particles, UGTB: urogenital tuberculosis, UK: United Kingdom; USA: United States of America; X: not reported/not available

CONCLUSION

Information about exposure to bioaerosols in the horse industry is derived primarily from international studies. The findings of this review highlight the unique occupational hazards faced by horse grooms, including exposure to bioaerosols, allergens, and communicable diseases. Addressing these risks through improved air quality, personal protective equipment, and better living conditions is essential to protect the health and wellbeing of this workforce. There is a need to identify and appropriately quantify the responsible agents and their health impacts on horse grooms in South Africa. Exposure to bioaerosols in South Africa's horse-racing industry is likely exacerbated by prolonged close contact with horses, frequent handling of bedding and feed materials, and inadequate ventilation in both stables and worker accommodations. This review serves as a foundation for future research endeavours and the development of targeted interventions aimed at promoting the occupational health and wellbeing of horse grooms in all relevant industries.

KEY MESSAGES

1. Horse grooms face significant exposure to bioaerosols, such as endotoxin and (1,3)-β-D-glucan, which are linked to respiratory diseases like asthma, bronchitis, and organic dust toxic syndrome.
2. Cleaning tasks contribute significantly to high endotoxin exposure.
3. Horse allergens in hair, dander, bedding materials, and feed pose a significant occupational hazard.
4. Horse grooms often live in overcrowded, poorly ventilated conditions, similar to other high-risk groups such as migrant workers and miners.

DISCLAIMER

Any opinions expressed, conclusions drawn, and recommendations provided here are those of the authors and do not necessarily reflect the views of the NHLS, NIOH, or the University of Johannesburg.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design of the study: TD, TS
Data acquisition: TD
Data analysis: TD
Interpretation of the data: TD, TS, NN
Drafting of the paper: TD, TS, NN
Critical revision of the paper: TD, TS, NN

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