

# BMJ Open

## Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: A cross-sectional case-control study

Journal:	BMJ Open
Manuscript ID	bmjopen-2016-012354
Article Type:	Research
Date Submitted by the Author:	20-Apr-2016
Complete List of Authors:	Salve, Pradeep; International Institute for Population Sciences, Public Health and Mortality Studies Chokhandre, Praveen; International Institute for Population Sciences, Mumbai,
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Public health
Keywords:	Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Hand & wrist < ORTHOPAEDIC & TRAUMA SURGERY, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, Shoulder < ORTHOPAEDIC & TRAUMA SURGERY, Street sweeper

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Manuscripts

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**Word count:** 2830

**Key words** Street sweepers, musculoskeletal disorders, shoulder and Hand & wrist, Back pain

## Abstract

**Objective:** This study aims to assess the exposure of those involved in street sweeping to development of musculoskeletal disorders (MSDs) as well as disabilities and tries to identify the individual risk factors leading to the development of MSDs and disabilities among street sweepers.

**Methods:** A cross-sectional case-control design was adopted. The respondents – street sweepers (n=180) and a control group (n=180) – were selected from six municipal wards, all of them being employees of the Municipal Corporation of Greater Mumbai. A modified Standardized Nordic Questionnaire was adopted to measure MSDs and disabilities. The impact of the occupation of sweeping on developing MSDs and disabilities was assessed using the propensity score matching (PSM) method. In addition, multivariate logistic regression model was employed to identify individual risk factors.

**Results:** The prevalence of MSDs was significantly higher among sweepers for shoulder (32%), wrist/hand (29%), elbow (27%) and neck (17%) compared to the control group, in which case the prevalence was 11%, 19%, 9%, and 11% respectively. Similarly, disabilities among street sweepers were significantly higher for lower back (27%), upper back (27%), wrist/hand (26%), shoulder (24%) and elbow (23%) compared to the control group, among which the figures were 18%, 19%, 13%, 9% and 6% respectively. PSM method highlighted that the sweeping occupation raised risk of developing MSDs as well as disabilities particularly for shoulder (17-16%), wrist/hand (14% each), elbow (13% each), and upper back (12-13%) respectively. After the workers' age and their BMIs were adjusted, years of engagement in street sweeping and their location of work emerged as potential individual risk factors for developing MSDs and, thereby, disabilities.

**Conclusion:** The study concluded that the occupation of street sweeping raises the risk of MSDs and musculoskeletal disabilities. Results from the study recommend preventive and curative measures to help abate the episodes of MSDs among street sweepers.

**Strengths and limitations of this study**

- ☐ Present study assessed the MSDs and MSDs led disabilities among street sweepers, whereas all past studies primarily focused on the occupational related morbidities other than MSDs among street sweepers.
- ☐ Propensity score matching method adopted to assess the exposure of street sweeping on developing the MSDs as well as disabilities
- ☐ The biasness in recalling MSDs and disabilities could be possible due to reference period of a year.
- ☐ The study was conducted with municipal street sweepers hence results may be generalised with caution

## INTRODUCTION

The occupation of sweeping is a vigorous task which involves sweeping of assigned areas such as roads, footpaths, parks, markets, and open settlements with the help of long-handle brooms and wheelbarrows, the waste in wheelbarrows being finally deposited in nearby community dustbins. This whole process requires continuous physical activities such as manual sweeping in the standing posture for long durations, bending while collecting the swept waste, pushing and pulling of the wheelbarrow, and manual lifting of baskets to deposit waste. The Municipal Corporation of Greater Mumbai (MCGM) has 9231 regular employees engaged in the street sweeping work, and this number is many times higher for India as a whole. Numerous studies have concluded that the occupational exposure of sweeping leads to the development of chronic respiratory diseases, skin diseases, eye irritation, asthma, tuberculosis, and hypertension among workers [1–4]. The other non-fatal injuries identified are mostly musculoskeletal in nature. Past studies conducted among solid waste collectors suggest a higher probability among them of developing musculoskeletal disorders (MSDs) compared to the general population [5–7]. Workers involved in repetitious physical activities of bending, lifting, and pushing and pulling work for long durations have been identified as facing the risk factors leading to development of MSDs [8–10]. Many of the past studies conducted among street sweepers have predominantly focused on respiratory morbidities in India [11–14]. The present study, in contrast, aims to assess the exposure of those involved in the sweeping occupation to developing MSDs as well as disabilities. Additionally, the study tries to identify the individual risk factors leading to the development of MSDs and disabilities among street sweepers.

## MATERIAL AND METHODS

The study applied cross-sectional case-control design to assess the prevalence of musculoskeletal disorders and related disabilities among street sweepers compared to a control group in Mumbai. A street sweeper sweeps assigned areas such as roads, residential areas, markets, public parks, and open settlements using a long-handle broom and a wheelbarrow to deposit collected wastes into nearby community dustbins. The sweepers work eight hours daily in a group of two employees. A group of municipal workers not exposed to sweeping—including employees associated with fogging and pesticide spraying and peons in offices having similar socioeconomic conditions was selected as the control group. These employees were basically field workers of the MCGM, continuously working in the field doing heavy physical activities such as carrying necessary equipment/machines; the nature of their work was more or less similar to that of the sweepers. Under the assumption of having controlled for other

socioeconomic factors, the study focused on exploring the occupational exposure of sweeping to development of MSDs among sweepers. The present primary study was conducted to examine the major morbidities, including MSDs, among municipal street sweepers. Applying stratified systematic random sampling design, the required sample was collected randomly from 6 out of 24 municipal wards of the MCGM based on the proportion of the slum population. The estimated sample size was 180 with p-value 0.30 [11] and design effect 1.25. The data was collected from 180 street sweepers and 180 control group of the MCGM from March to September 2015.

**Ethical considerations**

As the study involved government employees, permission to conduct the primary survey was approved by the MCGM. Ethical clearance prior to data collection was also approved by the Student Research Ethics Committee at the International Institute for Population Sciences, Mumbai. The informed consent of the participants was obtained in the local language, and the respondents were assured that the information would be confidential and used for research purposes only.

**Study tools and methods**

A modified Standardized Nordic Questionnaire was adopted to assess the musculoskeletal disorders [15]. A diagram with labels and arrows clearly indicating the different musculoskeletal regions was used for the assessment of the MSDs. The interview schedule collected information on the MSD symptoms from the respondents along with their demographic, socio-economic, and occupational characteristics. Specifically, the schedule covered age, years of work, substance use, social category, anthropometric measures, job satisfaction, mental health, frequency, and pain in the 9 musculoskeletal regions in the past 7 days and during the previous 12 months. Interviews were conducted during the working hours at the workplace.

The data was entered in the CSPro.06 software and analyzed using the STATA13 software. Descriptive statistics were used to understand the socioeconomic and occupational characteristics. Differences in the prevalence of the MSDs and the disabilities were tested using the Chi-square test. The multivariate logistic regression analysis was performed to assess the correlation between individual characteristics and the MSDs and, thereby, disabilities. To examine the impact of the street sweeping occupation on the development of MSDs and the disabilities, the propensity score matching method was applied.

**Variables**

## Outcomes variables

The respondents who reported pain in 9 anatomical regions, that is, neck, shoulder, wrist/hand, upper back, lower back, hip/thigh, knee, and ankle in the past 7 days and 12 months were considered as morbid with the MSDs. Sweepers were prevented from doing normal day-to-day activities at home or away from home due to the MSDs and were classified and recoded as disabled in the past 12 months.

## Exposure classification

Continuous physical activity in a particular posture leads to the development of musculoskeletal pain in employees associated with street sweeping and carrying wheelbarrow to community dustbins.

The age and years of working were significant predictors for the MSDs among solid waste collectors, where the risk of the MSDs increased with increasing age and years of working [5]. Past studies have concluded that overweight and obesity are positively associated with the MSDs because of the pressure exerted on the weight-bearing joints [16,17]. Past meta-analysis studies have exhibited that substance use, such as alcohol consumption, smoking and chewing tobacco, affects the physical capacity for work and causes musculoskeletal pain [18,19]. Symptoms of worry, tension, anxiety, work stress and low status of mood have correlation with the musculoskeletal pain [20–22]. Job satisfaction of employees influenced the prevalence of MSDs [23]. These psychosocial factors may increase or decrease the prevalence of the MSDs among the street sweepers too [24]. Similarly, the quantum of work that sweepers have to do in low or high slum concentrated areas may affect the prevalence of MSDs and disability among them. Since sweeping in the slum areas is a rigorous task due to disorganized garbage disposal, overflowing community dustbins, and open defecation by children on footpaths, the workload can be higher. Therefore, location of work was considered as one of the risk factors. Location of work, job satisfaction, and mental health state of the sweepers were considered as effect modifiers.

The mental health state of the sweepers was analyzed by applying the General Health Questionnaire of 12 items (GHQ-12) [25]. The workers were asked whether they had experienced any positive or negative emotions in the past month. Then, each negative response was coded 1, while the absence of it was coded 0. The items were summed to a score for each respondent. The higher the score increases through 0 to 12, the more severe the mental health



problem was considered. Further, the score was divided into three categories of low, medium and high. The mental health scale has acceptable internal consistency ( $\alpha=0.97$ ) [26].

The propensity score matching (PSM) method was adopted to examine the nearest neighborhood impact of sweeping exposure on the MSDs and disabilities among sweepers in cross-sectional survey data [27, 28]. The propensity score estimated by logistic regression with the dichotomous exposure variable, for instance 1 = exposed to sweeping and 0 = unexposed to sweeping, using associated observed demographic and occupational characteristics of the sweepers used as predictor variables. The principal assumption of the PSM is the condition that observable characteristics of exposed and control groups have similar distributions. This assumption test is applied by using the ‘p-score’ command. To calculate the impact of street sweeping on the MSDs and related disabilities in the past 12 months, the average effects in both the groups were weighted by the proportion of respondents in both the exposed and the control groups To understand the covariates affecting the MSDs among sweepers, multiple logistic regression analysis was applied.

**RESULTS**

**Characteristics of the study population**

The socioeconomic and occupational characteristics of the street sweepers and the control group are depicted in Table 1. There was a marginal difference in the mean age of the street sweepers (37 years, SD  $\pm$  9.12) and that of the control group (38 years, SD $\pm$ 7.39). A similar pattern was observed while looking at the number of working years among the street sweepers (11 years, SD $\pm$ 8.30) and the control group (11 years, SD $\pm$ 6.35). The occupational structure is predominately influenced by the social structure and the caste system of the Indian society. The Scheduled Caste communities that is, the communities who were previously untouchables and economically the weakest – were historically assigned cleaning or menial work and were discriminated against [29]. In the contemporary society, it is seen that the majority of the employees working in solid waste management belong to the Scheduled Castes (SCs), identified by the constitutional schedule of India. Descriptive statistics suggest that more than 86% of the sweepers belong to the Scheduled Castes. Personal behavior habits such as alcohol consumption, tobacco smoking, and chewing tobacco were common among the sweepers compared to the control group. For example, one-third (34%) sweepers had more than two addictions compared to the control group (19%). In the present study, 17% of the street sweepers reported that they were not satisfied with their occupation compared to 8% of the control group.



**Table 1 Descriptive statistics of the study groups**

Background Characteristics	Street Sweeper N=180	Control Group N=180
<b>Workers Age</b>		
19-34 years	45.56	34.4
35 & above	54.44	65.6
Mean age $\pm$ SD	37.27 $\pm$ 9.12	38.11 $\pm$ 7.39
<b>Years of working</b>		
Below 10	67.78	51.1
10 or more	32.22	48.8
Mean $\pm$ SD	10.63 $\pm$ 8.30	11.43 $\pm$ 6.35
<b>Addiction</b>		
No Addiction	33.33	53.3
Any one	34.44	27.2
Above Two	32.22	19.4
<b>Mental Health (GHQ-12)</b>		
Good	47.22	35.56
Intermediate	21.67	28.8
Poor	31.11	35.5
<b>Job Satisfaction</b>		
Good	17.87	30.6
Average	65	61.1
Bad	17.22	8.3
<b>BMI</b>		
<25	65.56	51.7
>25	34.44	48.3
Mean BMI $\pm$ SD	23.62 $\pm$ 1.41	25.14 $\pm$ 3.35
<b>Caste</b>		
SC/ST	85.56	51.7
Others	14.44	48.3

The prevalence of the MSDs and the disabilities in the past 12 months in various musculoskeletal sites is presented in Table 2 for the street sweepers and the control group. The results show that the street sweepers were at a significantly higher risk of developing MSDs compared to the control group, specifically for the shoulder (32%), wrist/hand (29%), elbow (27%) and neck (17%); these figures being 11%, 19%, 9% and 11% respectively for the control group. Similarly, the street sweepers significantly differed from the control group in terms of disabilities in the past 12 months. For instance, the sweepers were disabled due to pain in the lower back (27%), upper back (27%), wrist/hand (26%), shoulder (24%), elbow (23%) and hip/thigh (17%) compared to 18%, 19%, 13%, 9%, 6% and 8% respectively of the control group. Additionally, the incidence of the MSDs in the past 7 days was significantly higher among the sweepers,

particularly for the upper back (19%), wrist/hand (17%), hip/thigh (17%), elbow (16%), lower back (15%) and shoulders (11%) compared to the control group (4%, 3%, 7%, 4%, 9% and 4% respectively).

