

OCCUPATIONAL HEALTH HAZARDS OF STREET CLEANERS – A LITERATURE REVIEW CONSIDERING PREVENTION PRACTICES AT THE WORKPLACE

VERA VAN KAMPEN^{1*}, FRANK HOFFMEYER^{1*}, CHRISTOPH SEIFERT¹, THOMAS BRÜNING²,
and JÜRGEN BÜNGER¹

Institute for Prevention and Occupational Medicine of the German Social Accident Insurance,
Institute of the Ruhr University Bochum (IPA), Bochum, Germany

¹ Medical Department

² Head of Institute

Abstract

Street cleaning is an integral part of the solid waste management system. There are different ways to achieve clean streets depending on the availability of equipment, the type and magnitude of dirt, the surface conditions encountered or traffic conditions. In general, hand sweeping by an individual worker or a group, hose flushing, or machine sweeping or flushing are applied. In order to obtain information about the occurrence and relevance of occupational health hazards of street cleaners, the current international literature, as well as corresponding German regulations, were reviewed and evaluated. Street cleaning includes a variety of health hazards for employees. These can be subdivided into effects of occupational tasks and effects of working conditions such as weather or road traffic. The hazards result from physical, chemical and biological exposures, but may also be due to physiological and psychological burden or inadequate safety aspects. The most commonly reported work-related complaints are musculoskeletal and respiratory disorders, cuts, slips, and road traffic accidents. In developing countries, street cleaners seem to be still heavily exposed to dust and, in most cases, no suitable protective measures are available. Especially in industrialized countries there exist a number of standards and recommendations for waste workers that aim to reduce their occupational health impacts. *Int J Occup Med Environ Health*. 2020;33(6):701–32

Key words:

occupational health, hazards, musculoskeletal disorders, respiratory disorders, injuries, street cleaner/sweeper

INTRODUCTION

Solid waste management includes the collection, transport, deposition, treatment and recycling of waste produced by individual households, public institutions and workplaces. Street cleaning is an integral part of the solid waste management system and an important duty to ensure a clean environment. Specific challenges signifi-

cantly differ around the world. The increasing population, especially in Africa, Asia and South America, has resulted in severe pressure on urban land, urban utilities and services. In those areas, a major goal is the prevention of transmission of infectious diseases, and this is why street sweepers play an important role in maintaining health in the communities [1].

Received: December 4, 2019. Accepted: June 12, 2020.

* Both authors contributed equally to this manuscript.

Corresponding author: Vera van Kampen, Ruhr University Bochum (IPA), Institute for Prevention and Occupational Medicine of the German Social Accident Insurance Medical Department, Bürkle-de-la-Camp-Platz 1, 44789 Bochum, Germany (e-mail: kampen@ipa-dguv.de).

For waste collectors and compost workers, the activities and their influence on occupational health have been described in some European studies [2]. Waste collectors usually pick up waste from its point of production, empty refuse containers onto trucks, and deliver the waste to disposal and processing facilities [3,4]. In contrast to this, workers in composting facilities are occupied with the process of biodegradation of organic material by microorganisms under controlled conditions [5]. Most compost workers are involved in various working tasks and often spend more than half of their working day on the wheel loader [6]. A current review has shown that the main occupational hazards in the waste collecting and composting sector are heavy manual handling and exposure to bioaerosols [7]. Bioaerosol exposure is associated with eye, nose, throat, and respiratory symptoms of toxic, irritant or allergic origin [7,8]. In Germany, there exist certain accident prevention regulations for the waste collecting and composting sector [9,10].

Less is known about the hazards and health effects of street cleaning, and there are no general regulations in this field. Like waste and compost workers, street cleaners are physically stressed and exposed to bioaerosols which can cause musculoskeletal and respiratory symptoms. When cleaning public facilities or emptying garbage cans, they may suffer from cut injuries, skin irritations and infections. Because they mostly work outdoors, they are exposed to cold, wind or heat. Environmental/traffic pollution (dust, particulate matter, ozone, carbon monoxide, nitrogen oxides) and natural UV exposure have to be taken into account as well. In this context, it is of interest that solar occupational UV exposure is a major determinant of the incidence of cutaneous squamous cell carcinoma [11].

In most countries, regardless of whether these are developing, emerging or industrialized countries, street cleaning is predominantly done by hand sweeping by an individual worker or a group. Sweeping can be done with push brooms, as is often the case in developing countries, or mechanically, e.g., by using leaf blowers. However, street

cleaners also work with sweepers, machines and mowers or gritting vehicles. In general, activities of street cleaners and the associated health hazards seem to be very complex.

The aims of this review were to clarify which occupational hazards are relevant, whether appropriate studies on health effects have already been published, and whether preventive recommendations exist and are being followed. Moreover, the authors intended to prove whether some new preventive recommendations could be extracted from the scientific literature.

METHODS

A systematic search of international studies listed in PubMed (MEDLINE), using the following medical subject heading (MeSH) terms # sweepers or (street AND (cleaner OR cleaning OR sweeping) AND (occupational OR health OR adverse)) AND (“2000/01/01”[Date – Publication]: “3000”[Date – Publication]), and in Google SCHOLAR, using the following MeSH terms # street cleaner AND occupational health OR street sweeping AND occupational health OR street cleaning and occupational health, was conducted in January 2000–November 2018. Moreover, the authors checked references in the previously identified papers and added any relevant studies (snowballing). Only papers in English and German were included.

In addition, other sources were taken into consideration. The authors searched for the available “grey literature” of German origin about the working tasks of street cleaners, and their physical and mental stress. Grey literature means research that is either unpublished or has been otherwise published, e.g., reports from municipalities or occupational health centers, and the statutory accident insurance.

RESULTS

Selection of studies

The literature search using PubMed and Google Scholar retrieved 1220 studies, and 47 studies were found by snowballing, resulting in a total of 1267 publications (includ-

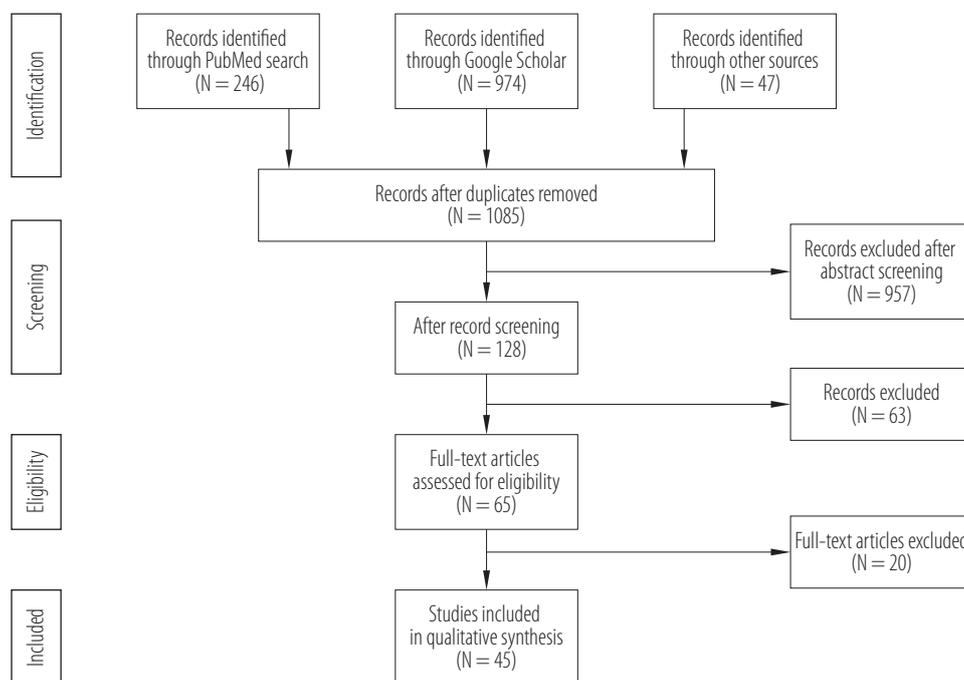
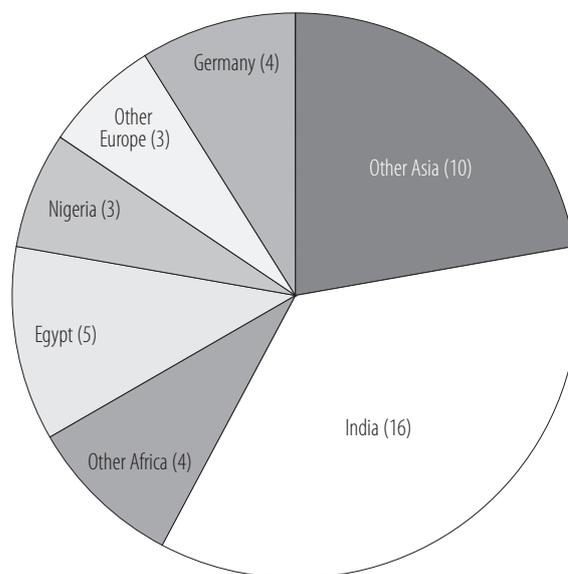


Figure 1. Flow diagram summarizing the selection and exclusion process during systematic search of international studies on street cleaning, selected in January 2000–November 2018

ing 34 grey literature papers). After duplicates were excluded, 1085 hits remained. The titles and abstracts were independently screened by 3 reviewers and 65 full-text articles were assessed for eligibility. Finally, 45 full-text articles were included (Figure 1). Most of these publications (N = 39, 83%) originated from countries outside Europe, mostly from emerging and developing countries like India, Egypt and Nigeria (Figure 2). Details and results of 28 studies evaluating health effects by using appropriate statistical methods are shown in Tables 1 and 2.

Due to the fact that waste management, as well as the composition and amount of waste, and also working conditions of employees, vary widely by country and region, the authors decided to analyze the literature from emerging and developing countries separately from that regarding industrialized countries. Due to the fact that the literature search did not reveal any publications from outside Europe (e.g., North America, Australia), the latter evaluation refers to countries within Europe.



Other Asia – Bangladesh (2), Iran (2), Thailand (2), Indonesia (2), Pakistan (2), Korea (1); other Africa – Ethiopia (1), Kenya (1), South Africa (1), Tanzania (1); other Europe – Greece (2), Spain (1).