Table 2 Prevalence and incidence of musculoskeletal disorder and disability among study groups in the past 7 days and 12 months			
Body regions	Street Sweeper N=180	Control Group N=180	X <sup>2</sup> test
<b>Neck</b>			
Past 12 months	16.7 %	10.6 %	X <sup>2</sup> = 2.8585; p = 0.091
Disabled in past 12 months	10.6 %	9.4 %	X <sup>2</sup> = 0.1235; p = 0.725
7 days	6.7 %	4.4 %	X <sup>2</sup> = 0.8471; p = 0.357
<b>Shoulder</b>			
Past 12 months	31.7 %	11.1 %	X <sup>2</sup> = 22.6167; p = 0.000
Disabled in past 12 months	24.4 %	9.4 %	X <sup>2</sup> = 14.3889; p = 0.000
7 days	10.6 %	4.4 %	X <sup>2</sup> = 4.8448; p = 0.028
<b>Elbow</b>			
Past 12 months	26.7 %	8.9 %	X <sup>2</sup> = 19.4595; p = 0.000
Disabled in past 12 months	23.3 %	5.6 %	X <sup>2</sup> = 23.0170; p = 0.000
7 days	16.1 %	4.4 %	X <sup>2</sup> = 13.2842; p = 0.000
<b>Wrist/ Hand</b>			
Past 12 months	29.4 %	18.9 %	X <sup>2</sup> = 5.4718; p = 0.019
Disabled in past 12 months	26.1 %	13.3 %	X <sup>2</sup> = 9.2812; p = 0.002
7 days	16.7 %	2.8 %	X <sup>2</sup> = 19.7802; p = 0.000
<b>Upper Back</b>			
Past 12 months	33.9 %	27.2 %	X <sup>2</sup> = 1.8851; p = 0.170
Disabled in past 12 months	26.7 %	18.9 %	X <sup>2</sup> = 3.0953; p = 0.079
7 days	18.9 %	3.9 %	X <sup>2</sup> = 20.0658; p = 0.000
<b>Low Back</b>			
Past 12 months	33.3 %	29.4 %	X <sup>2</sup> = 0.6320; p = 0.427
Disabled in past 12 months	26.7 %	17.8 %	X <sup>2</sup> = 4.1143; p = 0.043
7 days	15.6 %	8.9 %	X <sup>2</sup> = 3.7284; p = 0.053
<b>Hip/Thigh</b>			
Past 12 months	26.7 %	20.0 %	X <sup>2</sup> = 2.2360; p = 0.135
Disabled in past 12 months	16.7 %	7.8 %	X <sup>2</sup> = 6.6283; p = 0.010
7 days	17.2 %	6.7 %	X <sup>2</sup> = 9.5342; p = 0.002
<b>Knee</b>			
Past 12 months	1.7 %	3.9 %	X <sup>2</sup> = 1.6457; p = 0.200
Disabled in past 12 months	0.6 %	3.3 %	X <sup>2</sup> = 3.6423; p = 0.056
7 days	1.7 %	0.6 %	X <sup>2</sup> = 1.0112; p = 0.315
<b>Ankles/Feet</b>			
Past 12 months	3.9 %	2.2 %	X <sup>2</sup> = 0.8440; p = 0.358
Disabled in past 12 months	1.7 %	2.2 %	X <sup>2</sup> = 0.1457; p = 0.703
7 days	2.2 %	0.6 %	X <sup>2</sup> = 1.8254; p = 0.177

## Street sweeping augments the MSDs

In order to assess the effects of sweeping on the MSDs, the PSM method has been employed and the results are exhibited in Table 3 in terms of average exposure effects among exposed (AEEE) for the MSDs and the disabilities in the past 12 months. The results of AEEE highlighted that the occupation of sweeping raised the episodes of the MSDs, particularly for the shoulder (17%), wrist/hand (14%), elbow (13%), upper back (12%), neck (10%) and hip/thigh (9%). A similar pattern was observed for the MSDs led disability, which was found to be significantly higher for the shoulder (16%), lower back (14%), wrist/hand (14%), upper back (13%), elbow (13%) and hip/thigh (12%). In a nutshell, the results of the PSM demonstrated that the occupation of sweeping significantly enhanced the MSDs and the disabilities.

<b>Table 3 Average exposure effect among exposed (AEEE) to street sweeping occupation on developing MSDs and disability for various body regions in the past 12 months</b>				
<b>Body regions</b>	<b>MSDs</b>		<b>Disability# due to MSDs</b>	
	<b>Coef.</b>	<b>95% CI</b>	<b>Coef.</b>	<b>95% CI</b>
<b>Neck</b>	0.10**	(0.02 to 0.19)	0.02	(-0.05 to 0.09)
<b>Shoulder</b>	0.17***	(0.07 to 0.27)	0.16***	(0.07 to 0.24)
<b>Elbow</b>	0.13***	(0.05 to 0.21)	0.13***	(0.06 to 0.19)
<b>Wrist/hand</b>	0.14***	(0.06 to 0.22)	0.14***	(0.07 to 0.21)
<b>Upper back</b>	0.12***	(0.04 to 0.21)	0.13***	(0.05 to 0.22)
<b>Lower back</b>	0.08*	(-0.02 to 0.18)	0.14***	(0.05 to 0.23)
<b>Hip/thigh</b>	0.09**	(0.00 to 0.18)	0.12***	(0.05 to 0.18)
** $p < 0.05$ , *** $p < 0.01$ , * $p < 0.1$ ; # Prevented normal activity at home or away from home due to MSDs				

## The factors associated with the MSDs

While identifying the individual risk factors enhancing the MSDs among sweepers in the last 12 months with adjustment for workers' age and body mass index, the results are presented in Table 4. The results exhibited that years of working emerged as a significant predictor for developing the MSDs. For instance, the workers working for 10 or more years were significantly more likely to suffer from the MSDs in the elbow (OR=12.06;  $p < 0.01$ ), shoulder (OR=6.72;  $p < 0.01$ ), wrist/hand (OR=6.21;  $p < 0.01$ ), upper back (OR=5.80;  $p < 0.01$ ), neck (OR=5.07;  $p < 0.01$ ) and hip/thigh (OR=4.23;  $p < 0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction among sweepers was also found to be significantly correlated as sweepers who were not satisfied with their job were more likely to have suffered from the MSDs in the wrist/hand (OR=12.01;  $p < 0.05$ ), hip/thigh (OR=5.08;  $p < 0.05$ ), upper back (OR=4.27;  $p < 0.05$ ) and lower back (OR=3.65;  $p < 0.05$ ) as compared to the sweepers who reported to be satisfied with their jobs. The location of work was found to be a significant predictor for enhancing the MSDs given the higher quantum of work sweepers have to do in high slum concentrated areas.

Table 4 Odds ratio showing correlation in symptoms of MSDs and individual risk factors of street sweepers (past 12 months)							
	Neck	Shoulder	Elbow	Wrist/hand	Upper back	Lower back	Hip/thigh
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	5.07*** (1.52 to 16.89)	6.72*** (2.41 to 18.76)	12.06*** (3.23 to 45.10)	6.21*** (2.38 to 16.24)	5.80*** (2.36 to 14.30)	2.78** (1.19 to 6.57)	4.23*** (1.64 to 10.96)
<b>Job Satisfaction</b>							
Good®							
Average	0.50 (0.15 to 1.70)	2.11 (0.68 to 6.54)	2.32 (0.56 to 9.68)	6.62** (1.38 to 31.94)	4.92*** (1.45 to 16.74)	1.52 (0.57 to 4.06)	2.48 (0.75 to 8.19)
Bad	1.93 (0.51 to 7.33)	2.35 (0.63 to 8.75)	1.87 (0.36 to 9.59)	12.01** (2.18 to 66.24)	4.27** (1.07 to 17.06)	3.65** (1.13 to 11.82)	5.08** (1.28 to 20.21)
<b>Mental health</b>							
Low ®							
Medium	0.24 (0.03 to 2.21)	0.32 (0.06 to 1.59)	0.22 (0.03 to 1.89)	0.30* (0.07 to 1.30)	0.79 (0.23 to 2.73)	0.86 (0.25 to 2.92)	0.32 (0.06 to 1.78)
High	1.19 (0.45 to 3.14)	2.18 (0.95 to 4.96)	2.31* (0.91 to 5.94)	1.27 (0.53 to 3.05)	1.97* (0.87 to 4.48)	1.34 (0.59 to 3.04)	1.75 (0.71 to 4.33)
<b>Location of work</b>							
Low®							
Moderate	0.43 (0.14 to 1.30)	0.90 (0.36 to 2.27)	0.80 (0.29 to 2.18)	1.08 (0.43 to 2.71)	2.02 (0.82 to 4.97)	2.13* (0.85 to 5.37)	4.07** (1.29 to 12.79)
High	0.39* (0.13 to 1.12)	0.92 (0.37 to 0.43)	0.22*** (0.07 to 0.68)	0.44* (0.17 to 1.17)	2.10* (0.85 to 5.18)	5.10*** (2.07 to 12.60)	10.42*** (3.43 to 31.70)
® Reference category; *** $p<0.01$ , ** $p<0.05$ ; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers age and BMI							

**Table 5 Odds ratio showing correlation of disabilities# due to MSDs and individual risk factors of street sweepers (past 12 months)**

	Neck	Shoulder	Elbow	Wrist/hand	Upper back	Lower back	Hip/thigh
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	6.04** (1.11 to 32.88)	3.05** (1.20 to 7.77)	9.40*** (2.35 to 37.59)	5.13*** (1.93 to 13.64)	4.17*** (1.60 to 10.86)	2.95** (1.18 to 7.35)	5.88*** (1.93 to 17.89)
<b>Job Satisfaction</b>							
Good®							
Average	0.26* (0.06 to 1.15)	1.26 (0.43 to 3.68)	1.50 (0.35 to 6.39)	5.03** (1.02 to 24.73)	3.26* (0.97 to 11.02)	1.21 (0.43 to 3.45)	1.69 (0.46 to 6.23)
Bad	1.21 (0.25 to 5.94)	0.69 (0.18 to 2.69)	1.35 (0.25 to 7.15)	8.26** (1.47 to 46.48)	2.74 (0.68 to 11.11)	3.45** (1.02 to 11.75)	1.63 (0.35 to 7.53)
<b>Mental health</b>							
Low ®							
Medium	0.40 (0.04 to 4.06)	0.18 (0.02 to 1.51)	0.33 (0.04 to 2.89)	0.43 (0.10 to 1.84)	1.14 (0.31 to 4.19)	0.92 (0.24 to 3.53)	0.32 (0.03 to 2.99)
High	1.12 (0.34 to 3.74)	1.91 (0.83 to 4.38)	2.78** (1.03 to 7.48)	1.59 (0.65 to 3.87)	2.87** (1.22 to 6.74)	1.14 (0.47 to 2.76)	1.54 (0.56 to 4.27)
<b>Location of work</b>							
Low®							
Moderate	0.03*** (0.00 to 0.33)	0.56 (0.22 to 1.45)	0.74 (0.26 to 2.13)	0.90 (0.35 to 2.32)	2.55* (0.95 to 6.89)	2.30 (0.79 to 6.68)	7.30** (1.40 to 38.22)
High	0.24** (0.07 to 0.80)	0.61 (0.25 to 1.51)	0.18*** (0.05 to 0.62)	0.38** (0.14 to 1.02)	3.13** (1.19 to 8.27)	7.16*** (2.59 to 19.75)	15.77*** (3.23 to 77.07)
® Reference category; *** $p < 0.01$ , ** $p < 0.05$ ; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers age and BMI							

Sweepers working in the high slum concentrated areas were more likely to get the MSDs in the hip/thigh (OR=10.42;  $p<0.01$ ), lower back (OR=5.10;  $p<0.01$ ) and elbow (OR=0.22;  $p<0.05$ ) as compared to sweepers working in the low slum concentrated areas. An inquiry was also made to identify the individual factors enhancing the risk of the disabilities in the past 12 months; it is depicted in Table 5. The results suggest that the number of years of working is significantly correlated with disabilities. More specifically, the sweepers working for 10 and more years were significantly more likely to suffer from the disabilities in the elbow (OR=9.40;  $p<0.01$ ), hips/thigh (OR=5.88;  $p<0.01$ ), wrist/hand (OR=5.13;  $p<0.01$ ) and upper back (OR=4.17;  $p<0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction and mental health state were not significantly correlated with the disabilities among the sweepers. The sweepers working in high slum concentrated areas were significantly more likely to develop disabilities in the hip/thigh (OR=15.77;  $p<0.01$ ), lower back (OR=7.16;  $p<0.01$ ), elbow (OR=0.18;  $p<0.01$ ) and upper back (OR=3.13;  $p<0.05$ ) as compared to the sweepers working in the low slum concentrated areas.

DISCUSSION

The sweepers work for long hours in public places using long-handle brooms along with the wheelbarrows. This repetitive rigorous occupation enhances musculoskeletal disorders and disabilities among the street sweepers as compared to the control group. The results of bivariate analysis depicted that the prevalence of the MSDs among the sweepers was significantly higher for the shoulder (32%), wrist/hand (29%) and elbow (27%) as compared to the control group in the past 12 months. Field observation suggested that this may be because of the continuous sweeping with the long-handle broom and the carrying of the collected waste in the wheelbarrow to the community dustbins manually in an unvarying posture. Similarly, musculoskeletal-led disabilities were found to be significantly higher among the sweepers for the lower back (27%), wrist/hand (26%), shoulder (24%), elbow (23%) and hip/thigh (17%) as compared to the control group for the past 12 months. The results of the PSM method revealed that the average exposure effect among exposed (AEEE) to sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulder (17%), wrist/hand (14%), elbow (13%) and upper back (12%). A similar pattern was observed in case of disabilities, particularly for the shoulder (16%), wrist/hand (14%), lower back (14%), elbow (13%) and upper back (13%). After adjusting for working age and body mass index, the results of the multivariate logistic regression model revealed that years of working, job satisfaction and location of work were significantly correlated with pain in the shoulder, elbow, wrist/hand, lower back, upper back and hip/thigh.

Location of work emerged as a significant predictor of increased MSDs and related disabilities among the sweepers due to the higher quantum of work in the slum concentrated areas. In the absence of any studies based on the MSDs among the street sweepers, the results of the present study are comparable with other studies conducted among solid waste workers except for knee and ankle disorders [3,4,11,30,31]. This may be so because the street sweepers are not engaged in lifting heavy loads continuously or for carrying them for long duration as a result of which they do not put pressure on the knees and ankles as compared to the workers associated with solid waste collection.

The results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

### **Limitation of the Study**

In the present study, biases might have occurred due to the subjectivity in response. However, the chances of false reporting were low as the study guaranteed confidentiality. The cross-sectional survey method for data collection might have underestimated the actual prevalence of MSDs and related disabilities. Since the study was conducted among the municipal street sweepers sweeping public places, results may be generalized to other sweepers with caution.

### **Strategies to minimize the burden of MSDs**

- Since the location of the work was found to play a crucial role in the development of the MSDs and disabilities, it is recommended that the municipal corporations take initiatives to minimize the risks by changing the location of work quarterly.
- The street sweepers may undergo medical examination every quarter, whereby a physician can advise them about the preventive measures to minimize the MSDs and disabilities.
- The burden of functional impairment due to MSDs may be reduced by proper curative treatment.
- Municipal corporations may provide medical insurance assistance to reduce the financial burden on the sweepers.



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**Acknowledgement**

Authors acknowledge the English editing services from Ms. Shailja Thakur.

- a. **Contributors**  
Pradeep Salve contributed to the conceptualization, design and data analysis.  
Praveen Chokhandre led the conceptualization, data analysis and write up.  
Both the authors have read and approved the final manuscript.
- b. **Competing interests:** Declared None.
- c. **Funding:** This research work received no specific grant from any funding agency in the public, commercial or not for profit sector.
- d. **Ethics approval:** The study was approved by the institute research committee.
- e. **Data sharing statement:** There is no additional data available.