Figure 2. Number of included studies selected in January 2000–November 2018 regarding occupational hazards of street cleaners from different continents/countries (all N = 45)

Table 1. Characteristics and origin of the selected studies on the occupational health of street cleaners/sweepers, selected in January 2000–November 2018

Reference	Country	Study design	Study population	Selection criteria	Outcome parameters	Outcome assessment
Ajay et al., 2014 [27]	India	CS/CG	<ul style="list-style-type: none"> - 50 female street sweepers - 50 matched for age - healthy females 	none	lung function	spirometry, 3 maneuvers
Anwar et al., 2013 [26]	Pakistan	CS/CG	<ul style="list-style-type: none"> - 100 street sweepers (45% female) - 100 healthy non-smokers of both sexes from the same socio-economic group 	aged 30–60 years, occupational dust exposure continuing for > 5 years; of the 130 study subjects initially examined, 30 were excluded for various reasons	health problems	questionnaire, chest radiograph (p.a. view), and spirometry
Arora and Kaur, 2016 [58]	India	CS/CG	<ul style="list-style-type: none"> - 60 street sweepers - 60 control subjects not exposed to dust, matched for age, weight and height 	non-smokers, aged 25–30 years, employed for > 2 years; no chronic disease	health problems, lung function	spirometry
El-Wahab et al., 2015 [36]	Egypt	CS	<ul style="list-style-type: none"> - 346 waste workers (2 female) 	employed for ≥ 1 year; consent was signed by 346 of 1300 workers	HAV, HBV, HIV seroprevalence	interview (questionnaire), serology
Erah et al., 2018 [59]	Nigeria	CS	<ul style="list-style-type: none"> - 46 street sweepers (33% female) 	none	health problems, preventive measures	interview (administered questionnaire)
Ewis et al., 2013 [14]	Egypt	CS/CG	<ul style="list-style-type: none"> - 138 street sweepers and waste collectors (all male) - 127 matched university workers and clerks 	random sampling; 26 participants refused to give blood samples for the analysis and withdrew from the study	health problems, infections, occupational risks, preventive measures	questionnaire, medical examination, blood and stool samples, chest X-ray if chest complaints were reported
Habybabady et al., 2018 [21]	Iran	CS/CG	<ul style="list-style-type: none"> - 84 street sweepers - 80 office workers 	random sampling	respiratory problems, lung function	questionnaire, spirometry
Jeong, 2017 [37]	Korea	CS	<ul style="list-style-type: none"> - 354 persons (23% female) 	patients with accidental injuries from street cleaning jobs who took ≥ 4 days off work following an accident during a 3-year period (2009–2011)	work-related injuries, street cleaning processes were classified into 5 categories	official reports
Johncy et al., 2013 [51]	India	CS/CG Pre vs. post sweeping	<ul style="list-style-type: none"> - 25 female street sweepers aged 20–50 years - 25 healthy female control subjects 	subjects suffering from any diseases which affected their pulmonary functions, or from other systemic illnesses, were excluded	lung function	spirometry, 3 maneuvers

Johny et al., 2014 [30]	India	CS/CG	<ul style="list-style-type: none"> - 30 female street sweepers, mean age: 40 years - 30 healthy female control subjects, mean age: 40 years 	<p>subjects with past history of acute or chronic respiratory infections or other systemic illnesses were excluded</p> <p>subjects with diabetes mellitus, hypertension, pulmonary tuberculosis and respiratory diseases were excluded from the study</p>	lung function	spirometry, 3 maneuvers
Johny et al., 2014 [12]	India	CS/CG	<ul style="list-style-type: none"> - 30 female street sweepers, mean age: 40 years - 30 healthy female control subjects matched for age and socioeconomic standards 	<p>subjects with diabetes mellitus, hypertension, pulmonary tuberculosis and respiratory diseases were excluded from the study</p>	respiratory symptoms, irritation, skin, back pain	modified MRC
Juhi, 2016 [29]	India	CS/CG	<ul style="list-style-type: none"> - 86 street sweepers (63% female) - 86 healthy control subjects matched for age, sex, height and weight 	<p>non-smokers without chronic diseases, working for >5 years, aged 25–50 years</p>	health problems, occupational hazards	questionnaire, physical examination, spirometry
Mostafa et al., 2015 [28]	Egypt	CS/CG	<ul style="list-style-type: none"> - 107 male street sweepers - 104 male office workers 	<p>the sample size was calculated using information on the prevalence of respiratory symptoms in street sweepers (18%) from former studies</p>	socio-demographic factors, preventive measures, respiratory complaints	questionnaire, spirometry
Nku et al., 2005 [18]	Nigeria	CS/CG	<ul style="list-style-type: none"> - 200 female street sweepers - 200 matched healthy female control subjects 	<p>none</p>	exposure assessment, health problems	gravimetric dust sampler, modified MRC questionnaire, spirometer, peak flow meter
Pintakham and Siriwong, 2015 [34]	Thailand	CS	<ul style="list-style-type: none"> - 75 street sweepers 	<p>full-time workers aged 18–60 years</p>	health hazards	<ul style="list-style-type: none"> - first phase: face-to-face questionnaire interviews - second phase: focus group discussion
Preisser et al., 2016 [45]	Germany	CS	<ul style="list-style-type: none"> - 65 refuse collectors, including street sweepers (N = 18, female N = 3) 	<p>3 task-specific groups (residual and organic waste collection, street sweeping, street cleaning)</p>	physical endurance	<ul style="list-style-type: none"> - CPX under laboratory conditions - portable CPX system and pulse belt (N = 5) - spirometry and body plethysmography
Rachiotis et al., 2012 [47]	Greece	CS/CG	<ul style="list-style-type: none"> - 100 waste collectors (11% female) - 108 gardeners (55% female) 	<p>exclusion in the case of prior vaccination against hepatitis A virus infection</p>	health problems, HAV infections	<ul style="list-style-type: none"> - questionnaire, anti-HAV antibodies (ELISA)

Table 1. Characteristics and origin of the selected studies on the occupational health of street cleaners/sweepers, selected in January 2000–November 2018 – cont.

Reference	Country	Study design	Study population	Selection criteria	Outcome parameters	Outcome assessment
Rachiotis et al., 2012 [48]	Greece	CS/CG	– 100 waste collectors (11% female) – 108 gardeners (55% female)	exclusion in the case of prior vaccination against hepatitis B virus infection	health problems, HBV infections	questionnaire, HBsAg, anti-HBs, and anti-HBc (ELISA)
Sabde and Zodpey, 2008 [15]	India	CS/CG	– 273 street sweepers (45% female) – 142 class IV employees (32% female)	all street sweepers working in a randomly selected zone (Hanumannagar Zone) of Nagpur Municipal Corporation, Nagpur	health problems	pretested proforma
Sabde and Zodpey, 2008 [20]	India	CS/CG	– 273 street sweepers (45% female) – 142 class IV employees (32% female)	all street sweepers working in a randomly selected zone (Hanumannagar Zone) of Nagpur Municipal Corporation, Nagpur	health problems	pretested proforma
Salve and Bansod, 2017 [33]	India	CS/CG	– 180 street sweepers – 180 non-sweepers	systematic random sampling	MSDs	interviews (modified SNQ)
Salve and Chokhandre, 2016 [32]	India	CS/CG	– 180 street sweepers – 180 non-sweepers	stratified systematic random sampling design; representative samples of 30 street sweepers and 30 non-sweepers from 6 out of 24 municipal wards.	health problems, MSDs	interviews (modified SNQ)
Sangolli et al., 2018 [23]	India	CS/CG	– 80 street sweepers (29% female) – 50 control subjects matched for age and sex	street sweepers working for >5 years, no respiratory infection within 2 weeks, no chronic diseases	respiratory problems, lung function	semi-structured questionnaire, spirometry
Sani et al., 2017 [24]	Iran	CS/CG	– 100 street sweepers – 100 control subjects from the administrative staff	none	respiratory problems, lung function	examination regarding respiratory symptoms, spirometry
Shadab et al., 2013 [25]	India	CS/CG	– 110 street cleaners (30 smokers) – 60 matched control subjects (30 smokers)	street cleaners working for >5 years; subjects with URTI within 2 weeks prior to testing or having chronic illnesses were excluded	lung function	spirometry
Singh and Chokhandre, 2015 [31]	India	CS/CG	– 200 waste collectors (42% female) – 213 control subjects, mostly daily wage laborers (16% female)	power calculation N = 441; waste collectors' response rate: 90%; control subjects' response rate: 95%	health problems, MSDs	SNQ (translated into the Hindi language), anatomical diagram with labels and arrows

Stambuli, 2012 [22]	Tanzania	CS/CG	- 102 street sweepers (70% female) - 85 street vegetable sellers (82% female)	exposed and unexposed groups who were smoking and tobacco using (recent and past use) were excluded	health problems, preventive measures	Respiratory Symptoms Questionnaire by ATS, close-ended questions
---------------------	----------	-------	--	---	--------------------------------------	--

CG – control group; CS – cross-sectional study.
 ATS – American Thoracic Society; CPX – cardiopulmonary exercise testing; MRC – British Medical Council Respiratory Disease Questionnaire; SNQ – Standardized Nordic Questionnaire.
 HAV – hepatitis A virus; HBcAg – hepatitis B core antigen; HBsAg – hepatitis B surface antigen; HBV – hepatitis B virus; HIV – human immunodeficiency viruses;
 MSDs – musculoskeletal disorders; p.a. – posterior-anterior projection; URTI – upper respiratory tract infection.

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
Ajay et al., 2014 [27]	- none	- none	- street sweepers had lower FVC, FEV ₁ , PEFR than control subjects	- lung function parameters (p < 0.001); decrease in all values within the first 5 years of employment (p < 0.001).	- the authors discussed restrictions due to the deposition of harmful airborne dust particles that are inhaled during sweeping; FEV ₁ /FVC were not analyzed; smoking was not considered – the authors suggested using long-handled brooms to reduce the direct exposure to dust, using PPE, and sprinkling water on the street prior to sweeping
Anwar et al., 2013 [26]	- symptoms, i.e., cough with expectoration and shortness of breath in street sweepers (data on control subjects n.a.)	- subjects with exposure to dust for >10 years were more often symptomatic	- street sweepers had lower FVC, FEV ₁ , FEV ₁ /FVC, FMEF, MEF/FVC than control subjects	- FVC n.a., FEV ₁ p < 0.05, FMEF p < 0.0001 – subjects with exposure to dust for >17 years significantly (n.a.) more often suffered from airway obstruction	- X-ray evaluation and symptoms are only descriptive – sweepers did not use masks or other PPE during working hours
Arora and Kaur, 2016 [58]	- none	- none	- street sweepers had lower FVC, FEV ₁ , FEV ₁ /FVC, MVV, PEFR than control subjects	- all lung function parameters except PEFR (p < 0.05)	- the authors suggested that street sweepers should undergo a pre-employment surveillance test and regular health check-ups

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018 – cont.

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
El-Wahab et al., 2015 [36]	<ul style="list-style-type: none"> of the total group of waste workers (N = 346), HBV vaccination was reported by 199 (56.5%) 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> seropositivity: <ul style="list-style-type: none"> total group – HBV: N = 125 (36.1%), HCV: N = 29 (8.4%), HIV: N = 0 street sweepers – HBV: N = 0, HCV: N = 2 (12.5%), HIV: N = 0 	<ul style="list-style-type: none"> HCV infection associated with direct exposure to solid waste (Exp(B) 1.7, 95% CI 0.8–3.7). 	<ul style="list-style-type: none"> the need for compulsory HBV immunization prophylaxis was expressed strict compliance with established hygienic guidelines should be mandatory to avoid occupational HCV infections
Erah et al., 2018 [59]	<ul style="list-style-type: none"> 83% cough, 74% catarrh, 33% sneezing, 26% phlegm, 17% chest pain, 7% nose irritation, 4% noisy breathing, and 2% difficulty in breathing 67% had a good knowledge of respiratory symptoms 65% used PPE 	<ul style="list-style-type: none"> good knowledge was significantly associated with an increased use of PPE (p < 0.05) and a lower frequency of symptoms (p = 0.001) 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> most respondents used PPE, but the use was found to be irregular and infrequent about two-fifths of the respondents who failed to use PPE cited the unavailability of PPE as their excuse the authors suggested education and the use of PPE
Ewis et al., 2013 [14]	<ul style="list-style-type: none"> prevalence of symptoms higher in street sweepers than in control subjects: <ul style="list-style-type: none"> chronic productive cough (18.1% vs. 7.1%) skin irritation (13.8% vs. 2.4%) eye irritation, low back pain, joints pain 	<ul style="list-style-type: none"> p = 0.02 p = 0.002 not significant 	<ul style="list-style-type: none"> HBV (6.5% vs. 3.9%) HCV (18.1% vs. 8.7%) parasitic infections (21.7% vs. 11.8%) lower hemoglobin levels than in control subjects 	<ul style="list-style-type: none"> p = 0.5 p = 0.03 p = 0.04 p = 0.001 	<ul style="list-style-type: none"> none of the street sweepers, but all university workers, had health insurance and regular health check-ups none of the street sweepers used PPE street sweepers had significantly higher smoking rates than university workers (30.4% vs. 18.1%, p = 0.001) the authors suggested vaccination, PPE, and regular health check-ups

<p>Habybabady et al., 2018 [21]</p>	<ul style="list-style-type: none"> - chances of experiencing cough, phlegm, dyspnea and wheezing: 21.9, 48.6, 4.3 and 15.8 times higher in street sweepers than in control subjects 	<ul style="list-style-type: none"> - respiratory symptoms: more prevalent in street sweepers ($p < 0.001$) 	<ul style="list-style-type: none"> - all lung function parameters were lower in street sweepers than in control subjects 	<ul style="list-style-type: none"> - significantly lower PEF and FEV_{25-75%} in street sweepers ($p < 0.001$) 	<ul style="list-style-type: none"> - recommendations of preventive measures, such as long-handled brooms, modern cleaning equipment, sprinkling water on the street before sweeping - limiting the duration of work to 3-4 days/week, use of PPE, and regular spirometry - detailed information on the extent of injuries was not available in the source documents - equipment designed to suit older workers' physical conditions should be adopted for accident prevention - work should be arranged against the traffic flow, and highly visible clothing as well as glow-in-the-dark warning devices should be provided
<p>Jeong, 2017 [37]</p>	<ul style="list-style-type: none"> - slips, trips and falls (58%) were the most common types of accidents, followed by traffic accidents (24%) - 79% of all accidents involved injured persons aged >50 years - main injured parts of the body: trunk (24%), leg/foot (22%), arm (17%), hand/finger (7%) 	<ul style="list-style-type: none"> - distribution of injured persons was significantly influenced by the cleaning process and age ($p = 0.055$), work experience ($p = 0.004$), injured part of the body ($p < 0.001$), accident type ($p < 0.001$), agency of accident ($p < 0.001$) 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - workers work for 4-5 h/day and 6 days/week without using PPE - the sweepers included had mean FEV 77.1% predicted - recommendations: protection of the workers, effective dust control measures, assessment of lung function by spirometry
<p>Johny et al., 2013 [51]</p>	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - lung function measurements before and after sweeping: lower mean absolute values and percentage predicted values for FVC, FEV₁, PEF_r, FEF_{25-75%} and FEF₂₀₀₋₁₂₀₀ after sweeping; increase in FEV₁/FVC 	<ul style="list-style-type: none"> - decrease in the mean absolute values, all $p < 0.0001$ - decrease in the mean percentage predicted values, FVC, FEV₁/FVC, FEF_{25-75%}, all $p < 0.001$. - FEV₁ $p = 0.03$, PEF_r $p = 0.05$, FEF₂₀₀₋₁₂₀₀ $p = 0.02$ 	<ul style="list-style-type: none"> - workers work for 4-5 h/day and 6 days/week without using PPE - the sweepers included had mean FEV 77.1% predicted - recommendations: protection of the workers, effective dust control measures, assessment of lung function by spirometry

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018 – cont.

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
Johncy et al., 2014 [30]	<ul style="list-style-type: none"> street sweepers vs. control subjects: <ul style="list-style-type: none"> nose irritation (50% vs. 26.6%), sneezing (46.6% vs. 20%), rhinitis (40% vs. 16.6%), cough (36.6% vs. 13.3%), phlegm (26.6% vs. 6.6%), wheezing (23.3% vs. 3.3%), tightness (16.6% vs. 6.6%), dyspnea (13.3% vs. 3.3%) non-respiratory symptoms: back pain (70% vs. 36.6%), skin lesions (23.3% vs. 3.3%), chest pain (10% vs. 3.3%), headache (16.6% vs. 20%) 	<ul style="list-style-type: none"> prevalence of nose irritation, sneezing, cough, wheezing, rhinitis, phlegm, back pain in street sweepers significantly higher than in control subjects ($p < 0.05$) nose irritation, sneezing, cough, rhinitis, phlegm, back pain higher in workers with the duration of employment >10 years vs. <10 years ($p < 0.05$) 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> the authors suggested periodic assessments of lung function by spirometry sweeping should be done only 4 h/day and 6 days/week instead of using short-handled brooms which require bending the body and cause back pain in due course, sweepers may be advised to use long-handled brooms
Johncy et al., 2014 [12]	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> street sweepers had lower FVC, FEV₁, PEF_R, FEF_{25-75%} than control subjects no difference in FEV₁/FVC lung function impairment increased with the duration of exposure to dust in street sweepers 	<ul style="list-style-type: none"> FVC $p = 0.002$, FEV₁ $p = 0.007$, PEF_R $p = 0.003$, FEF_{25-75%} $p < 0.001$, FEF₂₀₀₋₁₂₀₀ $p = 0.01$ negative correlation between the duration of exposure and FVC, FEV₁, PEF_R, FEF_{25-75%} and FEF₂₀₀₋₁₂₀₀; all $p < 0.001$. 	<ul style="list-style-type: none"> the prolonged exposure to dust in street sweepers resulted in an obstructive pattern of lung impairment appropriate preventive and precautionary measures are needed
Juhi, 2016 [29]	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> none 	<ul style="list-style-type: none"> all lung function parameters in street sweepers were lower than in a general population 	<ul style="list-style-type: none"> street sweepers had significantly lower FVC, FEV₁, PEF_R, FEF_{25-75%} and FEF₂₀₀₋₁₂₀₀ ($p < 0.04$) 	<ul style="list-style-type: none"> the prolonged exposure to dust in street sweepers resulted in an obstructive pattern of lung impairment appropriate preventive and precautionary measures are needed

<p>Mostafá et al., 2015 [28]</p>	<ul style="list-style-type: none"> - chronic cough higher in street sweepers (17.5% vs. 5.8%), wheezes lower than in control subjects (1% vs. 23.1%); no difference in chest tightness (19.4% vs. 20.3%) 	<ul style="list-style-type: none"> - chronic cough p = 0.009 - wheezes p = 0.0001 	<ul style="list-style-type: none"> - more street sweepers had reduced lung function than control subjects: FEV₁ (62.1% vs. 34.6%), FVC (58.3% vs. 44.2%) FEV₁/FVC (32% vs. 18.3%) 	<ul style="list-style-type: none"> - FEV₁ p = 0.0001, FVC p = 0.049, FEV₁/FVC p = 0.022 - logistic regression model: smoking associated with impaired FEV₁/FVC (p = 0.045); duration of employment (≥ 10 years) associated with impaired FVC (p = 0.01) 	<ul style="list-style-type: none"> - all of the street sweepers enrolled in this study mentioned the non-use of PPE - it is recommended that occupational health services provide and train street sweepers to use PPE or to decrease the risk of exposure to road dust; they should also encourage quitting smoking - periodic medical examination should be done for the early detection of respiratory impairments
<p>Nku et al., 2005 [18]</p>	<ul style="list-style-type: none"> - higher prevalence of back pain (40.5% vs. 2.0%), cough (25.5% vs. 12.0%), chest pain (13.0% vs. 4.0%), catarrh and sneezing (6.0% vs. 0.5%) among street sweepers compared to control subjects 	<ul style="list-style-type: none"> - back pain p < 0.001, cough p < 0.001, chest pain p < 0.001, catarrh and sneezing p < 0.01 	<ul style="list-style-type: none"> - all lung function parameters were lower in street sweepers than in control subjects 	<ul style="list-style-type: none"> - FVC, FEV₁, FEV₁% and PEFR were not significantly different in the 2 groups 	<ul style="list-style-type: none"> - none of the street sweepers had served for > 2 years - street sweepers used only brooms for sweeping - street sweepers did use PPE to prevent the inhalation of dust - the streets were not watered before sweeping to minimize dust exposure - street sweepers used brooms and a dustpan for cleaning up waste on the road and footpaths
<p>Pintakham and Siriwong, 2015 [34]</p>	<ul style="list-style-type: none"> - health hazards: ergonomic 89.3%, psychological 80.0%, chemical 76.0%, biological 58.7%, physiological 57.3% 	<ul style="list-style-type: none"> - statistical significance was found for the different hazards, e.g., biological hazard with working experience (OR = 0.27, p = 0.009), physiological hazard with age (OR = 3.22, p = 0.048) 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - all workers diagnosed with pulmonary disorders were active or former smokers - employment as a refuse collector should be classified in the upper range of defined heavy work - the limit of heavy work at about 33% of the individual maximum load at continuous work should be reviewed
<p>Preisser et al., 2016 [45]</p>	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - 39% of the street cleaners had heart rate values (%HR_{R,db}) that were > 30% HRR; obstructive lung disease (FEV₁/FVC < 70%) was observed in 21.5% of the subjects 	<ul style="list-style-type: none"> - correlation of both absolute HR and VO₂ during CPX (HR/VO₂ r = 0.89, SD = 0.07) as well as during field measurements (r = 0.78, SD = 0.19) 	<ul style="list-style-type: none"> - all workers diagnosed with pulmonary disorders were active or former smokers - employment as a refuse collector should be classified in the upper range of defined heavy work - the limit of heavy work at about 33% of the individual maximum load at continuous work should be reviewed

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018 – cont.

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
Rachiotis et al., 2012 [47]	– none	– none	– prevalence of HAV infection among waste collectors higher (61% vs. 27%) than among the reference population (p < 0.001)	– logistic regression analysis: age (OR = 22.57, 95% CI: 7.29–69.88), occupational exposure to waste (OR = 2.87, 95% CI: 1.24–6.62), duration of employment (OR = 3.57, 95% CI: 1.15–11.08) and education (OR = 2.19, 95% CI: 1.01–4.78) were associated with HAV infection	– apart from vaccination against HAV, educational campaigns on good work and personal hygiene practices focused on municipal waste collectors could have further essential contribution to the control of HAV infection among members of this occupational group
Rachiotis et al., 2012 [48]	– none	– none	– prevalence of HBV among waste collectors was higher (23% vs. 5.5%) than among the reference population (p < 0.001)	– smoking, drinking or eating during waste collection increased the risk of HAV infection (RR = 2.84, 95% CI: 1.73–4.63). – logistic regression analysis showed that exposure to waste (OR = 4.05, 95% CI: 1.23–13.33) and age (OR = 5.22, 95% CI: 1.35–20.1) were associated with HBV	– no information was collected regarding the possible non-occupational exposure of the municipal employees to HBV (sexual behavior, intravenous use of drugs, tattooing, piercing)
Sabde and Zodpey, 2008 [15]	– more chronic bronchitis (5.9% vs. 1.4%) in street sweepers than in control subjects	– prevalence of chronic bronchitis significantly higher (p < 0.05)	– none	– none	– see the publication by Sabde and Zodpey [20], the same study group

<p>Sabde and Zодpey, 2008 [20]</p>	<ul style="list-style-type: none"> - street sweepers vs. control subjects: <ul style="list-style-type: none"> • respiratory system (15% vs. 9.2%), cardiovascular (9.9% vs. 12.7%), eyes (9.2% vs. 9.9%), upper respiratory tract infections (7.3% vs. 7.0%), chronic bronchitis (5.9% vs. 1.4%), bronchial asthma (1.8% vs. 0.7%). • respiratory morbidity (8.1% vs. 2.1%) 	<ul style="list-style-type: none"> - respiratory morbidity among street sweepers 4.24 higher (95% CI: 1.24–14.5) than in control subjects; the risk increased with the duration of employment 1.75 (95% CI: 1.09–2.81) 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - more smokers among street sweepers than among control subjects (17.9% vs. 10.5%) - none of the 273 street sweepers used PPE due to an irregular supply of PPE and a lack of motivation for using it - recommendation: the use of PPE, motivation to quit smoking, regular health check-ups automation of street sweeping
<p>Salve and Bansod, 2017 [33]</p>	<ul style="list-style-type: none"> - street sweepers were more disabled due to pain in the lower back (27% vs. 18%), wrist/hand (26% vs. 13%), shoulder (24% vs. 9%), elbow (23% vs. 6%), hip/thigh (17% vs. 8%) than control subjects; the number of years engaged in street sweeping, job satisfaction and location of work are important predictors of MSDs 	<ul style="list-style-type: none"> - all differences (p < 0.05); street sweepers working for ≥10 years were significantly more likely to suffer from disabilities in the elbow (OR = 8.12, p < 0.01), hip/thigh (OR = 6.27, p < 0.01), wrist/hand (OR = 4.98, p < 0.01), upper back (OR = 4.40, p < 0.01) and lower back (OR = 3.45, p < 0.01) as those working < 10 years 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - the authors suggested specific programs for educating street sweepers about the health hazards associated with street sweeping and rehabilitation programs for street sweepers with MSD-related disabilities

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018 – cont.