For peer review only

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## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b> (page.no 1-2)	1	<p>(a) Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: A cross-sectional case-control study</p> <p>(b) <b>Objective</b> Study aims to assess the exposure of street sweeping on developing the MSDs as well as disabilities and tried to identify the individual risk factors among street sweepers.</p> <p><b>Methods</b> A cross-sectional case-control design was adopted. The participants, street sweepers (n=180) and control group (n=180) were selected from six municipal wards and were employees of Municipal Corporation of Greater Mumbai. The standardized modified Nordic questionnaire was adopted to measure the MSDs and disabilities. The PSM method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities. In addition, a multivariate logistic regression model was employed to identify individual risk factors.</p> <p><b>Results</b> the prevalence of the MSDs and related disabilities found significantly higher for shoulder, wrist/hand, elbow and neck among street sweepers compared to control group. Results of PSM method highlighted that the sweeping occupation raised the risk of developing the MSDs and disabilities particularly for shoulder (17-16%), wrist/hand (14% each), elbow (13% each) and upper back (12-13%) respectively. After adjustment of the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities.</p> <p><b>Conclusion</b> The study portrayed that occupation of street sweeping raised the risk of the MSDs and extend to musculoskeletal disabilities. Individual risk factors increase the risk of developing the MSDs as well as musculoskeletal disabilities. Results from the study recommends preventive and curative measures to abate the episodes of the MSDs among street sweepers.</p>
<b>Introduction</b>		
Background/rationale (page.no 4)	2	Study assessed the MSDs among street sweepers, whereas all past studies primarily focused on the occupational related morbidities other than MSDs among street sweepers.
Objectives (page.no 4)	3	Study aims to assess the exposure of sweeping occupation on developing the MSDs as well as the disabilities. Additionally, the study tried to identify the individual risk factors leading to develop the MSDs and disabilities among street sweepers.
<b>Methods</b>		
Study design (page.no 4)	4	The study applied cross-sectional case-control design to assess the prevalence of musculoskeletal disorder and related disabilities among street sweepers compared to control group
Setting (page.no 5)	5	Both the type of workers i.e. street sweeper and control group were formal employees of Municipal Corporation of Greater Mumbai. A group of workers (non-exposed to sweeping occupation) consists of employees associated with fogging, pesticide spraying and peons in offices and were selected as a control group. These employees were basically field workers of the MCGM, continuously working on the field doing heavy physical activities by carrying all necessary equipment/machines and the nature of their work was more or less similar to sweepers. The data was collected during March to September

2015.		
Participants (page.no 5)	6	Workers who were engaged in the occupation at-least for a year were selected as participants for the study. Applying stratified systematic random sampling design, the required sample was collected randomly from six out of 24 municipal wards of the MCGM based on the proportion to the slum population.  A group of municipal workers non-exposed to sweeping consists of employees associated with fogging, pesticide spraying and peons in offices having similar socioeconomic condition were selected as a control group. These employees were basically field workers of the MCGM, continuously working on the field doing heavy physical activities by carrying all necessary equipment/machines and the nature of their work was more or less similar to sweepers. The sample for case-control is 1:1.
Variables (page.no 6)	7	Outcomes--The respondents reported pain in nine anatomical region i.e. neck, shoulder, wrist/hand, upper back, low back, hip/thigh, knee, and ankle in the past seven days and 12 months were considered as morbid with the MSDs. The sweepers were prevented from doing normal day to day activities at home or away from home due to the MSDs classified and recoded as disabled in past 12 months. Exposure--Continuous physical activity in a particular posture leads to development of the musculoskeletal pain for employees associated with street sweeping and carrying wheelbarrow to community dustbin. Effect modifier-- Hence the location of work, job satisfaction and mental health state of the sweepers were considered as effect modifier. Potential Confounders-- the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities
Data sources/ measurement (page.no 6)	8*	Primary data was collected for present study, and propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
Bias (page.no 17)	9	Biasness might have occurred due to the subjectivity in response, but there was less chance of false reporting as the study was guaranteed confidentiality.
Study size (page.no 5)	10	The estimated sample size was 180 with p-value 0.30 and design effect 1.25. Finally, the data collected from 180 street sweepers and 180 control group of MCGM.
Quantitative variables	11	Appropriate variables were recoded as per the requirement of applied methods.
Statistical methods (page.no 6,8)	12	Differences in prevalence of the MSDs and the disabilities were tested by Chi-square test. The multivariate logistic regression analysis were performed to assess the correlation between individual characteristics with the MSDs and thereby disabilities. To examine the impact of street sweeping occupation on the MSDs and the disabilities, propensity score matching method was applied.  Propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
<i>Cross-sectional study</i> —Socioeconomic and demographic characteristics variable of case and control has been addressed and match to control the		



effect on MSDs and disabilities. The PSM particularly match the these variables and assess the impact of sweeping on MSDs and disabilities  
Sample for case and control group were selected from same location and wards

Continued on next page

## Results

Participants (page.no 5)	13*	The cases (n=180) and control (n=180) were considered throughout the analysis.
Descriptive data (page.no 8)	14*	There was marginal difference in the mean age of the street sweepers (37 years, SD $\pm$ 9.12) and the control group (38 years, SD $\pm$ 7.39). Similar pattern was observed while looking at the working years among the street sweepers (11 years, SD $\pm$ 8.30) and the control group (11 years, SD $\pm$ 6.35). Occupational structure was predominately influenced by the social structure and caste system of the Indian society. The Schedule caste communities- i.e. the communities who were previously untouchables, economically weakest were historically assigned to cleaning or menial work and discriminated because of caste based society. In the contemporary society, it is reflects as majority of employees working in solid waste management belong to the schedule caste (SCs), identified by the constitutional schedule of India. Descriptive statistics suggest that more than 86% of the sweepers belonged to the schedule castes. Personal behavior habits such as alcohol consumption, tobacco smoking and chewing tobacco were common among the sweepers compared to the control group e.g. one third (34%) sweepers consumed more than two addiction compared to the control group (19%). In the present study, (17%) of the street sweepers reported that they were not satisfied with sweeping occupation compared to the control group (8%).
Outcome data (page.no 6)	15*	Standard Modified Nordic Questionnaire was adopted to measure the MSDs and related disabilities in the past 12 months.
Main results (page.no 16)	16	Along with the location of work, the risk factors such as years of working, job satisfaction and mental health of workers considered as individual risk factors. The MSDs were adjusted for workers age and BMI as they may affect in developing MSDs as well as disabilities.
Other analyses	17	No
<b>Discussion</b>		
Key results (page.no 2)	18	The prevalence of the MSDs and related disabilities found significantly higher for shoulder, wrist/hand, elbow and neck among street sweepers compared to control group. Results of PSM method highlighted that the sweeping occupation raised the risk of developing the MSDs as well as disabilities particularly for shoulder (17-16%), wrist/hand (14% each), elbow (13% each) and upper back (12-13%) respectively. After adjustment of the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities.
Limitations (page.no 3)	19	Biasness might have occurred due to the subjectivity in response, but there was less chance of false reporting as the study was guaranteed confidentiality.
Interpretation	20	In absence of any studies based on the MSDs among the street sweepers, the results of

(page.no 16) present study are comparable with other studies conducted with solid waste workers except knee and ankle disorders. This may be so because the street sweeper were not engaged in lifting heavy loads continuously as well as carrying it for long duration which might not put pressure on the knee and ankles as compared to the workers associated with the solid waste collection.

Generalisability 21 Results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

Other information

Funding 22 The present study is a part of PhD work and does not receive any funding neither for the paper nor for the original study.

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: A cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-012354.R1
Article Type:	Research
Date Submitted by the Author:	11-Aug-2016
Complete List of Authors:	Salve, Pradeep; International Institute for Population Sciences, Public Health and Mortality Studies Chokhandre, Praveen; International Institute for Population Sciences, Mumbai,
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Public health
Keywords:	Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Hand & wrist < ORTHOPAEDIC & TRAUMA SURGERY, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, Shoulder < ORTHOPAEDIC & TRAUMA SURGERY, Street sweepers

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**Title:** Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: a cross-sectional study

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**Key words** Back pain, Hand & wrist, Musculoskeletal disorders, Shoulder, Street sweepers

**Word count:** 3461

## Abstract

**Objective:** Study aims to assess the exposure of street-sweeping to the development of musculoskeletal disorders (MSDs) and related disabilities and tries to identify the individual risk factors leading to development of MSDs and related disabilities among sweepers.

**Participants:** A cross-sectional survey was conducted with a comparison group. Street-sweepers (n=180) and a comparison group (n=180) working for at least a year were randomly selected from six municipal wards, all were formal employees of the Municipal Corporation of Greater Mumbai.

**Method:** A Standardized Nordic Questionnaire was adopted to measure the MSDs and related disabilities. The impact of sweeping occupation on the development of MSDs and related disabilities was assessed using the propensity score matching (PSM) method. A multivariate logistic regression model was employed to identify the individual risk factors.

**Results:** The prevalence of MSDs was significantly higher among the sweepers for shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%) compared to the comparison group, in which the prevalence was 11%, 19%, 9%, and 11% respectively. Similarly, the disabilities among sweepers were significantly higher for lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), and elbows (23%) compared to the comparison group (18%, 19%, 13%, 9%, and 6% respectively). The PSM method highlighted that the occupation of sweeping raised the risk of developing MSDs as well as disabilities particularly for shoulders (17-16%), wrists/hands (14% each), elbows (13% each), and upper back (12-13%). After adjusting the workers' age and body mass index (BMI), the number of years of engagement in sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities.

**Conclusion:** Study concluded that the occupation of sweeping raises the risk of MSDs and related disabilities. Results from the study recommend preventive and curative measures to abate episodes of MSDs among street-sweepers.

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**Article summary**

**Strengths and limitations of this study**

- The present study assessed MSDs and MSD-led disabilities among street sweepers, whereas past studies primarily focused on the occupational morbidities other than MSDs among street sweepers.
- The propensity score matching (PSM) method was adopted to assess the exposure of street sweeping on the development of MSDs and related disabilities.
- Bias in recalling MSDs and disabilities is possible due to the reference period being one year long.
- The subjects of the study carried out sweeping manually; hence the results may be generalised with caution.

## INTRODUCTION

The occupation of sweeping is a vigorous task that involves sweeping of assigned areas such as roads, footpaths, parks, markets, and open settlements using long-handle brooms and wheelbarrows, the waste in wheelbarrows being finally deposited in nearby community dustbins. This whole process requires continuous physical activities such as manual sweeping in the standing posture for long durations, bending while collecting the swept waste, pushing and pulling of the wheelbarrow, and manual lifting of baskets to deposit waste. A similar process is followed in other cities in India and other developing countries. The Municipal Corporation of Greater Mumbai (MCGM) has 9231 regular employees engaged in the street sweeping occupation, and the corresponding figure for India as a whole must be many times higher. Numerous studies have concluded that the occupational exposure of sweeping is associated with the development of chronic respiratory diseases, skin diseases, eye irritation, asthma, tuberculosis, and hypertension among workers [1–4]. The other non-fatal injuries identified are mostly musculoskeletal in nature. Musculoskeletal disorders are defined as pain, ache or discomfort in any of the anatomical areas of the body viz. neck, shoulders, upper back, lower back, elbows, wrists or hands, hips or thighs, knees, and ankles or feet [5].

Past studies conducted among solid waste collectors suggest a higher probability among them of developing musculoskeletal disorders (MSDs) compared to the general population [5–7]. Workers involved in repetitious physical activities of bending, lifting, pushing and pulling for long durations have been identified as facing the risk factors leading to the development of MSDs [8–10]. So far, very few studies have been conducted among street sweepers. Moreover, there is hardly any study that has assessed the risk of musculoskeletal disorders thoroughly. Past studies conducted among street sweepers have predominantly focused on eye, skin and respiratory morbidities in India [4,11–14]. The present study, in contrast, aimed to assess the occupational exposure of sweeping to the development of MSDs as well as disabilities. Additionally, the study tried to identify the individual risk factors leading to the development of MSDs and disabilities among street sweepers.



**MATERIAL AND METHODS**

**Study design and participants**

The study applied cross-sectional design to assess the prevalence of musculoskeletal disorders and related disabilities among street sweepers compared to a comparison group. A street sweeper sweeps assigned areas, such as roads, residential areas, markets, public parks, and open settlements, using a long-handle broom and a wheelbarrow to deposit collected waste into nearby community dustbins. Sweepers work eight hours daily in groups of two. A group of municipal workers not exposed to sweeping – including employees associated with fogging and pesticide spraying, and peons having similar socioeconomic conditions were selected as comparison group. These employees were basically field workers of the MCGM, continuously working in the field, doing heavy physical activities such as carrying necessary equipment/machines. Their work load was more or less similar to that of the sweepers.

The present study was primarily conducted to examine the major morbidities, including MSDs, among municipal street sweepers. The estimated sample size was 180 with a prevalence rate value of 30 and a design effect of 1.25 [11]. Applying stratified systematic random sampling design, the required sample was collected randomly from 6 out of 24 municipal wards of the MCGM based on the proportion of the slum population. At the first stage, according to the proportion of the slum population, 24 municipal wards were arranged in the ascending order and divided into three strata, that is, low, moderate and high. At the second stage, two wards were randomly selected from each stratum. Based on the list of employees provided by the Municipal Corporation, a representative sample of 60 employees from each ward (that is 30 sweepers and non-sweepers) was selected through systematic random sampling. Finally, a sample of 180 street sweepers and 180 employees for a comparison group was interviewed at the workplace from March to September 2015.

**Measurements**

A Standardized Nordic Questionnaire was adopted to assess the musculoskeletal disorders [15]. A diagram with labels and arrows clearly indicating the different musculoskeletal regions was used for the assessment of MSDs during the past 12 months and the previous 7 days prior to survey. The interview schedule collected information on the MSDs along with the demographic,

socio-economic, and occupational characteristics. Specifically, the schedule covered age, years of work, substance use, anthropometric measures, job satisfaction, and mental health.

## Variables

### Outcome variables

The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled.

### Exposure classification

Age and years of working are significant predictors of development of MSDs among solid waste collectors, with the risk of MSDs increasing with increasing age and years of working [5]. Similarly, past studies have concluded that overweight and obesity are positively associated with MSDs because of the pressure exerted on the weight-bearing joints [16,17]. Symptoms of worry, tension, anxiety, work stress, and low mood too have correlation with musculoskeletal pain [18–20].

Job satisfaction of employees also influences the prevalence of MSDs [21]. Job satisfaction is measured on a scale of 1-5, with 1 being very bad and 5 being very good. In the present study, the responses were scored as 1,2,3 in place of being measured using the likert scale of 1-2-3-4-5 as this method is believed to help eliminate any biases which might result from the respondents choosing responses 1 and 2 or 4 and 5 respectively. Finally, the responses were recoded as low, medium and high. Past studies show that psychosocial factors such as mental health and job satisfaction may increase or decrease the prevalence of MSDs among the street sweepers too [22].