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
Salve and Chokhandre, 2016 [32]	– prevalence of MSDs in street sweepers vs. control subjects: shoulders (32% vs. 11%), wrists/hands (29% vs. 19%), elbows (27% vs. 9%) and neck (17% vs. 11%)	– factors associated with MSDs: duration of employment, job satisfaction, location of work (slums) – street sweepers working for ≥ 10 years more likely to suffer from MSDs in the elbows (OR = 10.79, $p < 0.01$), shoulders (OR = 6.40, $p < 0.01$), wrists/hands (OR = 6.08, $p < 0.01$), upper back (OR = 6.06, $p < 0.01$), neck (OR = 5.41, $p < 0.01$), hips/thighs (OR = 4.49, $p < 0.01$)	– none	– none	– while assessing the exposure of the occupation of sweeping to the development of MSDs, the study adopted the nearest neighborhood method of PSM – past studies demonstrated that job rotation between waste collectors, street sweepers and drivers helped to reduce the workload as well as the risk of MSDs
Sangolli et al., 2018 [23]	– prevalence of respiratory symptoms higher in street workers than in control subjects: cough (30% vs. 20%), chest pain (18% vs. 10%), cataract and sneezing (22% vs. 12%)	– none	– FEV ₁ , FVC, FEV ₁ /FVC, PEFR and FEF _{25-75%} were lower in non-smoking street sweepers than in non-smoking control subjects	– all values except FVC in street sweepers significantly lower ($p < 0.05$) – all values except FVC in smoking street sweepers and in those not using masks significantly lower ($p < 0.05$)	– only 20% of street sweepers regularly used masks – the authors highlighted the importance of using protective masks and of non-smoking

<ul style="list-style-type: none"> - non-smoking vs. smoking street sweepers, and non-smoking street sweepers using masks vs. non-smoking street sweepers not using masks: smokers and street sweepers not using masks had lower values 	<ul style="list-style-type: none"> - values for FEV₁, FVC, FEV₁/FVC, FEF_{25-75%} and PEF lower in street sweepers than in control subjects 	<ul style="list-style-type: none"> - after adjusting for smoking: street sweepers had significantly lower FEV₁ (p = 0.006), FEF_{25-75%} (p = 0.019) and PEF (p = 0.013) 	<ul style="list-style-type: none"> - exposure to dust in street sweepers is likely to cause obstruction in the small airways - recommendations of preventive measures, such as long-handled brooms, sprinkling water on the street before sweeping, restrictions on working hours and days, and regular spirometry
<ul style="list-style-type: none"> - non-smokers: FEV₁ 64% vs. 89% pred., PEFR 66% vs. 90 %pred, FEF_{25-75%} 53% vs. 84 %pred. - smokers: FEV₁ 60% vs. 78 %pred., FEF_{25-75%} 52% vs. 72 %pred 	<ul style="list-style-type: none"> - none 	<ul style="list-style-type: none"> - non-smoker: FEV₁, PEFR, FEF_{25-75%} all p < 0.01; FVC ns. - smokers: FEV₁ p < 0.01, FEF_{25-75%} p = 0.03, FVC, PEFR ns. 	<ul style="list-style-type: none"> - street cleaners should use PPE during cleaning work; the use of modern equipment, sprinkling water on the street before cleaning, and quitting smoking are also recommended; they should undergo regular health check-ups for the early detection of lung function impairment to promote better health of this socially underprivileged group

Sani et al., 2017 [24]

Shadab et al., 2013 [25]

Table 2. Overview on the reported and measured health outcomes from the studies on street cleaners/sweepers with significant findings, selected in January 2000–November 2018 – cont.

Reference	Self-reported health complaints	Significant findings, statistics	Measured health outcome	Significant findings, statistics	Comments/recommendations of authors
Singh and Chokhandre, 2015 [31]	– the 12-month prevalence of MSDs was significantly higher among waste collectors than among control subjects	– any MSDs: 79% vs. 55% ($p < 0.0001$), shoulder 32% vs. 12% ($p < 0.0001$), upper back 40% vs. 21% ($p < 0.0001$), lower back 54% vs. 36% ($p < 0.0001$), knee 48% vs. 35% ($p = 0.008$), ankle 19% vs. 13% ($p = 0.002$), street sweepers working for ≥ 10 years were more likely to report MSDs of the lower back (OR 2.15, $p < 0.05$) compared to those working for 4 years	– none	– none	– the authors stated that the low socio-economic status, housing conditions and poor household hygiene practices of waste collectors contributed to their health vulnerabilities; therefore, it is imperative to promote the state-sponsored cashless health insurance schemes
Stambuli, 2012 [22]	– cough (54.9% vs. 12.9%), phlegm (39.2% vs. 7.1%), wheezing (32.4% vs. 14.1%), nose irritation (35.8% vs. 4.7%) and sneezing (63.7% vs. 8.2%)	– logistic regression model revealed that exposure to street sweeping dust is an important predictor of cough (OR = 8.19, 95% CI: 3.89–17.23), phlegm (OR = 8.49, 95% CI: 3.38–21.23), nose irritation (OR = 0.09, 95% CI: 0.03–0.26), wheezing (OR = 2.91, 95% CI: 1.39–6.09) and sneezing (OR = 19.58, 95% CI: 8.18–46.83)	– none	– none	– recommendations of this Master of Public Health Dissertation: <ul style="list-style-type: none"> • pre-medical examination • workplace risk assessment should be done periodically to identify the level of dust produced during street sweeping because street sweeping dust was observed as the most important predictor for respiratory symptoms • appropriate PPE should be used

FEV₁ – forced expiratory volume in one second; FEF_{25–75%} – forced expiratory flow between 25% and 75% of FVC; FEF_{300–1200} – mean forced expiratory flow between 200 ml and 1200 ml of the FVC (formerly called the maximum expiratory flow rate [MEFR]); FVC – forced vital capacity; HAV – hepatitis A virus; HBV – hepatitis B virus; HIV – human immunodeficiency virus; HCV – hepatitis C virus; MSDs – musculoskeletal disorders; MVV – maximum voluntary ventilation; n.a. – not applicable; PEF(R) – peak expiratory flow (rate); PPE – personal protective equipment; PSM – propensity score matching.

Street cleaning in emerging and developing countries

General considerations

According to the study by Johncy et al. [12], street sweeping is one of the most popular occupations of less privileged people in India. Also in a Nigerian study, about 30% of street sweepers never had any formal education [1]. Most of the 70 street cleaners involved in a cross-sectional survey from Kenya had little knowledge on occupational health hazards and safety, e.g., regarding the transmission of infections [13].

While developed countries take measures to prevent occupational health hazards, this is not the case in developing countries [12,14]. In countries like India and Nigeria, street sweepers often use only short-handled brooms and take no precautionary measures, such as wearing face masks or sprinkling water on the street before sweeping, to minimize dust exposure [1,12]. An Egyptian study also resulted in the finding that none of the 138 street sweepers involved was instructed to use personal protective equipment (PPE), such as masks or gloves, while working. All of them reported neither being vaccinated nor trained before commencing employment. This is remarkable as all of the street sweepers reported coming into contact with blood, fecal matter, broken glass, needles/syringes and animal carcasses [14]. This finding is in accordance with the results obtained in other developing countries like India [15]. According to the authors of the latter study, the reasons for not using PPE were an insufficient supply of protective devices and a lack of motivation for using them.

The reported health problems of street sweepers in emerging and developing countries are manifold. A high percentage of Egyptian street sweepers (95%) reported experience of work-related injuries during the past year, compared to only 21% among university workers ($p = 0.0001$) [14]. Recently, a cross-sectional study from central India was published comprising 20 street sweepers (10 female) doing their job 8–9 h/day for >10 years [16].

Reported health impairments were musculoskeletal disorders (MSDs) (100%), respiratory problems (95%), dermatological problems (90%), headaches (75%) and gastrointestinal problems (15%). Concerning the respiratory problems, allergies (100%), cough and cold (75%), asthma and bronchitis (65%) were reported by the street sweepers surveyed. However, in another Indian study, street sweepers were the most satisfied subgroup of solid waste workers (91% of satisfied respondents). The reasons might be that they earn fixed salaries and there is usually no need to directly touch the municipal solid waste [17].

At this point, it has to be mentioned that even after an appropriate selection, the remaining publications from emerging and developing countries do not always meet the usual standards of international publications. Most of the studies have been published in online journals without a reliable peer review process. In a number of cases, the selection criteria of the examined workers, or the basic characteristics of the study group, such as age or gender distribution, were not described. Nevertheless, these articles show the occupational hazards of street cleaners outside Europe, and the authors often suggest appropriate protective measures, and also general instruction and education (Table 2). Due to this fact, and also because there are only few publications on occupational health hazards of street cleaners from peer-reviewed journals, these studies have been taken into account in the review. In the following, the studies on the main occupational health hazards are evaluated separately.

Working circumstances (e.g., dust exposure, noise, temperature)

Dust samples at the street sweepers' worksite in Calabar, Nigeria, revealed a significantly higher respirable dust level of 0.194 ± 0.002 mg/m³ compared to that of the control sites, which was 0.015 ± 0.003 mg/m³ [18].

Occupational hazards in terms of bioaerosols, noise and thermal conditions for municipal solid waste workers, including 12 street sweepers, were investigated in a study

conducted in South Africa [19]. Personal and environmental sampling was performed in the breathing zone of these workers. Concerning street cleaners, the concentrations of total dust were 0.02–0.5 mg/m³ and fungi were measured in the range of 1.2–2.4 × 10⁴ colony forming units (cfu)/m³.

In a cross-sectional survey based in Kenya, 19% of the surveyed group including 70 street cleaners and 1 public health staffing officer indicated, in the interviews about occupational health, that they were exposed to extreme noise [13]. The study showed that the majority of these workers were not provided with PPE, and that there was a lack of knowledge on occupational health hazards and safety.

Street cleaning, as an outdoor work, is also associated with exposure to cold and hot temperatures. Mean summer temperatures >33°C were measured during street sweeping and were associated with complaints such as headaches, sunburns, heat stress, excessive sweating, dehydration, and difficulties in concentration on the assigned tasks [19].

Respiratory morbidity

Street sweepers are exposed to a variety of inhalable agents such as dust, toxins and traffic emissions, which make them vulnerable to develop occupational respiratory diseases. In a supplementary evaluation of data from a cross-sectional study on 273 street sweepers in India [15], the authors reported chronic respiratory morbidity, taking into account various risk factors such as age, sex, socio-economic status, duration of employment, smoking habit, type of a house, area of residence, cooking fuel, and pets [20]. The proportion of chronic respiratory morbidity in terms of chronic bronchitis, asthma and bronchiectasis was significantly higher among street sweepers (8.1%) compared to a group of office workers (2.1%, $p = 0.016$). Multivariate logistic regression analyses revealed that the risk of having chronic respiratory morbidity among street sweepers was 4.24 times (95% con-

fidence interval [CI]: 1.24–14.50) higher than that in the control group, and the risk increased significantly with the duration of employment (odds ratio [OR] 1.75, 95% CI: 1.09–2.81).

Also, in a recent study using the American Thoracic Society respiratory questionnaire, involving 86 street sweepers and 80 office workers (matched by age and smoking habits), all respiratory symptoms, including cough, phlegm, cough with phlegm, dyspnea and wheezing, were more prevalent in street sweepers than in office workers ($p < 0.001$). It could be shown that the chances of experiencing cough, phlegm, dyspnea and wheezing were 21.9 (95% CI: 9.8–49), 48.6 (95% CI: 6.4–367), 4.3 (95% CI: 2.2–8.3), and 15.8 (95% CI: 6.9–8.3) times higher, respectively, in the exposed group than in the unexposed group [21]. Eleven publications showed that street sweepers reported more frequent respiratory complaints compared to the corresponding control group (Table 2). In this context, it is of interest that, in a study from Tanzania, street sweeping dust was the main factor associated with reported cough, phlegm, wheezing and nose irritation. While age was associated with cough and phlegm, the duration of employment as a street sweeper was associated with cough [22].

Detailed information on the respiratory effects of the occupational exposure of street sweepers is provided in 12 studies in which lung function measurements were performed on both exposed and non-exposed persons (Table 2). Generally, lower lung function values were measured for street cleaners than for control subjects, and with the exception of 1 study [18], this finding was significant. However, according to Nku et al. [18], the lack of any significant difference may be due to the fact that none of the street sweepers had worked for more than 2 years.

While in all studies the values of forced expiratory volume in 1 s (FEV₁) of street sweepers were significantly lower than those of control subjects, this was more moderate for the values of forced vital capacity (FVC) (Table 2). In 3 studies, no difference was found in the FVC values

between street cleaners and control subjects [23–25], indicating an obstructive pattern. Additionally, Sani et al. [24] discussed that, due to the significant decline in forced expiratory flow (FEF_{25-75}) and peak expiratory flow (PEF), dust exposure of street sweepers might cause obstructive changes also in the small airways.

In another study, street sweepers showed a significantly lower forced mid-expiratory flow (FMEF) ($p < 0.00001$) than the control group, which is, according to the authors, also a sign of a small airways disease [26]. In this study, a linear relationship between the development of obstructive airway disease and the duration of exposure to dust was evident. In particular, it could be shown that exposure to non-industrial dust lasting >10 years can be sufficient to cause a moderate degree of airflow obstruction [26].

Other authors also reported a negative correlation between the duration of exposure and lung function values for street sweepers [12,27–29].

In most of the recent studies, the results of lung function measurements were adjusted for smoking [24,28] or the comparison with control subjects was only performed in non-smoking subjects [23,25,29]. Most of these studies showed that the decline of lung function was aggravated in smoking individuals.

Musculoskeletal disorders

Nine studies reported a higher prevalence of back pain in street sweepers compared to control subjects (Table 2). Three studies described increased frequencies of back pain in addition to respiratory problems and other complaints [14,18,30]. Four studies focused on MSDs in street sweepers [31–33], and even some appropriate intervention programs were performed [34]. However, it should be noted that these results were based on interview data in all the studies except the latter.

The location of work performance (e.g., in slums) and the duration of employment in street sweeping were found to be predictors of MSDs after adjusting the data

of 180 Indian street sweepers for age, the body mass index and the caste [32]. In more detail, the street sweepers working for ≥ 10 years were significantly more likely to suffer from disabilities in the elbows (OR = 8.12, $p < 0.01$), hips/thighs (OR = 6.27, $p < 0.01$), wrists/hands (OR = 4.98, $p < 0.01$), upper back (OR = 4.40, $p < 0.01$) and lower back (OR = 3.45, $p < 0.01$), as compared with those working for < 10 years. Also in other studies, a longer duration of employment as a street sweeper turned out to be a significant risk factor for MSDs [31,33].

Interestingly, job satisfaction and MSDs were also found to be associated, as the sweepers who were not satisfied with their job were more likely to suffer from MSDs [32,33].

As mentioned before, in a quasi-experimental study, 68 Thai street sweepers with MSDs (scaled by physiotherapists and sports scientists) were randomly divided into a control group and an intervention group. The latter performed a multidimensional ergonomic intervention (MEI) program to reduce musculoskeletal discomfort. The MEI model was designed on the basis of cognitive behavioral therapy, ergonomic education training, stretching exercise, and the use of foam-sleeve broom-handle grips. While at baseline there was no difference between both groups, after 28 weeks the score of the musculoskeletal discomfort was significantly lower (3.44 vs. 7.06, $p < 0.01$), and the upper (12.4 vs. 9.9) as well as lower body strength (13.2 vs. 9.9) was significantly higher (both $p < 0.01$) in the intervention group than in the control group [34].

Infections

A number of studies have revealed that street sweepers, especially in emerging and developing countries, are at risk of infectious diseases as they are exposed to inhalable matter, microorganisms, injuries, cuts and wounds.

While a Kenyan study found that the involved street cleaners had little knowledge about the possible ways of transmitting infections and diseases [13], interviews with 70 street sweepers and garbage collectors from Egypt showed that

the workers were aware of these health hazards [35]. Nevertheless, they reported not to receive any vaccination against common infectious diseases, e.g., tetanus. They returned home wearing the same clothes as during street sweeping, and also other hygienic attitudes and practices were poor, including eating, drinking or smoking during their work shifts. Nearly all subjects reported that they worked with unprotected hands, and without using any gloves, head covers or masks. They stated that their administration did not offer them any PPE.

In Egypt, a total of 138 street sweepers and waste collectors were investigated for infectious diseases [14]. University workers and clerks ($N = 127$) served as the control group in this cross-sectional study. Besides questionnaire and medical examinations, blood and stool samples were taken for laboratory investigations. Significantly higher rates of hepatitis C virus (HCV) seropositivity (18.1% vs. 8.7%, $p = 0.03$), parasitic infestations (21.7% vs. 11.8%, $p = 0.04$), skin irritation (13.8% vs. 2.4%, $p = 0.002$), and work-related injuries (94.9% vs. 20.5%, $p < 0.0001$) were found in street sweepers. Also, the prevalence of hepatitis B virus (HBV) seropositivity (6.5% vs. 3.9%) was higher in street sweepers than in university workers; however, this difference was not statistically significant. While none of the 138 street sweepers was vaccinated, got periodic medical examinations or had health insurance, all university workers had health insurance and reported having regular health check-ups ($p = 0.0001$).

In another cross-sectional study conducted in Egypt, 346 municipal solid waste workers, including 38 street sweepers, were investigated to explore the occurrence of HBV, HCV and HIV [36]. Of the total number, HBV vaccination was reported by 199 (56.5%) workers. The overall seroprevalence, indicating a hepatitis infection in waste workers, was 36.1% (HBV) and 8.4% (HCV). Only 2 street sweepers showed isolated HCV seropositivity while no HIV infection was detected. In addition to past history of parenteral anti-schistosomal therapy and intravenous infu-

sion, the rate of HCV was associated with direct exposure to solid waste, as shown by stepwise logistic regression (Exp(B) 1.7, 95% CI 0.8–3.7). The relative higher prevalence of HBV compared to HCV among the whole group of waste workers was explained by the authors as hepatitis B being the most likely infection from a needle stick injury. They recommended a compulsory HBV immunization prophylaxis and strict compliance with established hygienic guidelines to avoid occupational HCV infections.

Cognitive and mental aspects of accidents

Human physiological functions change with age. Like older people in general, older cleaning and waste workers have a poor sense of balance, a limited perceptive ability and a lack of judgment in dangerous situations. This can cause problems especially in the dark season, or when working at night or early in the morning. If a worker cannot balance him/herself when he/she slips, he/she may lose balance and fall, which can lead to various injuries. These associations were reported in a study analyzing injuries from street cleaning jobs in Korea in 2009–2011. Slips, trips and falls represented the most common type of accidents (58%), followed by traffic accidents (24%), and 79% of all accidents involved injured persons aged >50 years. In addition, the rate of injuries caused by slipping on ice or snow was the highest among the elderly, and in particular among elderly women [37].

Additionally, authors from, e.g., India, Nigeria and Bangladesh reported that street sweepers were mostly less privileged, fell within the low income class, and had a relatively high proportion of illiterates [1,12]. All these socio-demographic characteristics are also related to physical and mental health hazards of street sweepers, and especially to accidents.

The low social position of street sweepers might contribute to a low risk perception at work, as shown by a study on 15 street sweepers in Dhaka, Bangladesh [38]. The sweepers come from a disadvantaged community in

the society where they feel significant social exclusion and internally adopt beliefs of inferiority. More than one-third of them were found to believe that infections, injuries, accidents and death can happen to anyone, at any time, and anywhere, thus normalizing the perception of injury and health problems. Some workers believed that they had developed a natural defense system in their body, and strong faith-based explanations were found to rationalize the possible health hazards. In addition, street sweepers were found to rationalize the amount of occupational and health hazards that they were exposed to as a result of their relatively low social position.

The prevalence and magnitude of health problems and associations with socio-demographic characteristics were evaluated in a cross-sectional study on 75 street sweepers (male and female) in Thailand [34]. The results of the hazard questionnaire indicated that ergonomics was ranked as a major hazard (89%), followed by psychological hazard (80%), chemical hazard (76%), biological hazard (59%), and physiological hazard (57%). In that study, the psychological hazard increased significantly with age ($p = 0.048$).

Street cleaning in Europe and Germany

General considerations

(with special consideration of the VerEna project)

With the creation of the EU internal market in 1993 and the privatization of municipal utilities, there was an increase in economic pressure in the entire waste management sector. For the already physically burdened employees, this resulted in workload compression and an increased burden of work [39]. Given this combined strain, the waste management sector continued to experience a high incidence of accidents. For the entire waste management sector, the 1000-Mann-Quote (TMQ), i.e., the number of accidents per 1000 full-time employees, is 98, for the solid waste disposal sector 128, and for the street cleaning sector 65 [39].

As a result of the reference circumstances, a project entitled “VerEna – Verhütung arbeitsbedingter Gesundheitsgefahren im Entsorgungsbereich” (Prevention of occupational health risks in the disposal sector) was initiated in 1999 [39], involving German social accident insurance institutions and different statutory health insurance institutions. In the VerEna-based prospective intervention study, a general risk assessment recording the health hazards in the sector of waste disposal (street cleaning, waste management, wastewater disposal) was performed, followed by specific instructions for prevention practices at the workplaces of street sweepers [39,40].

Twenty-one municipal waste management companies participated in the VerEna project. In order to get a picture of the work-related strain and health risks, primary data were collected by way of employee surveys (questionnaires), structured surveys (with executives, occupational safety experts, occupational health physicians and employee representatives), and workplace inspections. Physical examinations of employees were not carried out. In the second step, data regarding the frequencies and diagnoses of incapacity for work, as well as accidents at work, obtained from social accident insurance institutions and employee health insurances institutions, were analyzed. To ensure sustainability of the VerEna project, a follow-up project, VerEna II, was carried out in 2004–2005 [40]. Out of the 21 waste management companies, 16 were again involved in the VerEna II project.

A total of 4558 employees took part in the surveys, representing about 70% of possible participants. Concerning the 1470 street cleaning employees, 356 (24%) were drivers of large machines, 266 (18%) were drivers of small sweeping machines, and 848 employees (58%) were doing manual street cleaning. For some employees, a variety of health hazards were apparent. The experience of strain was modulated by high levels of physical stress, the increasing mental stress, the pressure to perform, social conflicts, organizational inefficiencies in the operation, and ruthless behavior of other road users.