The quantum of work that sweepers have to do in low or high slum concentrated areas too may affect the prevalence of MSDs and related disabilities among them. Since sweeping in the slum areas is a rigorous task due to disorganized garbage disposal, overflowing community dustbins, and open defecation by the children on the footpaths, the workload can be higher. Therefore, the

location of work was considered to be one of the risk factors. Based on the proportion of the slum population, the wards were divided into three, that is, low, moderate and high. Job satisfaction, location of work and mental health of sweepers were considered effect modifiers.

The mental health of sweepers was analyzed by applying the General Health Questionnaire of 12 items (GHQ-12) [23]. The workers were asked whether they had experienced any positive or negative emotions in the previous month. Each negative response was coded 1, while the absence of it was coded 0. The items were summed to a score for each respondent. The higher the score increased through 0 to 12, the more severe the mental health problem was considered to be. Further, the score was divided into three categories of low, medium and high. The mental health scale has acceptable internal consistency ( $\alpha=0.97$ ) [24].

**Statistical Analysis**

The data was entered in the CSPro.06 software and analyzed using the STATA13 software. Descriptive statistics were used to understand the socioeconomic and occupational characteristics. Differences in the prevalence of MSDs and the related disabilities were tested using the Chi-square test. The differences in groups were tested by independent sample t-test.

While assessing the exposure of the occupation of sweeping to the development of MSDs, the study adopted the nearest neighbourhood method of propensity score matching (PSM) [25,26]. The method allowed assessment of the impact of exposure on outcomes using cross-sectional survey data. The propensity score was estimated by logistic regression with the dichotomous exposure variable, for instance 1 = exposed to sweeping and 0 = unexposed to sweeping, using associated observed demographic and occupational characteristics of the sweepers used as predictor variables. The principal assumption of the PSM is the condition that observable characteristics of the exposed and the comparison groups have similar distributions. This assumption test was applied by using the ‘p-score’ command. The propensity score was calculated using the probability of treatment assignment given pre-treatment characteristics.

$$p(x) \equiv \text{prob} (D = 1|x_i) = E(D|x_i)$$

where,  $D = \{0, 1\}$  is the indicator of exposure and  $x$  is the multidimensional vector of pretreatment characteristics.

The average exposure effect on exposed (AEEE) is defined as the conditional expectation of the difference in the exposure effect for the treated units only. After matching the propensity scores, we compared the outcomes of the exposed and the counterfactual scores of the comparison group.

$$AEEE = E(\Delta | p(x), D=1) = E(y_1 | p(x), D=1) - E(y_0 | p(x), D=1)$$

To calculate the impact of street sweeping on MSDs and related disabilities during the last 12 months, the average effects in both the groups were weighted by the proportion of respondents in both the exposed and the comparison groups. Further, to understand the individual risk factors for MSDs and disabilities among sweepers, multiple logistic regression analysis was applied.

### **Ethical considerations**

As the study involved government employees, permission to conduct the primary survey was approved by the MCGM. Ethical clearance prior to data collection was also approved by the Student Research Ethics Committee at the International Institute for Population Sciences, Mumbai. The informed consent of the participants was obtained in the local language, and the respondents were assured that the information would be confidential and used for research purposes only.

## **RESULTS**

### **Characteristics of the study population**

The socioeconomic and occupational characteristics of the street sweepers and the comparison group have been depicted in Table 1. There was a small difference in the mean age of the street sweepers (37 years, SD  $\pm$  9.12) and that of the comparison group (38 years, SD  $\pm$  7.39). A similar pattern was observed while looking at the years of working of the street sweepers (11 years, SD  $\pm$  8.30) and those of the comparison group (11 years, SD  $\pm$  6.35). Similarly, substance use, such as alcohol consumption, smoking, and chewing tobacco, were higher among the sweepers compared to the comparison group. For instance, nearly 70 percent of the sweepers were using at least one type of substance. A little less than one-third were using two or more types of substance. The corresponding figure for the comparison group was (19%). Further, 17% of the street sweepers reported that they were not satisfied with their occupation compared to 8% of the comparison group.

Table 1 Descriptive statistics of the study groups		
Background Characteristics	Street Sweeper N=180	Comparison group N=180
<b>Workers Age</b>	(t= -0.952; p=0.3416 )	
19-34 years	45.5	34.4
35 & above	54.4	65.5
Mean age ± SD	37.3 ± 9.1	38.1 ± 7.4
<b>Years of Working</b>	(t = -1.123; p= 0.261)	
Below 10	67.8	51.1
10 or more	32.2	48.9
Mean ± SD	10.6 ± 8.3	11.4 ± 6.3
<b>Substance use</b>		
No Addiction	33.3	53.3
Any one	68.6	46.6
Two or more	32.2	19.4
<b>Mental Health (GHQ-12)</b>		
Low	47.2	35.6
Medium	21.7	28.9
High	31.1	35.6
<b>Job Satisfaction</b>		
High	17.8	30.5
Medium	65.0	61.1
Low	17.2	8.3
<b>BMI</b>		
<25	65.6	51.7
>25	34.4	48.3
Mean BMI±SD	23.6 ± 1.4	25.1 ± 3.3
<b>Caste</b>		
SC/ST	85.6	51.7
Others	14.4	48.3

The prevalence of MSDs and related disabilities during the past 12 months in various musculoskeletal sites is presented in Table 2 for the street sweepers and the comparison group. The results show that the street sweepers were at a significantly higher risk of developing MSDs compared to the comparison group, specifically for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%). These figures were 11%, 19%, 9%, and 11% respectively for the

comparison group. Similarly, the street sweepers significantly differed from the comparison group in terms of disabilities during the past 12 months. For instance, the sweepers were disabled due to pain in the lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) compared to 18%, 19%, 13%, 9%, 6% and 8% respectively in the case of the comparison group. Additionally, the incidence of MSDs during the previous 7 days was significantly higher among the sweepers, particularly for the upper back (19%), wrists/hands (17%), hips/thighs (17%), elbows (16%), lower back (15%), and shoulders (11%) compared to the comparison group (4%, 3%, 7%, 4%, 9%, and 4% respectively).

**Table 2 Prevalence and incidence of musculoskeletal disorder and disability among study groups in the past 7 days and 12 months**

Body regions	Street Sweeper N=180	Comparison group N=180	X <sup>2</sup> test
<b>Neck</b>			
Past 12 months	16.7 %	10.6 %	X <sup>2</sup> = 2.858; p = 0.091
Disabled in past 12 months	10.6 %	9.4 %	X <sup>2</sup> = 0.123; p = 0.725
7 days	6.7 %	4.4 %	X <sup>2</sup> = 0.847; p = 0.357
<b>Shoulder</b>			
Past 12 months	31.7 %	11.1 %	X <sup>2</sup> = 22.616; p = 0.000
Disabled in past 12 months	24.4 %	9.4 %	X <sup>2</sup> = 14.388; p = 0.000
7 days	10.6 %	4.4 %	X <sup>2</sup> = 4.844; p = 0.028
<b>Elbow</b>			
Past 12 months	26.7 %	8.9 %	X <sup>2</sup> = 19.459; p = 0.000
Disabled in past 12 months	23.3 %	5.6 %	X <sup>2</sup> = 23.017; p = 0.000
7 days	16.1 %	4.4 %	X <sup>2</sup> = 13.284; p = 0.000
<b>Wrist/ Hand</b>			
Past 12 months	29.4 %	18.9 %	X <sup>2</sup> = 5.471; p = 0.019
Disabled in past 12 months	26.1 %	13.3 %	X <sup>2</sup> = 9.281; p = 0.002
7 days	16.7 %	2.8 %	X <sup>2</sup> = 19.780; p = 0.000
<b>Upper Back</b>			
Past 12 months	33.9 %	27.2 %	X <sup>2</sup> = 1.885; p = 0.170
Disabled in past 12 months	26.7 %	18.9 %	X <sup>2</sup> = 3.095; p = 0.079
7 days	18.9 %	3.9 %	X <sup>2</sup> = 20.065; p = 0.000
<b>Low Back</b>			
Past 12 months	33.3 %	29.4 %	X <sup>2</sup> = 0.632; p = 0.427
Disabled in past 12 months	26.7 %	17.8 %	X <sup>2</sup> = 4.114; p = 0.043



7 days	15.6 %	8.9 %	$X^2 = 3.728$ ; $p = 0.053$
<b>Hip/Thigh</b>			
Past 12 months	26.7 %	20.0 %	$X^2 = 2.236$ ; $p = 0.135$
Disabled in past 12 months	16.7 %	7.8 %	$X^2 = 6.628$ ; $p = 0.010$
7 days	17.2 %	6.7 %	$X^2 = 9.534$ ; $p = 0.002$
<b>Knee</b>			
Past 12 months	1.7 %	3.9 %	$X^2 = 1.6457$ ; $p = 0.200$
Disabled in past 12 months	0.6 %	3.3 %	$X^2 = 3.6423$ ; $p = 0.056$
7 days	1.7 %	0.6 %	$X^2 = 1.0112$ ; $p = 0.315$
<b>Ankles/Feet</b>			
Past 12 months	3.9 %	2.2 %	$X^2 = 0.8440$ ; $p = 0.358$
Disabled in past 12 months	1.7 %	2.2 %	$X^2 = 0.1457$ ; $p = 0.703$
7 days	2.2 %	0.6 %	$X^2 = 1.8254$ ; $p = 0.177$

Street sweeping augments the MSDs

In order to assess the effects of sweeping on the development of MSDs, the PSM method was employed. The results have been exhibited in Table 3 in terms of the average exposure effects among exposed (AEEE) for the MSDs and disabilities during the past 12 months. The results of the AEEE highlighted that the occupation of sweeping raised the episodes of MSDs, particularly for the shoulders (17%), wrists/hands (14%), elbows (13%), upper back (12%), neck (10%), and hips/thighs (9%). A similar pattern was observed for the MSD led disability, which was significantly higher for the shoulders (16%), lower back (14%), wrists/hands (14%), upper back (13%), elbows (13%), and hips/thighs (12%). In a nutshell, the results of the PSM demonstrated that the occupation of sweeping significantly enhanced MSDs and disabilities.

Table 3 Average exposure effect among exposed (AEEE) to street sweeping occupation on developing MSDs and disability for various body regions in the past 12 months				
Body regions	MSDs		Disability# due to MSDs	
	Coef.	95% CI	Coef.	95% CI
Neck	0.10**	(0.02 to 0.19)	0.02	(-0.05 to 0.09)
Shoulder	0.17***	(0.07 to 0.27)	0.16***	(0.07 to 0.24)
Elbow	0.13***	(0.05 to 0.21)	0.13***	(0.06 to 0.19)
Wrist/hand	0.14***	(0.06 to 0.22)	0.14***	(0.07 to 0.21)
Upper back	0.12***	(0.04 to 0.21)	0.13***	(0.05 to 0.22)
Lower back	0.08*	(-0.02 to 0.18)	0.14***	(0.05 to 0.23)



<b>Hip/thigh</b>	0.09**	(0.00 to 0.18)	0.12***	(0.05 to 0.18)
** $p < 0.05$ , *** $p < 0.01$ , * $p < 0.1$ ; # Prevented normal activity at home or away from home due to MSDs				

### The factors associated with the MSDs

The individual risk factors enhancing the MSDs among the sweepers in the last 12 months were identified after adjusting for workers' age and BMI. The results for the same have been presented in Table 4. The results exhibited that years of working emerged as a significant predictor of the development of the MSDs. For instance, the workers working for 10 or more years were significantly more likely to suffer from MSDs in the elbows (OR=12.06;  $p < 0.01$ ), shoulders (OR=6.72;  $p < 0.01$ ), wrists/hands (OR=6.21;  $p < 0.01$ ), upper back (OR=5.80;  $p < 0.01$ ), neck (OR=5.07;  $p < 0.01$ ), and hips/thighs (OR=4.23;  $p < 0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction among the sweepers was also found to be significantly correlated as the sweepers who were not satisfied with their job were more likely to have suffered from the MSDs in the wrists/hands (OR=12.01;  $p < 0.05$ ), hips/thigh (OR=5.08;  $p < 0.05$ ), upper back (OR=4.27;  $p < 0.05$ ), and lower back (OR=3.65;  $p < 0.05$ ) as compared to the sweepers who reported to be satisfied with their jobs.

Similarly, the location of work was found to be a significant predictor of developing MSDs. As, sweepers working in the high slum concentrated areas were more likely to get MSDs in the hips/thighs (OR=10.42;  $p < 0.01$ ), lower back (OR=5.10;  $p < 0.01$ ), and elbows (OR=0.22;  $p < 0.05$ ) as compared to sweepers working in the low slum concentrated areas.

Table 4 Odds ratio showing individual risk factors for MSDs among street sweepers (past 12 months)							
	Neck	Shoulder	Elbow	Wrist/hand	Upper back	Lower back	Hip/thigh
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	5.07*** (1.52 to 16.89)	6.72*** (2.41 to 18.76)	12.06*** (3.23 to 45.10)	6.21*** (2.38 to 16.24)	5.80*** (2.36 to 14.30)	2.78** (1.19 to 6.57)	4.23*** (1.64 to 10.96)
<b>Job satisfaction</b>							
High ®							
Medium	0.50 (0.15 to 1.70)	2.11 (0.68 to 6.54)	2.32 (0.56 to 9.68)	6.62** (1.38 to 31.94)	4.92*** (1.45 to 16.74)	1.52 (0.57 to 4.06)	2.48 (0.75 to 8.19)
Low	1.93 (0.51 to 7.33)	2.35 (0.63 to 8.75)	1.87 (0.36 to 9.59)	12.01** (2.18 to 66.24)	4.27** (1.07 to 17.06)	3.65** (1.13 to 11.82)	5.08** (1.28 to 20.21)
<b>Mental health</b>							
Low ®							
Medium	0.24 (0.03 to 2.21)	0.32 (0.06 to 1.59)	0.22 (0.03 to 1.89)	0.30* (0.07 to 1.30)	0.79 (0.23 to 2.73)	0.86 (0.25 to 2.92)	0.32 (0.06 to 1.78)
High	1.19 (0.45 to 3.14)	2.18 (0.95 to 4.96)	2.31* (0.91 to 5.94)	1.27 (0.53 to 3.05)	1.97* (0.87 to 4.48)	1.34 (0.59 to 3.04)	1.75 (0.71 to 4.33)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.43 (0.14 to 1.30)	0.90 (0.36 to 2.27)	0.80 (0.29 to 2.18)	1.08 (0.43 to 2.71)	2.02 (0.82 to 4.97)	2.13* (0.85 to 5.37)	4.07** (1.29 to 12.79)
High	0.39* (0.13 to 1.12)	0.92 (0.37 to 0.43)	0.22*** (0.07 to 0.68)	0.44* (0.17 to 1.17)	2.10* (0.85 to 5.18)	5.10*** (2.07 to 12.60)	10.42*** (3.43 to 31.70)
® Reference category; ***p<0.01, **p<0.05, *<0.1; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers age and BMI							