The fields of action derived from the results of the first VerEna-based study (2001–2002) were only qualitatively mentioned in the guidelines for prevention practices. Quantitative data on the proportionate distribution of the problem areas were not mentioned [40]. Especially for street cleaners, the following problem areas could be identified:

- low social recognition of cleaning work,
- special burdens due to winter service,
- inadequate cooperation of waste management and street cleaning departments in the disposal areas,
- deficits in equipment with technical aids,
- social conditions in the depots, e.g., partly insufficient equipment of companies with sanitary facilities and social rooms.

Companies were able to derive specific proposals for action and recommendations by the involvement of the considered companies, health and safety professionals and the external prevention advisors of the social insurance. Considered topics were:

- work planning and procedures,
- teamwork,
- work equipment,
- working atmosphere,
- communication and information,
- management style,
- behavioral prevention,
- canteen catering.

Steering committees were set up in many participating waste management companies. They were important for the implementation of occupational health management and served as an intermediary between the company management and employees.

The processes initiated by the VerEna and VerEna II projects led to changes as far as the soft factors are concerned. Thus, both job satisfaction and the working climate improved. Job satisfaction rose from 11.4% to nearly 29%. However, job satisfaction remains rather low and there

is still a need for preventive action in the area of work organization and personnel management. Moreover, the evaluation of the data of the health insurance institutions showed that there is a need for further prevention. The disposal industry is still dominated by MSDs followed by respiratory diseases. Heterogeneous developments were seen when comparing the development over time. For example, the proportion of MSDs that led to a reportable incapacity for work fell from around 27% in 2000 to around 23% in 2004, while the share of respiratory illness increased by about the same proportion. It should also be emphasized that the proportion of mental illnesses more than doubled within the survey period. With regard to the age structure of the workforce, the municipal waste disposal sector is characterized by a relatively high average age (45–48 years). Although the older employees were not more often on sick leave than the younger ones, they were absent for longer periods when they were ill.

At the end of the VerEna project, it became clear that, in order to be successful, prevention must be an integral part of day-to-day operations, and that there is still a need for action especially in the area of human resources management and work organization.

In another German study, which was also carried out together with statutory health insurance institutions, the sick leave in single occupations due to cardiovascular diseases and MSDs was documented [41]. Based on the data of insured subjects from almost all statutory health insurance institutions, aged 18–64 years in 2008, the standardized morbidity ratios (SMRs) of sick leaves of 55 316 male street cleaners and waste workers, in comparison to 844 709 office workers and higher qualified occupations in the administration and business sectors, are shown in Table 3. With regard to the 19 diseases, only for 2 diseases (heart failure and stroke) the insured street cleaners showed lower SMRs than control subjects. Otherwise, they had significantly higher SMRs, especially for MSDs such as back pain, shoulder lesions, and other enthesopathies.

Since smoking has an important influence especially on cardiovascular diseases, and may be higher in the rather low-skilled group of street cleaners/waste workers than in office workers, the authors also analyzed the corresponding data on sick leaves of other cleaners (working in buildings) which, however, showed much lower SMRs than among street cleaners/waste workers (data not shown).

Working circumstances (e.g., dust exposure, noise, temperature)

During different jobs in street cleaning, such as sweeping with push brooms, using leaf blowers and emptying public rubbish bins, workers are exposed to biological agents. According to the German regulation, these activities are among the non-targeted activities with biological agents within the meaning of the Biological Agents Ordinance, BioStoffV. Against this background, Neumann et al. [42] aimed to quantify the amount of biological agents during different activities in street cleaning. The concentration range for total fungi was around a magnitude of 10^3 – 10^4 cfu/m³ which is rather low in comparison to other jobs in the waste disposal and removal sector, with levels in the range of 10^5 – 10^6 cfu/m³ [2]. The highest values for total fungi were measured during the manual handling of trash. In general, bacteria concentrations were higher than those for fungi; especially the concentrations recorded for dust-raising activities, such as working with leaf blowers, reached values $>10^4$ cfu/m³.

The relevant sources of noise in leaf blowers are combustion engines and blowers. The sound power levels of the engines are generally 106–112 dBA. Devices with internal combustion engines emit, besides particles, exhaust gases including hydrocarbons and nitrogen oxides, which also contribute to the formation of ground-level ozone, and carbon monoxide [43].

Depending on the season, relevant exposure to soil particles and pollen may also occur. Fungal spores and pollen may have allergenic properties while microorganisms derived from animals, e.g., dog feces, may be pathogenic to

humans. When applying leaf blowers, significant increases in germ concentrations for intestinal bacteria (Enterobacteriaceae: 120 cfu/m³), compared to background measurements, were registered. Fungal concentrations were in the range of 2 – 10×10^3 cfu/m³ [44].

The workload of refuse workers (including 18 street cleaners) in Hamburg, Germany, was determined in a field study [45]. Cardiopulmonary exercise (CPX) testing was performed in 13 subjects (5 street cleaners) using a mobile CPX device. Compared to the known reference limits for heavy work, 44% of the total group had shift values $>30\%$ of the heart rate reserve; 34% of the individuals had values of the mean heart rate during work that were above the heart rate corresponding to 30% of the individual maximum oxygen uptake. All individuals had a mean oxygen uptake $>30\%$ of the maximum oxygen uptake. The authors suggested that employment as a refuse worker should be classified in the upper range of defined heavy work.

Respiratory morbidity

Seele et al. [46] performed a retrospective analysis of a chronic obstructive pulmonary disease (COPD) screening initiative in a large German waste disposal company. The results of medical anamnesis, work-related questionnaire data and lung function data of 645 participants were included in the analysis. A statistical relationship between the probability of COPD diagnosis and employment in street cleaning, refuse collection, fleet management and administration was observed. However, due to the high proportion of smokers and the high prevalence of COPD also in the administration sector, the authors considered a causal link to substances inhaled at the workplace to be unlikely.

Musculoskeletal disorders

In a German cross-sectional study, 62 employees of the municipal waste collection services of the City of Hamburg were investigated. The most common health problem was back pain, reported by 67.2% of the participants.

Table 3. Standardized morbidity ratios (SMRs) of 55 316 male street cleaners and waste workers, based on the sick leave data of German statutory health insurance institutions in 2008 [41]

Disease	Cases [n]	SMR (99.9% CI)	Label
Hypertension	2106	1.57 (1.44–1.70)	+
Angina pectoris	307	1.30 (1.03–1.60)	+
Myocardial infarction	145	1.46 (1.04–1.98)	+
Chronic ischemic heart disease	626	1.42 (1.22–1.65)	+
Heart failure	127	1.08 (0.75–1.49)	
Stroke	87	1.31 (0.84–1.93)	
Varicose of the lower extremities	216	1.68 (1.28–2.16)	+
Hemorrhoids	405	1.73 (1.42–2.08)	+
Mononeuropathy of the upper extremities	391	3.40 (2.78–4.10)	++
Coxarthrosis	328	2.34 (1.88–2.87)	+
Gonarthrosis	857	3.22 (2.82–3.66)	++
Rhizarthrosis	38	4.30 (2.13–7.63)	++
Damage of the knee joint	1121	2.11 (1.88–2.36)	+
Spondylosis	823	2.84 (2.48–3.24)	++
Back pain	12 892	3.13 (3.02–3.23)	+++
Synovitis and tenosynovitis	639	3.20 (2.74–3.71)	++
Other diseases of synovialis and tendons	202	2.63 (1.98–3.40)	+
Shoulder lesion	1790	4.01 (3.66–4.38)	+++
Other enthesopathies	1725	4.77 (4.34–5.22)	+++

The data of 844 709 office workers in the administration and business sectors are considered as reference.

Significantly more sick leaves than in the control group was labeled by.

“+” – SMR is safely >1 (SMR >1); “++” – certainly >2 as many sick leaves (lower CI ≥2); “+++” – >3 times as many sick leaves (lower CI ≥3).

In the clinical examination, spinal percussion and/or palpation were painful in 11.5% of the subjects. According to the authors, there was a higher prevalence of back complaints among waste collectors compared to the general German population [3].

The evaluation of MSDs was also a main topic in the above-mentioned VerEna project and its follow-up (VerEna II). In both VerEna-based studies, the prevalence values of self-reported MSDs were quite similar for back pain (45.3%; follow-up 44.2%), leg/foot pain (27.9%; 28.7%), neck and shoulder pain (27.0%; 29.1%), and muscular cramps (26.0%; 25.7%) [40].

Infections

The authors included 2 studies on gardeners because they share some duties done by street sweepers, e.g., being responsible for maintaining municipal gardens. The prevalence and risk factors of hepatitis A virus (HAV) infection among 100 municipal waste collectors and 108 gardeners were evaluated in central Greece [47]. None of the participants had been vaccinated. The prevalence of HAV infection among the waste collectors and gardeners was 61% and 27%, respectively. Logistic regression analysis showed that, besides exposure to waste (OR = 2.87) and age (OR = 22.57), also habits like smoking, drinking or eating during waste collec-

tion were significantly associated with a higher relative risk of HAV infection (RR = 2.84). The authors also reported, for the same workers, an independent association of exposure to waste (OR = 4.05) and age (OR = 5.22), and a higher risk of HBV infections in the case of occupational injuries with needle sticks (RR = 2.64) [48].

Cognitive and mental aspects

Health-related quality of life (QoL) is a well-established aspect of health and general well-being. It could be assumed that the overall QoL is better among subjects having an occupation than in unemployed people. In addition, elderly persons who work are more likely to have a better QoL with regard to self-esteem, family, interpersonal relationships, and economic status [49]. On the other hand, employment can lead to the development of occupational diseases with a well-known impact on QoL. This means that QoL could be influenced by specific occupations, and by corresponding tasks and duties. In a German cross-sectional study, an association between back complaints and limitations in QoL was observed in municipal waste collectors. The authors stated that interventions addressing the ergonomic handling of waste containers and street sweeping may reduce back complaints and finally contribute to improved QoL among the workers [3].

DISCUSSION

Street cleaning is a hazardous occupation due to the fact that there is a high physical burden, work is conducted mostly outdoors, in traffic, and is concerned with dirt and refuse. Additional psychological and mental effects can result from management responsibilities, the intensity of work, or interactions within the working team.

There are some great differences in exposure and working conditions between developing and emerging countries, and countries within Europe. Important aspects to talk about are climate, the use of machinery, traffic conditions, the use of PPE, socio-economic status, or health and accident in-

surances. Therefore, the current literature review and also the following discussion were stratified accordingly.

The situation of street cleaners in developing and emerging countries

It seems that in many countries, to this very day, little attention has been paid to the health of the workers who are chronically exposed to hazards due to street sweeping. After the evaluation of the literature, it could be assumed that in many developing and emerging countries hardly any protection measures, like masks or gloves, are used. This is often due to the fact that they are not made available to the workers at all. In addition, ergonomic or work flow recommendations are rarely established. As a result, respiratory, muscular and joint problems are still quite common. The following aspects have to be taken into account concerning workwear. Slight injuries such as abrasions can be avoided by clothing. In addition, workwear should protect against infections and cuts, e.g., from broken glass. Moreover, a reflecting surface of clothing represents a part of the warning effect and protects against sunlight. Even if work equipment is provided, the cleaning tools are sometimes improper. For example, short-handled brooms were found to be frequently used in India [12], which increase exposure simply due to the short distance to emissions from the street. Furthermore, the use of short-handled brooms favors MSDs.

The amount and qualitative composition of dust and garbage are determined by local circumstances. Slum areas and animals in the streets, partly for cultural reasons as in India, create conditions and infections that are not found in Europe.

Overall, it can be deduced that, under the conditions described, the exposures experienced by street cleaners are capable of causing respiratory complaints (coughing) as well as illnesses (chronic bronchitis, COPD). The study by Nku et al. [18] indicated the duration of exposure to street dust as an important factor influencing the manifestation

of symptoms. This relationship can be considered validated and has also led to the assessment of occupational respiratory diseases in Germany. In more detail, COPD is causally attributed to the occupational activity of a miner after a sufficiently intense level of exposure to stone coal dust. Concerning the assessment of respiratory health risk in street cleaners, the enhanced physical effort and muscle work that activities such as lifting and manhandling of the various containers entail have to be considered. As a result, ventilation response increases, which is characterized by an increased flow volume and respiratory frequency [45]. Consecutively, the amount of inhaled bioaerosol is also raised. The exposure includes not only airborne organic compounds, but also dust particles and vehicle exhaust fumes and gases. Therefore, it is important to minimize the inhalation exposure to street dust, whether by wearing masks or sprinkling water on the street before sweeping. In addition, employees in general, and street cleaners in particular, should be encouraged to quit smoking to prevent obstructive lung diseases. Moreover, work-related complaints are a result of perception and interpretation, and could be modified by the local social or religious values that could not be applied for Europe. In addition, the different social systems play a role in the risk assessment of street sweepers in different countries. Due to special social systems in some countries (e.g., the caste system), the primary work of street sweeping and waste collecting is done by so-called underprivileged individuals. The perception of occupational risk and safety is largely determined by the position and rank of the individual and/or group within a given situation. Since these street sweepers do not view themselves as having a large amount of personal value, they remain less concerned about their own health and safety.

Moreover, the high proportion of female street sweepers in some countries outside Europe should be mentioned. While in Germany only 3.2% of street cleaners and waste workers in 2011 were female [50], in other countries, particularly in Latin America, women participate extensively in

street sweeping. Also in India and Nigeria, mostly women are engaged as street cleaners, which is why in some studies regarding these countries only female street cleaners were included [1,12,27,51]. Potential sex differences were suggested in terms of susceptibility to various exposures and the development of occupational lung disease, which may be due to the differential rates of absorption of toxins in men and women [52], but also due to the differences in exposure conditions and working areas [53].

In conclusion, the challenges for developing and emerging countries concern, in the first place, the implementation of known recommendations to protect against injuries or health impairments. Illnesses, infections and accidents can be prevented, to some extent, by the use of protective clothing, such as safety shoes, helmets, ear protection and high-visibility vests or clothing. General training should be included and mechanical equipment should be operated only by trained workers. There should be a conveniently accessible central point providing good washing facilities, a cloakroom with arrangements for changing and drying clothes, a common room and a first-aid room. Finally, periodic medical examinations, including recommended vaccinations, are desirable. Recommendations have to be always based on hazard sources and risk assessments of the specific working conditions of street sweepers.

The situation of street cleaners in Europe

In Europe, and especially in Germany, the situation is different and, to a certain extent, the other way round, as there already exist a lot of regulations and instructions which do not always seem to be consequently followed. Overall, regarding the following topics: “street sweeping in general, manual tasks, machine operating, and winter services,” >30 recommendations and guidelines concerning prevention practices have been published.

It is to question whether all these statements are really helpful, and it seems difficult for employers and workers to get a proper overview of the multitude of regulations. The

Table 4. Occupational health hazards of street cleaners, appropriate personal protective equipment (PPE) and suggestions for health examinations and preventive strategies

Hazard	PPE	Health examinations/ preventive strategies
Skin		
irritations, infections	gloves, skin protection, possibility to wash hands	skin check
UV radiation	sun protection (sunscreens, headgears, clothing)	skin cancer screening
Infections (blood)	vaccination	inquiry about the vaccination status, titer determination, vaccination offer
Hearing (noise, e.g., leaf blowers)	hearing protection	audiometry
Bioaerosols		
airways: allergy, asthma, COPD (occupationally acquired or aggravated)	face masks	skin prick test, specific IgE determination, spirometry (lung function test)
risk of infection/ carryover	workwear, black and white areas, cleaning the driver's cab	
Eyes		
irritation (particles, dust)	protection goggles	
night blindness (winter service at night)	glasses	visual test
Weather ("uncomfortable," increase in infections, increase in sick leaves)	appropriate clothing, sun protection (see above)	
MSDs	appropriate ergonomic equipment (e.g., long-handled brooms)	ergonomic training, stretching exercise
Cuts/wounds (needle stick injuries)	gloves	
Road traffic (accidents, environmental/traffic pollution [dust, particulate matter, ozone, carbon monoxide, nitrogen oxides])	reflecting clothes, face masks	
Mental stress		work planning, teamwork, working atmosphere, communication, information, management style

COPD – chronic obstructive pulmonary disease; MSDs – musculoskeletal disorders.

aspects of safety, simplification, productivity and effectiveness of prevention practices at the workplace in general were addressed in a recent comprehensive article from Italy [54], the main statement being: "Although reducing prevention is never justified, it should still be 'sustainable' economically in order to avoid waste of resources."

As shown by the VerEna-based study, prevention must be integrated and practicable in all day-to-day operations in order to be successful. About 80–90% of the German pop-

ulation had back problems at least once in their lives [55]. Thus, an aggravation of a pre-existing pain condition by work should be considered. In addition, in order to prevent mental stress, further action and recommendations are needed in the areas of human resources management and work organization. Psychological and mental effects based on improper management, the intensity of work, or inadequate interactions within the working team could result in psycho-somatic disorders hardly indistinguish-

able from organic ones. For instance, psycho-social occupational factors are also considered important within the complex and multidimensional etiology of back pain and other MSDs. In addition, with respect to a growing share of older workforce in the future, it is necessary to develop means to motivate and train older workers.

Regarding COPDs in the occupational and social medical field, the early detection of these diseases is of particular importance. The earlier COPD is detected, the better the therapeutic prospects. Due to its chronic course in advanced stages, COPD can have a negative effect on the ability to work. Therefore, preventive check-ups are offered in Germany, e.g., regular lung function tests to prevent obstructive pulmonary diseases. However, in a prevention study initiated by a great German waste management company, <2% of employees make use of this occupational health care provision [46].

Thinking in terms of prevention, vaccination is a powerful tool to avoid several infectious diseases. In particular, the results of the Greek study in which up to 61% of the non-vaccinated workers had HAV infections [47] show the importance to recommend vaccination to those individuals who are at increased risk due to their occupation. However, it should be stressed that the use of PPE and appropriate personal hygiene control could also limit the chances of coming into contact with infectious agents.

CONCLUSIONS

Around the world, street cleaners are physically burdened and exposed to various hazards. Musculoskeletal, and in many countries also respiratory, complaints are in the foreground. During their work, workers can incur cut injuries, skin irritations and infections. Since most of the work takes place outdoors, street cleaners are exposed to cold or heat, wind, and UV radiation, and exposure to dust and particles, as well as ozone, carbon monoxide and nitrogen oxides may occur. This can cause irritation not only to the respiratory tract but also to the eyes. In ad-

dition, street cleaners are faced with all the hazards of working in traffic, and accident rates are high. All health hazards and appropriate preventive measures are summarized in Table 4.

In all cases, proper education and briefing should be provided to help street cleaners become aware of the hazards. Appropriate communication, consideration and appreciation could reduce mental stress.

Closing remarks

Regardless of the improvements and regulations on the effect side, it should not be forgotten that the burden on the waste system and its employees also depends significantly on the total amount of waste. In the area of street cleaners, the amount of improperly disposed waste also plays a role. In this context, the introduction of disposable containers and products has contributed to the amount of street refuse. Thus, besides waste removal, regulations for food industry (e.g., a limitation of disposable containers), and the education of people to avoid waste in general and on the streets, have gained high importance. In this respect, behaviors with a low tendency towards responsible environmental behaviors were identified [56]. As regards reasons for street littering, Nkwocha [57] reported that subjects littered the streets because of an absence of bins, inefficiencies of local authorities, ignorance, weak legislation, anger, and stress. More responsible behaviors would be desirable worldwide.

REFERENCES

1. Wahab B, Ogunlola B. The Nature and challenges of street sweeping in Ado-Ekiti. *Afr J Psychol Study Soc Issues*. 2014;7(3):145–67.
2. Walser SM, Gerstner DG, Brenner B, Bünger J, Eikmann T, Janssen B, et al. Evaluation of exposure-response relationships for health effects of microbial bioaerosols – A systematic review. *Int J Hyg Environ Health*. 2015;218(7):577–89, <https://doi.org/10.1016/j.ijheh.2015.07.004>.

3. Velasco Garrido M, Bittner C, Harth V, Preisser AM. Health status and health-related quality of life of municipal waste collection workers – a cross-sectional survey. *J Occup Med Toxicol.* 2015;10:22, <https://doi.org/10.1186/s12995-015-0065-6>.
4. Hoffmeyer F, van Kampen V, Taeger D, Deckert A, Rosenkranz N, Kassen M, et al. Prevalence of and relationship between rhinoconjunctivitis and lower airway diseases in compost workers with current or former exposure to organic dust. *Ann Agric Environ Med.* 2014;21(4):705–11, <https://doi.org/10.5604/12321966.1129919>.
5. Bünger J, Antlauf-Lammers M, Schulz TG, Westphal GA, Müller MM, Ruhnu P, et al. Health complaints and immunological markers of exposure to bioaerosols among bio-waste collectors and compost workers. *Occup Environ Med.* 2000;57(7):458–64, <https://doi.org/10.1136/oem.57.7.458>.
6. Van Kampen V, Hoffmeyer F, Deckert A, Kendzia B, Casjens S, Neumann HD, et al. Effects of bioaerosol exposure on respiratory health in compost workers: a 13-year follow-up study. *Occup Environ Med.* 2016;73(12):829–37, <https://doi.org/10.1136/oemed-2016-103692>.
7. Poole CJM, Basu S. Systematic Review: Occupational illness in the waste and recycling sector. *Occup Med (Lond).* 2017;67(8):626–36, <https://doi.org/10.1093/occmed/kqx153>.
8. Schantora AL, Casjens S, Deckert A, van Kampen V, Neumann HD, Brüning T, et al. Prevalence of work-related rhino-conjunctivitis and respiratory symptoms among domestic waste collectors. *Adv Exp Med Biol.* 2015;834:53–61, https://doi.org/10.1007/5584_2014_71.
9. [Regulation of the German Social Accident Insurance, DGUV Regel 114-601: Waste management, part I: waste collection] [Internet]. Sankt Augustin: DGUV; 2016 [cited 2019 Nov 26]. Available from: <https://www.bg-verkehr.de/medien/medienkatalog/dguv-regeln-und-dguv-grundsaeetze/dguv-regel-114-601>. German.
10. [Regulation of the German Social Accident Insurance, DGUV Regel 114-602: Waste management, part II: waste treatment] [Internet]. Sankt Augustin: DGUV; 2016 [cited 2019 Nov 26]. Available from: <https://www.bg-verkehr.de/medien/medienkatalog/dguv-regeln-und-dguv-grundsaeetze/dguv-regel-114-602>. German.
11. Schmitt J, Haufe E, Trautmann F, Schulze HJ, Elsner P, Drexler H, et al. Is ultraviolet exposure acquired at work the most important risk factor for cutaneous squamous cell carcinoma? Results of the population-based case-control study FB-181. *Br J Dermatol.* 2018;178(2):462–72, <https://doi.org/10.1111/bjd.15906>.
12. Johny SS, Dhanyakumar G, Kanyakumari K, Samuel TV. Chronic Exposure to Dust and Lung Function Impairment: A Study on Female Sweepers in India. *Natl J Physiol Pharm Pharmacol.* 2014b;4(1):15–9, <https://doi.org/10.5455/njppp.njppp.2014.4.140620131>.
13. Munubi AA. Effects of Occupational Health Hazards on Street Cleaners' Health in Eldoret Town, Uasin Gishu County, Kenya. *Int J Health Pharm Res.* 2017;3(4):1–10.
14. Ewis AA, Rahma MA, Mohamed ES, Hifnawy TM, Arafa AE. Occupational health-related morbidities among street sweepers and waste collectors at Beni-Suef, Egypt. *Egypt J Occup Med.* 2013;37(1):79–94, <https://doi.org/10.21608/ejom.2013.773>.
15. Sabde YD, Zodpey SP. A study of morbidity pattern in street sweepers: A cross-sectional study. *Indian J Community Med.* 2008;33(4):224–8, <https://doi.org/10.4103/0970-0218.43226>.
16. Patil PV, Kamble RK. Occupational health hazards in street sweepers of Chandrapur City, Central India. *Int J Environ.* 2017;6(2):9–18, <https://doi.org/10.3126/ije.v6i2.17358>.
17. Ravindra K, Kaur K, Mor S. Occupational exposure to the municipal solid waste workers in Chandigarh, India. *Waste Manag Res.* 2016;34(11):1192–5, <https://doi.org/10.1177/0734242X16665913>.
18. Nku CO, Peters EJ, Eshiet AI, Oku O, Osim EE. Lung function, oxygen saturation and symptoms among street sweepers in Calabar-Nigeria. *Niger J Physiol Sci.* 2005;20(1–2):79–84.
19. Ncube F, Ncube EJ, Voyi K. Bioaerosols, noise, and ultraviolet radiation exposures for municipal solid waste handlers. *J Environ Public Health.* 2017;2017:3081638, <https://doi.org/10.1155/2017/3081638>.