<b>Table 5 Odds ratio showing individual risk factors for disabilities due to MSDs among street sweepers (past 12 months)</b>							
	<b>Neck</b>	<b>Shoulder</b>	<b>Elbow</b>	<b>Wrist/hand</b>	<b>Upper back</b>	<b>Lower back</b>	<b>Hip/thigh</b>
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	6.04** (1.11 to 32.88)	3.05** (1.20 to 7.77)	9.40*** (2.35 to 37.59)	5.13*** (1.93 to 13.64)	4.17*** (1.60 to 10.86)	2.95** (1.18 to 7.35)	5.88*** (1.93 to 17.89)
<b>Job Satisfaction</b>							
High ®							
Medium	0.26* (0.06 to 1.15)	1.26 (0.43 to 3.68)	1.50 (0.35 to 6.39)	5.03** (1.02 to 24.73)	3.26* (0.97 to 11.02)	1.21 (0.43 to 3.45)	1.69 (0.46 to 6.23)
Low	1.21 (0.25 to 5.94)	0.69 (0.18 to 2.69)	1.35 (0.25 to 7.15)	8.26** (1.47 to 46.48)	2.74 (0.68 to 11.11)	3.45** (1.02 to 11.75)	1.63 (0.35 to 7.53)
<b>Mental health</b>							
Low ®							
Medium	0.40 (0.04 to 4.06)	0.18 (0.02 to 1.51)	0.33 (0.04 to 2.89)	0.43 (0.10 to 1.84)	1.14 (0.31 to 4.19)	0.92 (0.24 to 3.53)	0.32 (0.03 to 2.99)
High	1.12 (0.34 to 3.74)	1.91 (0.83 to 4.38)	2.78** (1.03 to 7.48)	1.59 (0.65 to 3.87)	2.87** (1.22 to 6.74)	1.14 (0.47 to 2.76)	1.54 (0.56 to 4.27)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.03*** (0.00 to 0.33)	0.56 (0.22 to 1.45)	0.74 (0.26 to 2.13)	0.90 (0.35 to 2.32)	2.55* (0.95 to 6.89)	2.30 (0.79 to 6.68)	7.30** (1.40 to 38.22)
High	0.24** (0.07 to 0.80)	0.61 (0.25 to 1.51)	0.18*** (0.05 to 0.62)	0.38** (0.14 to 1.02)	3.13** (1.19 to 8.27)	7.16*** (2.59 to 19.75)	15.77*** (3.23 to 77.07)
® Reference category; *** $p < 0.01$ , ** $p < 0.05$ , * $p < 0.1$ ; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers age and BMI							

An inquiry was also made to identify the individual factors enhancing the risk of disabilities during the past 12 months and has been depicted in Table 5. The results suggested that the number of years of working is significantly correlated with disabilities. More specifically, the sweepers working for 10 and more years were significantly more likely to suffer from the disabilities in the elbows (OR=9.40;  $p<0.01$ ), hips/thighs (OR=5.88;  $p<0.01$ ), wrists/hands (OR=5.13;  $p<0.01$ ), and upper back (OR=4.17;  $p<0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction and mental health were not significantly correlated with the disabilities among the sweepers. The sweepers working in the high slum concentrated areas were significantly more likely to develop disabilities in the hips/thigh (OR=15.77;  $p<0.01$ ), lower back (OR=7.16;  $p<0.01$ ), elbows (OR=0.18;  $p<0.01$ ), and upper back (OR=3.13;  $p<0.05$ ) as compared to the sweepers working in the low slum concentrated areas.

DISCUSSION

The sweepers work for long hours in public places using long-handle brooms along with the wheelbarrows. This repetitive, rigorous occupation enhances musculoskeletal disorders and related disabilities among the street sweepers as compared to the comparison group. The results of bivariate analysis showed that the prevalence of the MSDs among the street sweepers was significantly higher for the shoulders (32%), wrists/hands (29%), and elbows (27%) as compared to the comparison group during the past 12 months. Field observation suggested that this may be because of the continuous sweeping with the long-handle broom and carrying of the collected waste in the wheelbarrow to the community dustbins manually in an unvarying posture. Similarly, MSDs were found to be significantly higher among the street sweepers for the lower back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) as compared to the comparison group over the past 12 months.

The results of PSM method revealed that the average exposure effect among exposed (AEEE) to the sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulders (17%), wrists/hands (14%), elbows (13%), and upper back (12%). A similar pattern was observed in case of disabilities, particularly for the shoulders (16%), wrists/hands (14%), lower back (14%), elbows (13%) and upper back (13%). After adjusting for working age and BMI, the results of the multivariate logistic regression model revealed that years of working, job

satisfaction and location of work were significantly correlated with pain in the shoulders, elbows, wrists/hands, lower back, upper back, and hips/thighs.

The location of work emerged as a significant predictor of increased likelihood of MSDs and related disabilities among the street sweepers due to the higher quantum of work in the high slum concentrated areas. In the absence of any studies on MSDs among the street sweepers, the results of the present study are comparable with the other studies conducted among the solid waste workers except in the case of knee and ankle disorders [3,4,11,27,28]. This may be because the street sweepers are not engaged in lifting heavy loads continuously or for carrying them for long duration, as a result of which they do not put as much pressure on the knees and ankles as those engaged in solid waste collection. A cross-sectional study conducted in Iran on 217 municipal solid waste workers showed the workers to have a higher prevalence of the MSDs of the lower back (45%), knees (29%), shoulders (24%), upper back (23%), and neck (22%) as compared to the comparison group [5]. A similar study conducted in India with 313 waste workers concluded that the prevalence of MSDs was high among the solid waste workers particularly for the knees (39%), lower back (33%), shoulders (30%), elbows (27%), ankles (22%), wrists (21.7%), and neck (17%) [11]. These findings are in tune with the present study in offering the evidence that workers associated with municipal solid waste management have higher musculoskeletal disorders compared to the general population. The results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

Past meta-analysis studies have exhibited that substance use, such as alcohol consumption, smoking and chewing tobacco, affects the physical capacity for work and causes musculoskeletal pain [29,30]. We observed that seven out of ten sweepers were using at least one type of substance (tobacco, smoking or consumption of alcohol) and around one-third were using two or more type of substances.

The occupational structure is predominantly influenced by the social structure and the caste system of Indian society. The Scheduled Caste communities that is, communities who were previously untouchables and economically the weakest – were historically assigned cleaning or menial work and were discriminated against [31]. In the contemporary times, things have not much changed and it is seen that the majority of the employees working in solid waste management belong to the Scheduled Castes (SCs) as identified by the constitutional schedule of

India. The present study shows that more than 86% of the sweepers belong to the Scheduled Castes and only a marginal proportion come from the other caste groups.

**Limitations of the Study**

In the present study, biases might have occurred due to subjectivity in the response since the severity of MSDs was not quantified. However, the chances of false reporting are low as the study guaranteed confidentiality. The cross-sectional survey method for data collection might have underestimated or overestimated the actual prevalence of MSDs and related disabilities due to the reference period being one year long which may have led to the recall bias. Further, there may be seasonal variations. For instance, the prevalence of the MSDs may increase during the rainy season because wet waste requires extra energy for sweeping. This study was conducted among municipal street sweepers sweeping public places; the results may be generalized with caution.

**Strategies to minimize the burden of MSDs**

- Job rotation between sweepers, waste collectors and compactor drivers [32].
- Since the location of work was found to play a crucial role in the development of MSDs and related disabilities, it is recommended that the municipal corporations minimize the risk by changing the location of work quarterly.
- The street sweepers may undergo medical examination every quarter, whereby a physician can advise them on the preventive measures to minimize MSDs and disabilities.
- The burden of functional impairment due to MSDs may be reduced by proper curative treatment.
- Municipal corporations may provide medical insurance assistance to reduce the financial burden on the sweepers.

Past studies have demonstrated that job rotation between waste collectors, street sweepers and drivers help in reducing workload and as well as the risk of MSDs [32,33]. Sweepers sweeping in high slum concentrated areas may be shifted to low slum concentrated areas since the workload varies by place of work. This flexibility in job rotation and alternative

changes in the place of work may reduce the risk of MSDs and related disabilities. MCGM has a provision for medical examination of its workers on a yearly basis, but due to the corporation's negligence, the implementation of this provision is not efficient. The burden of disabilities may be reduced by taking curative measures at the initial point and by providing proper treatment.

## Acknowledgement

Authors acknowledge the English editing services from Ms. Shailja Thakur.

### a. Contributors

Pradeep Salve contributed to the conceptualization, design and data analysis.

Praveen Chokhandre led the conceptualization, data analysis and write up.

Both the authors have read and approved the final manuscript.

### b. Competing interests: Declared None.

### c. Funding: This research work received no specific grant from any funding agency in the public, commercial or not for profit sector.

### d. Ethics approval: The study was approved by the institute research committee.

### e. Data sharing statement: There is no additional data available.

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## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b> (page.no 1-2)	1	<p>(a) Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: A cross-sectional case-control study</p> <p>(b) <b>Objective</b> Study aims to assess the exposure of street sweeping on developing the MSDs as well as disabilities and tried to identify the individual risk factors among street sweepers.</p> <p><b>Methods</b> A cross-sectional case-control design was adopted. The participants, street sweepers (n=180) and control group (n=180) were selected from six municipal wards and were employees of Municipal Corporation of Greater Mumbai. The standardized modified Nordic questionnaire was adopted to measure the MSDs and disabilities. The PSM method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities. In addition, a multivariate logistic regression model was employed to identify individual risk factors.</p> <p><b>Results</b> the prevalence of the MSDs and related disabilities found significantly higher for shoulder, wrist/hand, elbow and neck among street sweepers compared to control group. Results of PSM method highlighted that the sweeping occupation raised the risk of developing the MSDs and disabilities particularly for shoulder (17-16%), wrist/hand (14% each), elbow (13% each) and upper back (12-13%) respectively. After adjustment of the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities.</p> <p><b>Conclusion</b> The study portrayed that occupation of street sweeping raised the risk of the MSDs and extend to musculoskeletal disabilities. Individual risk factors increase the risk of developing the MSDs as well as musculoskeletal disabilities. Results from the study recommends preventive and curative measures to abate the episodes of the MSDs among street sweepers.</p>
<b>Introduction</b>		
Background/rationale (page.no 4)	2	Study assessed the MSDs among street sweepers, whereas all past studies primarily focused on the occupational related morbidities other than MSDs among street sweepers.
Objectives (page.no 4)	3	Study aims to assess the exposure of sweeping occupation on developing the MSDs as well as the disabilities. Additionally, the study tried to identify the individual risk factors leading to develop the MSDs and disabilities among street sweepers.
<b>Methods</b>		
Study design (page.no 4)	4	The study applied cross-sectional case-control design to assess the prevalence of musculoskeletal disorder and related disabilities among street sweepers compared to control group
Setting (page.no 5)	5	Both the type of workers i.e. street sweeper and control group were formal employees of Municipal Corporation of Greater Mumbai. A group of workers (non-exposed to sweeping occupation) consists of employees associated with fogging, pesticide spraying and peons in offices and were selected as a control group. These employees were basically field workers of the MCGM, continuously working on the field doing heavy physical activities by carrying all necessary equipment/machines and the nature of their work was more or less similar to sweepers. The data was collected during March to September

		2015.
Participants (page.no 5)	6	Workers who were engaged in the occupation at-least for a year were selected as participants for the study. Applying stratified systematic random sampling design, the required sample was collected randomly from six out of 24 municipal wards of the MCGM based on the proportion to the slum population.  A group of municipal workers non-exposed to sweeping consists of employees associated with fogging, pesticide spraying and peons in offices having similar socioeconomic condition were selected as a control group. These employees were basically field workers of the MCGM, continuously working on the field doing heavy physical activities by carrying all necessary equipment/machines and the nature of their work was more or less similar to sweepers. The sample for case-control is 1:1.
Variables (page.no 6)	7	Outcomes--The respondents reported pain in nine anatomical region i.e. neck, shoulder, wrist/hand, upper back, low back, hip/thigh, knee, and ankle in the past seven days and 12 months were considered as morbid with the MSDs. The sweepers were prevented from doing normal day to day activities at home or away from home due to the MSDs classified and recoded as disabled in past 12 months. Exposure--Continuous physical activity in a particular posture leads to development of the musculoskeletal pain for employees associated with street sweeping and carrying wheelbarrow to community dustbin. Effect modifier-- Hence the location of work, job satisfaction and mental health state of the sweepers were considered as effect modifier. Potential Confounders-- the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities
Data sources/ measurement (page.no 6)	8*	Primary data was collected for present study, and propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
Bias (page.no 17)	9	Biasness might have occurred due to the subjectivity in response, but there was less chance of false reporting as the study was guaranteed confidentiality.
Study size (page.no 5)	10	The estimated sample size was 180 with p-value 0.30 and design effect 1.25. Finally, the data collected from 180 street sweepers and 180 control group of MCGM.
Quantitative variables	11	Appropriate variables were recoded as per the requirement of applied methods.
Statistical methods (page.no 6,8)	12	Differences in prevalence of the MSDs and the disabilities were tested by Chi-square test. The multivariate logistic regression analysis were performed to assess the correlation between individual characteristics with the MSDs and thereby disabilities. To examine the impact of street sweeping occupation on the MSDs and the disabilities, propensity score matching method was applied.  Propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
		<i>Cross-sectional study</i> —Socioeconomic and demographic characteristics variable of case and control has been addressed and match to control the

effect on MSDs and disabilities. The PSM particularly match the these variables and assess the impact of sweeping on MSDs and disabilities  
Sample for case and control group were selected from same location and wards

Continued on next page

## Results

Participants (page.no 5)	13*	The cases (n=180) and control (n=180) were considered throughout the analysis.
Descriptive data (page.no 8)	14*	There was marginal difference in the mean age of the street sweepers (37 years, SD $\pm$ 9.12) and the control group (38 years, SD $\pm$ 7.39). Similar pattern was observed while looking at the working years among the street sweepers (11 years, SD $\pm$ 8.30) and the control group (11 years, SD $\pm$ 6.35). Occupational structure was predominately influenced by the social structure and caste system of the Indian society. The Schedule caste communities- i.e. the communities who were previously untouchables, economically weakest were historically assigned to cleaning or menial work and discriminated because of caste based society. In the contemporary society, it is reflects as majority of employees working in solid waste management belong to the schedule caste (SCs), identified by the constitutional schedule of India. Descriptive statistics suggest that more than 86% of the sweepers belonged to the schedule castes. Personal behavior habits such as alcohol consumption, tobacco smoking and chewing tobacco were common among the sweepers compared to the control group e.g. one third (34%) sweepers consumed more than two addiction compared to the control group (19%). In the present study, (17%) of the street sweepers reported that they were not satisfied with sweeping occupation compared to the control group (8%).
Outcome data (page.no 6)	15*	Standard Modified Nordic Questionnaire was adopted to measure the MSDs and related disabilities in the past 12 months.
Main results (page.no 16)	16	Along with the location of work, the risk factors such as years of working, job satisfaction and mental health of workers considered as individual risk factors. The MSDs were adjusted for workers age and BMI as they may affect in developing MSDs as well as disabilities.
Other analyses	17	No
<b>Discussion</b>		
Key results (page.no 2)	18	The prevalence of the MSDs and related disabilities found significantly higher for shoulder, wrist/hand, elbow and neck among street sweepers compared to control group. Results of PSM method highlighted that the sweeping occupation raised the risk of developing the MSDs as well as disabilities particularly for shoulder (17-16%), wrist/hand (14% each), elbow (13% each) and upper back (12-13%) respectively. After adjustment of the workers age and their BMI; years of engagement in the street sweeping and their location of work emerged as potential individual risk factors for developing the MSDs and thereby disabilities.
Limitations (page.no 3)	19	Biasness might have occurred due to the subjectivity in response, but there was less chance of false reporting as the study was guaranteed confidentiality.
Interpretation	20	In absence of any studies based on the MSDs among the street sweepers, the results of



(page.no 16) present study are comparable with other studies conducted with solid waste workers except knee and ankle disorders. This may be so because the street sweeper were not engaged in lifting heavy loads continuously as well as carrying it for long duration which might not put pressure on the knee and ankles as compared to the workers associated with the solid waste collection.

Generalisability 21 Results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

Other information

Funding 22 The present study is a part of PhD work and does not receive any funding neither for the paper nor for the original study.

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



# BMJ Open

## Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and disabilities: A cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-012354.R2
Article Type:	Research
Date Submitted by the Author:	17-Oct-2016
Complete List of Authors:	Salve, Pradeep; International Institute for Population Sciences, Public Health and Mortality Studies Chokhandre, Praveen; International Institute for Population Sciences, Mumbai,
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Public health
Keywords:	Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Hand & wrist < ORTHOPAEDIC & TRAUMA SURGERY, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, Shoulder < ORTHOPAEDIC & TRAUMA SURGERY, Street sweepers

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**Title:** Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study

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**Word count:** 2830

**Key words** Street sweepers, musculoskeletal disorders, shoulder and Hand & wrist, Back pain

## Abstract

**Objective:** This study aims to assess the exposure of those involved in street sweeping to the development of musculoskeletal disorders (MSDs) and related disabilities and tries to identify the individual risk factors leading to the development of MSDs and related disabilities among street sweepers.

**Design:** A cross-sectional survey was conducted with a comparison group. A modified Standardized Nordic Questionnaire was adopted to measure MSDs and related disabilities. The impact of the occupation of sweeping on the development of MSDs and related disabilities was assessed using the propensity score matching (PSM) method. A multivariate logistic regression model was employed to identify the individual risk factors.

**Participants:** Street sweepers (n=180) and a comparison group (n=180) working for at least a year were randomly selected from six municipal wards, all of them being formal employees of the Municipal Corporation of Greater Mumbai.

**Results:** The prevalence of the MSDs was significantly higher among the sweepers for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%) compared to the comparison group, in which the prevalence was 11%, 19%, 9%, and 11% respectively. Similarly, the disabilities among the street sweepers were significantly higher for the lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), and elbows (23%) compared to the comparison group, for which the figures were 18%, 19%, 13%, 9%, and 6% respectively. The PSM method highlighted that the occupation of sweeping raised the risk of developing MSDs as well as disabilities particularly those of the shoulders (17-16%), wrists/hands (14% each), elbows (13% each), and the upper back (12-13%). After adjusting the workers' age, body mass index (BMI) and caste, the number of years of engagement in street sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities.

**Conclusion:** The study concluded that the occupation of street sweeping raises the risk of MSDs and musculoskeletal disabilities. Results from the study recommend preventive and curative measures to abate episodes of MSDs among street sweepers.

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**Strengths and limitations of this study**

- The present study assessed MSDs and MSD-led disabilities among street sweepers, whereas past studies primarily focused on the occupational morbidities other than MSDs among street sweepers.
- The propensity score matching (PSM) method was adopted to assess the exposure of street sweeping on the development of MSDs and related disabilities.
- Bias in recalling MSDs and disabilities is possible due to the reference period being one year long.
- The subjects of the study carried out sweeping manually; hence the results may be generalised with caution.

## INTRODUCTION

The occupation of sweeping is a vigorous task which involves sweeping of assigned areas such as roads, footpaths, parks, markets, and open settlements with the help of long-handle brooms and wheelbarrows, the waste in wheelbarrows being finally deposited in nearby community dustbins. This whole process requires continuous physical activities such as manual sweeping in the standing posture for long durations, bending while collecting the swept waste, pushing and pulling of the wheelbarrow, and manual lifting of baskets to deposit waste. A similar process is followed in other cities in India and other developing countries. The Municipal Corporation of Greater Mumbai (MCGM) has 9231 regular employees engaged in the street sweeping occupation, and the corresponding figure must be many times higher for India as a whole. Numerous studies have concluded that the occupational exposure of sweeping is associated with the development of chronic respiratory diseases, skin diseases, eye irritation, asthma, tuberculosis, and hypertension among workers [1–4]. The other non-fatal injuries identified are mostly musculoskeletal in nature. Musculoskeletal disorders are defined as pain, ache or discomfort in any of the anatomical areas of the body viz. neck, shoulders, upper back, lower back, elbows, wrists or hands, hips or thighs, knees, and ankles or feet [5].

Past studies conducted among solid waste collectors suggest a higher probability among them of developing musculoskeletal disorders (MSDs) compared to the general population [5–7]. Workers involved in repetitious physical activities of bending, lifting, pushing and pulling for long durations have been identified as facing the risk factors leading to the development of MSDs [8–10]. So far, very few studies have been conducted among street sweepers. Moreover, there is hardly any study that has assessed the risk of musculoskeletal disorders thoroughly. Past studies conducted among street sweepers have predominantly focused on eye, skin and respiratory morbidities in India [4,11–14]. The present study, in contrast, aimed to assess the occupational exposure of sweeping to the development of MSDs as well as disabilities. Additionally, the study tried to identify the individual risk factors leading to the development of MSDs and disabilities among street sweepers.

## MATERIAL AND METHODS

### Study design and participants

The study applied cross-sectional design to assess the prevalence of musculoskeletal disorders and related disabilities among street sweepers compared to a comparison group. A street sweeper sweeps assigned areas, such as roads, residential areas, markets, public parks, and open settlements, using a long-handle broom and a wheelbarrow to deposit collected waste into nearby community dustbins. They work eight hours daily in groups of two. A group of municipal workers not exposed to sweeping – including employees associated with fogging and pesticide spraying, and peons having similar socioeconomic conditions were selected as comparison group. These employees were basically field workers of the MCGM, continuously working in the field, doing heavy physical activities such as carrying necessary equipment/machines. Their work load was more or less similar to that of the sweepers.

The present study was primarily conducted to examine the major morbidities, including MSDs, among municipal street sweepers. The estimated sample size was 180 with a prevalence rate value of 30 and a design effect of 1.25 [11]. Applying stratified systematic random sampling design, the required sample was collected randomly from 6 out of 24 municipal wards of the MCGM based on the proportion of the slum population. At the first stage, according to the proportion of the slum population, 24 municipal wards were arranged in the ascending order and divided into three strata, that is, low, moderate and high. At the second stage, two wards were randomly selected from each stratum. Based on the list of employees provided by the Municipal Corporation, a representative sample of 60 employees from each ward (that is 30 sweepers and non-sweepers) was selected through systematic random sampling. Finally, a sample of 180 street sweepers and 180 employees for a comparison group was interviewed at the workplace from March to September 2015.

**Measurements**

A modified Standardized Nordic Questionnaire was adopted to assess the musculoskeletal disorders [15]. A diagram with labels and arrows clearly indicating the different musculoskeletal regions was used for the assessment of MSDs during the past 12 months and the previous 7 days prior to survey. The interview schedule collected information on the MSDs along with the demographic, socio-economic, and occupational characteristics. Specifically, the schedule covered age, years of work, substance use, anthropometric measures, job satisfaction, caste and mental health.

## Variables

### Outcome variables

The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled.

### Exposure classification

Age and years of working are significant predictors of development of MSDs among solid waste collectors, with the risk of MSDs increasing with the advancing age and years of working [5]. Similarly, past studies have concluded that overweight and obesity are positively associated with MSDs because of the pressure exerted on the weight-bearing joints [16,17]. Symptoms of worry, tension, anxiety, work stress, and low mood too have correlation with musculoskeletal pain [18–20]. The prevalence of MSDs and disability can vary between group of workers sharing different cultural characteristics [21], therefore the caste category of workers are considered.

Job satisfaction of employees also influences the prevalence of MSDs [22]. Job satisfaction is measured on a scale of 1-5, with 1 being very bad and 5 being very good. In the present study, the responses were scored as 1,2,3 in place of being measured using the Likert scale of 1-2-3-4-5 as this method is believed to help eliminate any biases which might result from the respondents choosing responses 1 and 2 or 4 and 5 respectively. Finally, the responses were recoded as low, medium and high. Past studies show that psychosocial factors such as mental health and job satisfaction may increase or decrease the prevalence of MSDs among the street sweepers too [21].

The quantum of work that sweepers have to do in low or high slum concentrated areas too may affect the prevalence of MSDs and related disabilities among them. Since sweeping in the slum areas is a rigorous task due to disorganized garbage disposal, overflowing community dustbins, and open defecation by the children on the footpaths, the workload can be higher. Therefore, the location of work was considered to be one of the risk factors. Based on the proportion of the



slum population, the wards were divided into three that is, low, moderate and high. Job satisfaction, location of work and mental health of sweepers were considered effect modifiers.

The mental health of sweepers was analyzed by applying the General Health Questionnaire of 12 items (GHQ-12) [23]. The workers were asked whether they had experienced any positive or negative emotions in the previous month. Each negative response was coded 1, while the absence of it was coded 0. The items were summed to a score for each respondent. The higher the score increased through 0 to 12, the more severe the mental health problem was considered to be. Further, the score was divided into three categories of low, medium and high. The mental health scale has acceptable internal consistency ( $\alpha=0.97$ ) [24].

**Statistical Analysis**

The data was entered in the CSPro.06 software and analyzed using the STATA13 [25] software. Descriptive statistics were used to understand the socioeconomic and occupational characteristics. Differences in the prevalence of MSDs and the related disabilities were tested using the Chi-square test. The differences in groups were tested by independent sample t-test.

While assessing the exposure of the occupation of sweeping to the development of MSDs, the study adopted the nearest neighbourhood method of propensity score matching (PSM) [26,27]. The method allowed assessment of the impact of exposure on outcomes using cross-sectional survey data. The propensity score was estimated by logistic regression with the dichotomous exposure variable, for instance 1 = exposed to sweeping and 0 = unexposed to sweeping, using associated observed demographic and occupational characteristics of the sweepers used as predictor variables. The principal assumption of the PSM is the condition that observable characteristics of the exposed and the comparison groups have similar distributions. This assumption test was applied by using the ‘p-score’ command. The propensity score was calculated using the probability of exposure assignment given pre-exposure characteristics.

$$p(x) \equiv \text{prob}(D = 1|x_i) = E(D|x_i)$$

where,  $D = \{0, 1\}$  is the indicator of exposure and  $x$  is the multidimensional vector of pre-exposure characteristics.

The average exposure effect on exposed (AEEE) is defined as the conditional expectation of the difference in the exposure effect for the exposed units only. After matching the propensity

scores, we compared the outcomes of the exposed and the counterfactual scores of the comparison group.

$$AEEE = E(\Delta | p(x), D=1) = E(y_1 | p(x), D=1) - E(y_0 | p(x), D=1)$$

To calculate the impact of street sweeping on MSDs and related disabilities during the previous 12 months, the average effects in both the groups were weighted by the proportion of respondents in both the exposed and the comparison groups. Further, to understand the individual risk factors for MSDs and disabilities among sweepers, multiple logistic regression analysis was applied.

### **Ethical considerations**

As the study involved government employees, permission to conduct the primary survey was approved by the MCGM. Ethical clearance prior to data collection was also approved by the Student Research Ethics Committee at the International Institute for Population Sciences, Mumbai. The informed consent of the participants was obtained in the local language, and the respondents were assured that the information would be confidential and used for research purposes only.

## **RESULTS**

### **Characteristics of the study population**

The socioeconomic and occupational characteristics of the street sweepers and the comparison group have been depicted in Table 1. There was a small difference in the mean age of the street sweepers (37 years, SD  $\pm$  9.12) and that of the comparison group (38 years, SD  $\pm$  7.39). A similar pattern was observed while looking at the years of working of the street sweepers (11 years, SD  $\pm$  8.30) and those of the comparison group (11 years, SD  $\pm$  6.35). Similarly, substance use, such as alcohol consumption, smoking, and chewing tobacco, were higher among the sweepers compared to the comparison group. For instance, nearly 70 percent of the sweepers were using at least one type of substance. A little less than one-third were using two or more types of substance. The corresponding figure for the comparison group was (19%). Further, 17% of the street sweepers reported that they were not satisfied with their occupation compared to 8% of the comparison group.

Table 1 Descriptive statistics of the study groups		
Background Characteristics	Street Sweeper N=180	Comparison group N=180
<b>Workers Age</b>	(t= -0.952; p=0.3416 )	
19-34 years	45.5	34.4
35 & above	54.4	65.5
Mean age ± SD	37.3 ± 9.1	38.1 ± 7.4
<b>Years of Working</b>	(t = -1.123; p= 0.261)	
Below 10	67.8	51.1
10 or more	32.2	48.9
Mean ± SD	10.6 ± 8.3	11.4 ± 6.3
<b>Substance use</b>		
No Addiction	33.3	53.3
Any one	68.6	46.6
Two or more	32.2	19.4
<b>Mental Health (GHQ-12)</b>		
Good	47.2	35.6
Intermediate	21.7	28.9
Poor	31.1	35.6
<b>Job Satisfaction</b>		
Good	17.8	30.5
Average	65.0	61.1
Bad	17.2	8.3
<b>BMI</b>		
<25	65.6	51.7
>25	34.4	48.3
Mean BMI±SD	23.6 ± 1.4	25.1 ± 3.3
<b>Caste</b>		
SC/ST	85.6	51.7
Others	14.4	48.3

The prevalence of MSDs and related disabilities during the previous 12 months in various musculoskeletal sites is presented in Table 2 for the street sweepers and the comparison group. The results show that the street sweepers were at a significantly higher risk of developing MSDs compared to the comparison group, specifically for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%). These figures were 11%, 19%, 9%, and 11% respectively for the comparison group. Similarly, the street sweepers significantly differed from the comparison

group in terms of disabilities during the previous 12 months. For instance, the sweepers were disabled due to pain in the lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) compared to 18%, 19%, 13%, 9%, 6% and 8% respectively in the case of the comparison group. Additionally, the incidence of MSDs during the previous 7 days was significantly higher among the sweepers, particularly for the upper back (19%), wrists/hands (17%), hips/thighs (17%), elbows (16%), lower back (15%), and shoulders (11%) compared to the comparison group (4%, 3%, 7%, 4%, 9%, and 4% respectively).