20. Sabde YD, Zodpey SP. Respiratory morbidity among street sweepers working at Hanumannagar Zone of Nagpur Municipal Corporation, Maharashtra. *Indian J Public Health*. 2008b;52(3):147–9.
21. Habybady RH, Sis HN, Paridokht F, Ramrudinasab F, Behmadi A, Khosravi B, et al. Effects of Dust Exposure on the Respiratory Health Symptoms and Pulmonary Functions of Street Sweepers. *Malays J Med Sci*. 2018;25(6):76–84, <https://doi.org/10.21315/mjms2018.25.6.8>.
22. Stambuli P. Occupational respiratory health symptoms and associated factors among street sweepers in Ilala municipality [dissertation]. Tanzania: Muhimbili University of Health and Allied Sciences; 2012.
23. Sangolli B, Rashmi BM, Jagadish S, Sreeharsha, Chaitra B. A cross-sectional study of pulmonary function tests among the municipal street sweepers of Chitradurga District, Karnataka. *Indian J Immunol Respir Med*. 2018;3(39):108–13, <https://doi.org/10.18231/2581-4222.2018.0029>.
24. Sani HE, Najafi MN, Sharifi H. Spirometry pattern and respiratory symptoms in sweepers. *Hormozgan Med J*. 2017;21(4): 271–7, <https://doi.org/10.29252/hmj.21.4.271>.
25. Shadab M, Agrawal DK, Ahmad Z, Aslam M. A cross sectional study of Pulmonary Function Tests in street cleaners in Aligarh, India. *Biomed Res*. 2013;24(4):449–52.
26. Anwar SK, Mehmood N, Nasim N, Khurshid M, Khurshid B. Sweeper's lung disease: a cross-sectional study of an overlooked illness among sweepers of Pakistan. *Int J Chron Obstruct Pulmon Dis*. 2013;8:193–7, <https://doi.org/10.2147/COPD.S40468>.
27. Ajay KT, Vatsala AR, Danyakumar G, Bondadae SY. A study of impairment of lung functions in adult sweepers. *J Pharm Sci Res*. 2014;6(6):239–41.
28. Mostafa NS, Abdel-Hamid M, Al Bagoury LS. Work-related respiratory disorders among street sweepers in Cairo, Egypt, a comparative study. *Egypt J Community Med*. 2015;33(2):85–97, <https://doi.org/10.21608/ejcm.2015.711>.
29. Juhi A. Pulmonary function test in street sweepers compared to general population of Hyderabad, India. *Int J Sci Res*. 2016;5(10):332–4, <https://doi.org/10.36106/ijsr>.
30. Johny SS, Samuel TV, Jayalakshmi MK, Dhanyakumar G, Bondade SY. Prevalence of respiratory and non respiratory symptoms in female sweepers. *Int J Biomed Res*. 2014a;5(6): 408–10, <https://doi.org/10.7439/ijbr.v5i6.685>.
31. Singh S, Chokhandre P. Assessing the impact of waste picking on musculoskeletal disorders among waste pickers in Mumbai, India: a cross-sectional study. *BMJ Open*. 2015;5(9): e008474, <https://doi.org/10.1136/bmjopen-2015-008474>.
32. Salve PS, Chokhandre P. Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study. *BMJ Open*. 2016;6(12):e012354, <https://doi.org/10.1136/bmjopen-2016-012354>.
33. Salve PS, Bansod D. Street sweeping occupation and potential risk factors for developing musculoskeletal disorders and related disabilities: A study in Mumbai. In: Chaurasia AR, editor. *Demographic dimensions of sustainable development*. Bhopal: MLC Foundation, “Shyam” Institute; 2017. p. 101–14.
34. Pintakham K, Siritwong W. Prevalence rate and risk factors associated with health hazards to select the magnitude of health problems among street sweepers in Chiang Rai province, Thailand. *IOSR-JESTFT*. 2015;9(7):15–8, <https://doi.org/10.9790/2402-09721518>.
35. Rahma MA, Ewis AA, Hifnawy TMS. Awareness of occupational health hazards among street sweepers and garbage collectors at Beni-Suef city, Egypt; a cross-sectional study. *Bull High Inst Public Health*. 2009;39(4):654–68, <https://doi.org/10.21608/jhiph.2009.20859>.
36. El-Wahab EWA, Eassa SM, Lotfi SE, Kotkat AM, Shatat HZ, El Masry SA. Seroprevalence, immunostatus and factors associated with blood borne viral infections among Egyptian municipal solid waste workers. *J Virol Antivir Res*. 2015;4:4, <https://doi.org/10.4172/2324-8955.1000144>.
37. Jeong BY. Occupational deaths and injuries by the types of street cleaning process. *Int J Occup Saf Ergon*. 2017;23(1): 76–82, <https://doi.org/10.1080/10803548.2016.1199500>.
38. Kabir A, Farhana N, Akter F, Jesmin S, Ali A. Sweeping practices, perceptions and knowledge about occupational safety

- and health hazards of street sweepers in Dhaka city, Bangladesh: a qualitative inquiry. *Int J Community Med Public Health*. 2015;2(3):237–43, <https://doi.org/10.18203/2394-6040.ijcmph20150476>.
39. Grandek M, Päßler K. [Model project VerEna – New organizational structures should improve occupational health and safety at waste disposal companies]. *GUVV*. 2005;16(1):18–21. German.
40. Lemke-Goliasch P. [Guideline for occupational health management in waste management companies, INQA (New Quality of Work Initiative)] [Internet]. In: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, editor. Report 6, 04. Bremerhaven: Wirtschaftsverlag NW; 2005. [cited 2020 June 25]. Available from: <https://www.yumpu.com/de/document/view/21185550/betriebliches-gesundheitsmanagement-im-entsorgungsbereich/16>. German.
41. Liebers F, Brendler C, Latza U. [Occupation specific risk for sick leave due to musculoskeletal disorders or cardiovascular diseases. Project F 2255 of the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)] [Internet]. Dortmund: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin; 2016 [cited 2019 Dec 2]. Available from: <https://www.baua.de/DE/Angebote/Publikationen/Berichte/F2255.html>. German.
42. Neumann HD, Buxtrup M, Balfanz J, Lohmeyer M. [Burdens due to biological agents and machine exhaust gases in the area of municipal street cleaning and leaf blowing]. *Gefahrst Reinhalt Luft*. 2005;65:195–203. German.
43. Dürkop J, Englert N, Kreowski E, Stinshoff K, Giese E. [Leaf vacuum cleaners and leaf blowers - are there negative consequences to be feared when using them?]. *UMID*. 2002;1:7–10. German.
44. Moriske H-J, Bach S, Ebert G, Virgil S. [Airborne germ measurements during operation of portable leaf blowers]. *UMID*. 2002;2:12–5. German.
45. Preisser AM, Zhou L, Velasco Garrido M, Harth V. Measured by the oxygen uptake in the field, the work of refuse collectors is particularly hard work: Are the limit values for physical endurance workload too low? *Int Arch Occup Environ Health*. 2016;89(2):211–20, <https://doi.org/10.1007/s00420-015-1064-8>.
46. Seele S, Groneberg D, Spallek M. [Possibilities for the prevention of work-related chronic obstructive pulmonary diseases (COPD) in a large company in the waste management sector]. *ASU*. 2014;49:603–11. German.
47. Rachiotis G, Papagiannis D, Thanasis E, Dounias G, Hadjichristodoulou C. Hepatitis A virus infection and the waste handling industry: a seroprevalence study. *Int J Environ Res Public Health*. 2012a;9(12):4498–503, <https://doi.org/10.3390/ijerph9124498>.
48. Rachiotis G, Papagiannis D, Markas D, Thanasis E, Dounias G, Hadjichristodoulou C. Hepatitis B virus infection and waste collection: prevalence, risk factors, and infection pathway. *Am J Ind Med*. 2012b;55(7):650–5, <https://doi.org/10.1002/ajim.22057>.
49. Min D, Cho E. Patterns in quality of life according to employment among the older adults: the Korean longitudinal study of aging (2008–2014). *BMC Public Health*. 2018;18:379, <https://doi.org/10.1186/s12889-018-5296-x>.
50. Institut für Arbeitsmarkt und Berufsforschung [Internet]. Nuremberg: The Institute; 2019 [cited 2019 Dec 2]. Professions as reflected in statistics. Available from: <http://bisds.infosys.iab.de/bisds/result?region=19&beruf=BO935&qualifikation=2>. German.
51. Johncy SS, Dhanyakumar G, Samuel TV, Ajay KT, Bondade SY. Acute lung function response to dust in street sweepers. *J Clin Diagn Res*. 2013;7(10):2126–9, <https://doi.org/10.7860/JCDR/2013/5818.3449>.
52. Wai Y, Tarlo SM. Occupational lung disease in women. In: Buist S, Mapp CE, editors. *Respiratory diseases in women*. *Eur Respir Mon*. 2003;25:131–45.
53. Raulf M, Brüning T, Jensen-Jarolim E, van Kampen V. Gender-related aspects in occupational allergies – Secondary publication and update. *World Allergy Organ J*. 2017;10(1):44, <https://doi.org/10.1186/s40413-017-0175-y>.
54. Messineo A, Cattaruzza MS, Prestigiacomo C, Giordano F, Marsella LT. Sustainability of prevention practices at

- the workplace: safety, simplification, productivity and effectiveness. *Ann Ig.* 2017;29:407–21, <https://doi.org/10.7416/ai.2017.2173>.
55. Schmidt CO, Kohlmann T. [What do we know about the symptom of back pain? Epidemiological results on prevalence, incidence, course, risk factors]. *Z Orthop.* 2005;143(3): 292–8. German.
56. Ojedokun AO, Balogun SK. Responsible environmental behaviour among residents of Ibadan: Where is the place of attitude towards littering in the agenda to keep Ibadan clean? *Ib Plan J.* 2011;1(1):67–81.
57. Nkwocha EE. Street littering in Nigerian towns: Towards a framework for sustainable urban cleanliness. *AFRREV.* 2009;3(5):147–64.
58. Arora R, Kaur H. Lung function response to dust in Safai workers. *Int J Med Dent Sci.* 2016;5(1):1038–41.
59. Erah FO, Edeawe PE, Airefetalor I, Omorogbe IN, Onyebujoh JT, Ohwovoriole EO, et al. Effect of dust on the respiratory health of street sweepers in Benin City, Edo State, Nigeria. *Ann Med Surg Pract.* 2018;3(2):71–9.