**Table 2 Prevalence and incidence of musculoskeletal disorder and disability among study groups in the past 7 days and 12 months**

Body regions	Street Sweeper N=180	Comparison group N=180	X <sup>2</sup> test
<b>Neck</b>			
Past 12 months	16.7 %	10.6 %	X <sup>2</sup> = 2.858; p = 0.091
Disabled in past 12 months	10.6 %	9.4 %	X <sup>2</sup> = 0.123; p = 0.725
7 days	6.7 %	4.4 %	X <sup>2</sup> = 0.847; p = 0.357
<b>Shoulder</b>			
Past 12 months	31.7 %	11.1 %	X <sup>2</sup> = 22.616; p = 0.000
Disabled in past 12 months	24.4 %	9.4 %	X <sup>2</sup> = 14.388; p = 0.000
7 days	10.6 %	4.4 %	X <sup>2</sup> = 4.844; p = 0.028
<b>Elbow</b>			
Past 12 months	26.7 %	8.9 %	X <sup>2</sup> = 19.459; p = 0.000
Disabled in past 12 months	23.3 %	5.6 %	X <sup>2</sup> = 23.017; p = 0.000
7 days	16.1 %	4.4 %	X <sup>2</sup> = 13.284; p = 0.000
<b>Wrist/ Hand</b>			
Past 12 months	29.4 %	18.9 %	X <sup>2</sup> = 5.471; p = 0.019
Disabled in past 12 months	26.1 %	13.3 %	X <sup>2</sup> = 9.281; p = 0.002
7 days	16.7 %	2.8 %	X <sup>2</sup> = 19.780; p = 0.000
<b>Upper Back</b>			
Past 12 months	33.9 %	27.2 %	X <sup>2</sup> = 1.885; p = 0.170
Disabled in past 12 months	26.7 %	18.9 %	X <sup>2</sup> = 3.095; p = 0.079
7 days	18.9 %	3.9 %	X <sup>2</sup> = 20.065; p = 0.000
<b>Low Back</b>			
Past 12 months	33.3 %	29.4 %	X <sup>2</sup> = 0.632; p = 0.427
Disabled in past 12 months	26.7 %	17.8 %	X <sup>2</sup> = 4.114; p = 0.043
7 days	15.6 %	8.9 %	X <sup>2</sup> = 3.728; p = 0.053
<b>Hip/Thigh</b>			
Past 12 months	26.7 %	20.0 %	X <sup>2</sup> = 2.236; p = 0.135

Disabled in past 12 months	16.7 %	7.8 %	$X^2 = 6.628$ ; $p = 0.010$
7 days	17.2 %	6.7 %	$X^2 = 9.534$ ; $p = 0.002$
<b>Knee</b>			
Past 12 months	1.7 %	3.9 %	$X^2 = 1.6457$ ; $p = 0.200$
Disabled in past 12 months	0.6 %	3.3 %	$X^2 = 3.6423$ ; $p = 0.056$
7 days	1.7 %	0.6 %	$X^2 = 1.0112$ ; $p = 0.315$
<b>Ankles/Feet</b>			
Past 12 months	3.9 %	2.2 %	$X^2 = 0.8440$ ; $p = 0.358$
Disabled in past 12 months	1.7 %	2.2 %	$X^2 = 0.1457$ ; $p = 0.703$
7 days	2.2 %	0.6 %	$X^2 = 1.8254$ ; $p = 0.177$

Street sweeping augments the MSDs

In order to assess the effects of sweeping on the development of MSDs, the PSM method was employed. The results have been exhibited in Table 3 in terms of the average exposure effects among exposed (AEEE) for the MSDs and disabilities during the previous 12 months. The results of the AEEE highlighted that the occupation of sweeping raised the episodes of MSDs, particularly for the shoulders (17%), wrists/hands (14%), elbows (13%), upper back (12%), neck (10%), and hips/thighs (9%). A similar pattern was observed for the MSD led disability, which was significantly higher for the shoulders (16%), lower back (14%), wrists/hands (14%), upper back (13%), elbows (13%), and hips/thighs (12%). In a nutshell, the results of the PSM demonstrated that the occupation of sweeping significantly enhanced MSDs and disabilities.

Table 3 Average exposure effect among exposed (AEEE) to street sweeping occupation on developing MSDs and disability for various body regions in the past 12 months				
Body regions	MSDs		Disability# due to MSDs	
	Coef.	95% CI	Coef.	95% CI
Neck	0.10**	(0.02 to 0.19)	0.02	(-0.05 to 0.09)
Shoulder	0.17***	(0.07 to 0.27)	0.16***	(0.07 to 0.24)
Elbow	0.13***	(0.05 to 0.21)	0.13***	(0.06 to 0.19)
Wrist/hand	0.14***	(0.06 to 0.22)	0.14***	(0.07 to 0.21)
Upper back	0.12***	(0.04 to 0.21)	0.13***	(0.05 to 0.22)
Lower back	0.08*	(-0.02 to 0.18)	0.14***	(0.05 to 0.23)
Hip/thigh	0.09**	(0.00 to 0.18)	0.12***	(0.05 to 0.18)
** $p < 0.05$ , *** $p < 0.01$ , * $p < 0.1$ ; # Prevented normal activity at home or away from home due to MSDs				

### The factors associated with the MSDs

The individual risk factors enhancing the MSDs among the sweepers in the last 12 months were identified after adjusting for workers' age, BMI and caste. The results for the same have been presented in Table 4. The results exhibited that years of working emerged as a significant predictor of the development of the MSDs. For instance, the workers working for 10 or more years were significantly 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;  $p<0.01$ ), and hips/thighs (OR=4.49;  $p<0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction among the sweepers was also found to be significantly correlated as the sweepers who were not satisfied with their job were more likely to have suffered from the MSDs in the wrists/hands (OR=11.43;  $p<0.01$ ), hips/thigh (OR=5.42;  $p<0.01$ ), upper back (OR=4.52;  $p<0.05$ ), and lower back (OR=3.91;  $p<0.05$ ) as compared to the sweepers who reported to be satisfied with their jobs.

Similarly, the location of work was found to be a significant predictor of developing MSDs. As, sweepers working in the high slum concentrated areas were more likely to get MSDs in the hips/thighs (OR=10.64;  $p<0.01$ ), lower back (OR=5.22;  $p<0.01$ ), and elbows (OR=0.23;  $p<0.01$ ) as compared to sweepers working in the low slum concentrated areas.

Table 4 Odds ratio showing individual risk factors for MSDs among street sweepers (past 12 months)							
	Neck	Shoulder	Elbow	Wrist/hand	Upper back	Lower back	Hip/thigh
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	5.41*** (1.60 to 18.26)	6.40*** (2.45 to 16.73)	10.79*** (3.49 to 33.38)	6.08*** (2.31 to 15.99)	6.06*** (2.42 to 15.19)	2.96*** (1.23 to 7.09)	4.49*** (1.69 to 11.91)
<b>Job satisfaction</b>							
High ®							
Medium	0.53 (0.15 to 1.85)	2.16 (0.74 to 6.30)	2.55 (0.70 to 9.26)	6.41** (1.32 to 31.11)	5.13*** (1.49 to 17.66)	1.58 (0.58 to 4.26)	2.58 (0.77 to 8.63)
Low	2.19 (0.55 to 8.63)	1.89 (0.52 to 6.84)	2.38 (0.53 to 10.68)	11.43*** (2.04 to 64.08)	4.52** (1.11 to 18.42)	3.91** (1.19 to 12.83)	5.42*** (1.33 to 21.94)
<b>Mental health</b>							
Low ®							
Medium	0.22 (0.02 to 2.11)	0.24* (0.05 to 1.17)	0.21* (0.04 to 1.15)	0.30* (0.07 to 1.32)	0.78 (0.22 to 2.68)	0.84 (0.24 to 2.88)	0.31 (0.56 to 1.77)
High	1.15 (0.43 to 3.05)	1.83 (0.81 to 4.14)	1.57 (0.63 to 3.87)	1.30 (0.53 to 3.17)	1.90* (0.83 to 4.37)	1.28 (0.56 to 2.94)	1.70 (0.68 to 4.22)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.43 (0.14 to 1.32)	0.93 (0.38 to 2.26)	0.96 (0.38 to 2.41)	1.06 (0.42 to 2.68)	2.04 (0.82 to 5.06)	2.18* (0.86 to 5.51)	4.12*** (1.30 to 13.01)
High	0.40* (0.13 to 1.16)	0.77 (0.32 to 1.87)	0.23*** (0.08 to 0.66)	0.44* (0.16 to 1.15)	2.13* (0.86 to 5.27)	5.22*** (2.10 to 12.95)	10.64*** (3.48 to 32.50)
® Reference category; ***p<0.01, **p<0.05, *p<0.1; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers Age, BMI and Caste							



**Table 5 Odds ratio showing individual risk factors for disabilities due to MSDs among street sweepers (past 12 months)**

	Neck	Shoulder	Elbow	Wrist/hand	Upper back	Lower back	Hip/thigh
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more	6.38** (1.16 to 34.91)	3.13*** (1.22 to 8.05)	8.12*** (2.62 to 25.13)	4.98*** (1.86 to 13.33)	4.40*** (1.66 to 11.62)	3.45*** (1.33 to 8.91)	6.27*** (2.00 to 19.60)
<b>Job Satisfaction</b>							
High ®							
Medium	0.28* (0.06 to 1.27)	1.30 (0.44 to 3.82)	1.85 (0.50 to 6.76)	4.78** (0.96 to 23.68)	3.37** (0.99 to 11.47)	1.33 (0.46 to 3.86)	1.75 (0.46 to 6.59)
Low	1.32 (0.26 to 6.66)	0.73 (0.18 to 2.90)	1.98 (0.44 to 8.93)	7.66** (1.33 to 43.87)	2.93 (0.71 to 12.11)	4.08** (1.16 to 14.35)	1.80 (0.37 to 8.62)
<b>Mental health</b>							
Low ®							
Medium	0.37 (0.35 to 3.86)	0.18 (0.02 to 1.49)	0.29 (0.05 to 1.56)	0.43 (0.10 to 1.87)	1.12 (0.30 to 4.13)	0.88 (0.22 to 3.48)	0.31 (0.03 to 3.00)
High	1.10 (0.32 to 3.72)	1.85 (0.79 to 4.29)	1.67 (0.67 to 4.18)	1.65 (0.67 to 4.08)	2.77** (1.17 to 6.55)	1.05 (0.43 to 2.58)	1.49 (0.53 to 4.16)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.03*** (0.00 to 0.34)	0.56 (0.21 to 1.44)	0.93 (0.36 to 2.38)	0.88 (0.34 to 2.28)	2.58* (0.95 to 6.97)	2.45* (0.83 to 7.23)	7.31*** (1.39 to 38.24)
High	0.25** (0.07 to 0.85)	0.6 (0.25 to 1.53)	0.22*** (0.07 to 0.65)	0.37** (0.13 to 1.00)	3.20*** (1.21 to 8.48)	7.79*** (2.76 to 21.99)	16.17*** (3.30 to 79.22)
® Reference category; *** $p < 0.01$ , ** $p < 0.05$ , * $p < 0.1$ ; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers Age, BMI and Caste							

An inquiry was also made to identify the individual factors enhancing the risk of disabilities during the previous 12 months and has been depicted in Table 5. The results suggested that the number of years of working is significantly correlated with disabilities. More specifically, the sweepers working for 10 and more years were significantly more likely to suffer from the 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 to the sweepers working for less than 10 years. Job satisfaction and mental health were not significantly correlated with the disabilities among the sweepers. The sweepers working in the high slum concentrated areas were significantly more likely to develop disabilities in the hips/thigh (OR=16.17;  $p<0.01$ ), lower back (OR=7.79;  $p<0.01$ ), upper back (OR=3.20;  $p<0.01$ ) and elbows (OR=0.22;  $p<0.01$ ), as compared to the sweepers working in the low slum concentrated areas.

DISCUSSION

The sweepers work for long hours in public places using long-handle brooms along with the wheelbarrows. This repetitive, rigorous occupation enhances musculoskeletal disorders and related disabilities among the street sweepers as compared to the comparison group. The results of bivariate analysis showed that the prevalence of the MSDs among the street sweepers was significantly higher for the shoulders (32%), wrists/hands (29%), and elbows (27%) as compared to the comparison group during the previous 12 months. Field observation suggested that this may be because of the continuous sweeping with the long-handle broom and carrying of the collected waste in the wheelbarrow to the community dustbins manually in an unvarying posture. Similarly, MSDs were found to be significantly higher among the street sweepers for the lower back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) as compared to the comparison group over the previous 12 months.

The results of PSM method revealed that the average exposure effect among exposed (AEEE) to the sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulders (17%), wrists/hands (14%), elbows (13%), and upper back (12%). A similar pattern was observed in case of disabilities, particularly for the shoulders (16%), wrists/hands (14%), lower back (14%), elbows (13%) and upper back (13%). After adjusting for working age, BMI and caste, the results of the multivariate logistic regression model revealed that years of working, job

satisfaction and location of work were significantly correlated with pain in the shoulders, elbows, wrists/hands, lower back, upper back, and hips/thighs.

The location of work emerged as a significant predictor of increased likelihood of MSDs and related disabilities among the street sweepers due to the higher quantum of work in the high slum concentrated areas. In the absence of any studies on MSDs among the street sweepers, the results of the present study are comparable with the other studies conducted among the solid waste workers except in the case of knee and ankle disorders [3,4,11,28,29]. This may be because the street sweepers are not engaged in lifting heavy loads continuously or for carrying them for long duration, as a result of which they do not put as much pressure on the knees and ankles as those engaged in solid waste collection. A cross-sectional study conducted in Iran with 217 municipal solid waste workers showed the higher prevalence of the MSDs for lower back (45%), knees (29%), shoulders (24%), upper back (23%), and neck (22%) as compared to the comparison group [5]. A similar study conducted in India with 313 waste workers concluded that the prevalence of MSDs was high among the solid waste workers particularly for the knees (39%), lower back (33%), shoulders (30%), elbows (27%), ankles (22%), wrists (21.7%), and neck (17%) [11]. These findings are in tune with the present study in offering the evidence that workers associated with municipal solid waste management have higher musculoskeletal disorders compared to the general population. The results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

Past meta-analysis studies have exhibited that substance use, such as alcohol consumption, smoking and chewing tobacco, affects the physical capacity for work and causes musculoskeletal pain [30,31]. We observed that seven out of ten sweepers were using at least one type of substance (tobacco, smoking or consumption of alcohol) and around one-third were using two or more type of substances.

The occupational structure is predominantly influenced by the social structure and the caste system in Indian society. The Scheduled Caste communities that is, communities who were previously untouchables and economically the weakest – were historically assigned cleaning or menial work and were discriminated against [32]. In the contemporary times, things have not much changed and it is seen that the majority of the employees working in solid waste management belong to the Scheduled Castes (SCs) as identified by the constitutional schedule of

India. The present study shows that more than 86% of the sweepers belong to the Scheduled Castes and only a marginal proportion come from the other caste groups.

**Limitations of the Study**

In the present study, biases might have occurred due to subjectivity in the response since the severity of MSDs was not quantified. However, the chances of false reporting are low as the study guaranteed confidentiality. The cross-sectional survey method for data collection might have underestimated or overestimated the actual prevalence of MSDs and related disabilities due to the reference period being one year long which may have led to the recall bias. Additionally, cross-sectional study design has a limitation of time period, however, by the fact that study carried out at one time point and give no indication of the sequence of events [33]. Further, there may be seasonal variations in the prevalence rate of MSDs. For instance, the prevalence of the MSDs may increase during the rainy season because wet waste requires extra energy for sweeping. This study was conducted among municipal street sweepers sweeping public places; the results may be generalized with caution.

**Strategies to minimize the burden of MSDs**

- Job rotation between sweepers, waste collectors and compactor drivers [34].
- Since the location of work was found to play a crucial role in the development of MSDs and related disabilities, it is recommended that the municipal corporations minimize the risk by changing the location of work quarterly.
- The street sweepers may undergo medical examination every quarter, whereby a physician can advise them on the preventive measures to minimize MSDs and disabilities.
- The burden of functional impairment due to MSDs may be reduced by proper curative treatment.
- Municipal corporations may provide medical insurance assistance to reduce the financial burden on the sweepers.

Past studies have demonstrated that job rotation between waste collectors, street sweepers and drivers help in reducing workload and as well as the risk of MSDs [34,35]. Sweepers

sweeping in high slum concentrated areas may be shifted to low slum concentrated areas since the workload varies by place of work. This flexibility in job rotation and alternative changes in the place of work may reduce the risk of MSDs and related disabilities. MCGM has a provision for medical examination of its workers on a yearly basis, but due to the corporation's negligence, the implementation of this provision is not efficient. The burden of disabilities may be reduced by taking curative measures at the initial point and by providing proper treatment.

## Acknowledgement

Authors acknowledge the English editing services from Ms. Shailja Thakur.

### a. Contributors

Pradeep Salve contributed to the conceptualization, design and data analysis.

Praveen Chokhandre led the conceptualization, data analysis and write up.

Both the authors have read and approved the final manuscript.

### b. Competing interests: Declared None.

### c. Funding: This research work received no specific grant from any funding agency in the public, commercial or not for profit sector.

### d. Ethics approval: The study was approved by the institute research committee.

### e. Data sharing statement: There is no additional data available.

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## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	<p>(a) Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study</p> <p>(b) <b>Objective</b> This study aims to assess the exposure of those involved in street sweeping to the development of musculoskeletal disorders (MSDs) and related disabilities and tries to identify the individual risk factors leading to the development of MSDs and related disabilities among street sweepers.</p> <p><b>Methods</b> A cross-sectional survey was conducted with a comparison group. A modified Standardized Nordic Questionnaire was adopted to measure MSDs and related disabilities. The impact of the occupation of sweeping on the development of MSDs and related disabilities was assessed using the propensity score matching (PSM) method. A multivariate logistic regression model was employed to identify the individual risk factors.</p> <p><b>Participants</b> Street sweepers (n=180) and a comparison group (n=180) working for at least a year were randomly selected from six municipal wards, all of them being formal employees of the Municipal Corporation of Greater Mumbai.</p> <p><b>Results</b> The prevalence of the MSDs was significantly higher among the sweepers for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%) compared to the comparison group, in which the prevalence was 11%, 19%, 9%, and 11% respectively. Similarly, the disabilities among the street sweepers were significantly higher for the lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), and elbows (23%) compared to the comparison group, for which the figures were 18%, 19%, 13%, 9%, and 6% respectively. The PSM method highlighted that the occupation of sweeping raised the risk of developing MSDs as well as disabilities particularly those of the shoulders (17-16%), wrists/hands (14% each), elbows (13% each), and the upper back (12-13%). After adjusting the workers' age, body mass index (BMI) and caste the number of years of engagement in street sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities.</p> <p><b>Conclusion</b> The study concluded that the occupation of street sweeping raises the risk of MSDs and musculoskeletal disabilities. Results from the study recommend preventive and curative measures to abate episodes of MSDs among street sweepers.</p>
<b>Introduction</b>		
Background/rationale	2	Study assessed the MSDs among street sweepers, whereas all past studies primarily focused on the occupational related morbidities other than MSDs among street sweepers.
Objectives	3	Study aims to assess the exposure of sweeping occupation on developing the MSDs as well as the disabilities. Additionally, the study tried to identify the individual risk factors leading to develop the MSDs and disabilities

among street sweepers.

Methods		
Study design	4	The study applied cross-sectional design to assess the prevalence of musculoskeletal disorder and related disabilities among street sweepers compared to comparison group
Setting	5	A group of municipal employees of MCGM engaged in street sweeping were selected as cases and another group of municipal employees non-exposed to sweeping consists of employees associated with fogging, pesticide spraying and peons in offices having similar socioeconomic condition were selected as a comparison group. The data was collected during March to September 2015.
Participants	6	Workers who were engaged in the occupation at-least for a year were selected as participants for the study. Applying stratified systematic random sampling design, the required sample was collected randomly from six out of 24 municipal wards of the MCGM based on the proportion to the slum population. The sample for case-comparison group is 1:1.
Variables	7	<b>Outcome variables:</b> The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled. <b>Exposure:</b> The location of work, job satisfaction and mental health state of the sweepers were considered as effect modifier. Potential Confounders: The workers age, caste, BMI; years of engagement in the street sweeping and their location of work were consider potential individual risk factors for developing the MSDs and thereby disabilities
Data sources/ measurement	8*	Primary data was collected for the present study. Chi-square method and multivariate logistics regression was used to assess the association and correlation between potential risk factors and MSDs; disability. Additionally, the propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
Bias	9	<b>Subjectivity:</b> Biasness might have occurred due to the subjectivity in response but there was less chance of false reporting as the study was guaranteed confidentiality.
Study size	10	The estimated sample size was 180 with p-value 0.30 and design effect 1.25. Finally, the data collected from 180 street sweepers and 180 comparison group of MCGM.
Quantitative variables	11	Appropriate variables were recoded as per the requirement of applied methods such as, age, year of working, BMI, job satisfaction, and mental health. The details of considered variables for analysis discussed in methods section.
Statistical methods	12	<b>Chi-square Test:</b> Differences in prevalence of the MSDs and the disabilities were tested by Chi-square test. <b>Multivariate Regression:</b> The multivariate logistic regression analysis was performed to assess the correlation between individual characteristics with the MSDs and thereby disabilities.

**Propensity score matching (PSM):** To examine the impact of street sweeping occupation on the MSDs and the disabilities, propensity score matching method was applied.

Continued on next page

## Results

Participants	13*	The cases (n=180) and comparison group (n=180) were considered throughout the analysis.
Descriptive data	14*	There was a small difference in the mean age of the street sweepers (37 years, SD $\pm$ 9.12) and that of the comparison group (38 years, SD $\pm$ 7.39). A similar pattern was observed while looking at the years of working of the street sweepers (11 years, SD $\pm$ 8.30) and those of the comparison group (11 years, SD $\pm$ 6.35). Similarly, substance use, such as alcohol consumption, smoking, and chewing tobacco, were higher among the sweepers compared to the comparison group. For instance, nearly 70 percent of the sweepers were using at least one type of substance. A little less than one-third were using two or more types of substance. The corresponding figure for the comparison group was (19%). Further, 17% of the street sweepers reported that they were not satisfied with their occupation compared to 8% of the comparison group.
Outcome data	15	The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled.
Main results	16	The street sweepers significantly have higher prevalence of MSDs and disabilities for shoulders, wrists/hand and elbow compared to the comparison groups. Similarly, street sweepers were more significantly disabled than comparison group for lower back, wrists/hand, shoulders, elbow and hips/thigh. The number of years of engagement in street sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities. The PSM method highlighted that the occupation of sweeping significantly raised the risk of developing MSDs as well as disabilities particularly for shoulders, wrists/hands, elbows, and upper back.
Other analyses	17	No
<b>Discussion</b>		
Key results	18	The results of bivariate analysis showed that the prevalence of the MSDs among the street sweepers was significantly higher for the shoulders (32%), wrists/hands (29%), and elbows (27%) as compared to the comparison group during the previous 12 months. Similarly, MSDs were found to be significantly higher among the street sweepers for the lower back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) as compared to the comparison group over the previous 12 months. The results of PSM method revealed that the average exposure effect among exposed (AEEE) to the sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulders (17%), wrists/hands (14%), elbows (13%), and upper back (12%). A similar pattern was observed in case of disabilities, particularly for the shoulders (16%), wrists/hands (14%), lower back (14%), elbows (13%) and upper back (13%).
Limitations	19	<b>Subjectivity:</b> Biases might have occurred due to subjectivity in the response since the severity of MSDs was not quantified. However, the chances of false reporting are

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low as the study guaranteed confidentiality.

**Cross-sectional:** Cross-sectional study design has a limitation of time period, however, by the fact that study carried out at one-time point and give no indication of the sequence of events.

**Seasonal variation:** There may be seasonal variations in the prevalence rate of MSDs. For instance, the prevalence of the MSDs may increase during the rainy season because wet waste requires extra energy for sweeping. This study has not considered the seasonal variation because the data collection for this study is not done in rainy season.

Interpretation	20	The results of bivariate analysis showed the higher prevalence of MSDs among the street sweepers compared to comparison group. Field observation suggested that this may be because of the continuous sweeping with the long-handle broom and carrying of the collected waste in the wheelbarrow to the community dustbins manually in an unvarying posture. The location of work emerged as a significant predictor of increased likelihood of MSDs and related disabilities among the street sweepers. It may be due to the higher quantum of work in the high slum concentrated areas.
Generalisability	21	In absence of any studies based on the MSDs among the street sweepers, the results of present study are comparable with other studies conducted with solid waste workers except knee and ankle disorders. This may be so because the street sweeper were not engaged in lifting heavy loads continuously as well as carrying it for long duration which might not put pressure on the knee and ankles as compared to the workers associated with the solid waste collection.
<b>Other information</b>		
Funding	22	The present study is a part of PhD work and does not receive any funding neither for the paper nor for the original study.

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-012354.R3
Article Type:	Research
Date Submitted by the Author:	01-Nov-2016
Complete List of Authors:	Salve, Pradeep; International Institute for Population Sciences, Public Health and Mortality Studies Chokhandre, Praveen; International Institute for Population Sciences, Mumbai,
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Public health
Keywords:	Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Hand & wrist < ORTHOPAEDIC & TRAUMA SURGERY, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, Shoulder < ORTHOPAEDIC & TRAUMA SURGERY, Street sweepers

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**Title:** Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study

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**Word count:** 4031

**Key words** Street sweepers, musculoskeletal disorders, shoulders, and hands and wrists, back pain



## Abstract

**Objective:** This study aims to assess the exposure of those involved in street-sweeping to the development of musculoskeletal disorders (MSDs) and related disabilities and tries to identify the individual risk factors thereof.

**Design:** A cross-sectional survey was conducted among street sweepers together with a comparison group. A modified Standardized Nordic Questionnaire was adopted to measure the prevalence of MSDs and related disabilities. The impact of the occupation of sweeping on the development of MSDs and related disabilities was assessed using the propensity score matching (PSM) method. A multivariate logistic regression model was employed to identify the individual risk factors.

**Participants:** Street-sweepers (n=180) and a comparison group (n=180), working for at least a year as formal employees of the MCGM, were randomly selected from six municipal wards.

**Results:** The prevalence of the MSDs was significantly higher among the sweepers for shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%) compared to the comparison group, in which the prevalence was 11%, 19%, 9%, and 11% respectively. The disabilities too were significantly higher among the street-sweepers for the lower-back (27%), upper-back (27%), wrists/hands (26%), shoulders (24%), and elbows (23%) compared to the comparison group, for which the figures were 18%, 19%, 13%, 9%, and 6% respectively. The PSM method highlighted that the occupation of sweeping raised the risk of developing MSDs and disabilities particularly for the shoulders (17-16%), wrists/hands (14% each), elbows (13% each), and the upper-back (12-13%). After adjusting the age, body-mass-index (BMI) and the caste of the street-sweepers, the number of years of engagement in street-sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities.

**Conclusion:** The study concluded that the occupation of street-sweeping raises the risk of MSDs and related disabilities. This study recommends preventive and curative measures to deal with MSDs among street-sweepers.

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**Strengths and limitations of this study**

- The present study assessed MSDs and MSD-related disabilities among street sweepers, whereas past studies have primarily focused on the occupational morbidities other than MSDs among street sweepers.
- The propensity score matching (PSM) method was adopted to assess the exposure of street sweeping on the development of MSDs and related disabilities.
- Bias in recalling MSDs and disabilities is possible due to the reference period being one year long.
- The subjects of the study carried out sweeping manually; hence the results may be generalised with caution.

## INTRODUCTION

The occupation of sweeping is a vigorous task that involves sweeping of assigned areas such as roads, footpaths, parks, markets, and open settlements with the help of long-handle brooms and wheelbarrows and deposition of the waste in nearby community dustbins. This whole process requires continuous physical tasks such as manually sweeping in the standing posture for long durations, bending while collecting the swept waste, pushing and pulling the wheelbarrow, and manually lifting the baskets to deposit waste. A similar process is followed in other cities in India and other developing countries. The Municipal Corporation of Greater Mumbai (MCGM) has 9231 regular employees engaged in the street sweeping occupation, and the corresponding figure must be many times higher for India as a whole. Numerous studies have concluded that the occupational exposure of sweeping is associated with the development of chronic respiratory diseases, skin diseases, eye irritation, asthma, tuberculosis, and hypertension among workers [1–4]. The other non-fatal injuries identified are mostly musculoskeletal in nature. Musculoskeletal disorders are defined as pain, ache or discomfort in any of the anatomical areas of the body, namely neck, shoulders, upper back, lower back, elbows, wrists or hands, hips or thighs, knees, and ankles or feet [5].

Past studies conducted among solid waste collectors suggest a higher probability among them of developing MSDs compared to the general population [5–7]. Workers involved in repetitious physical tasks by bending, lifting, pushing and pulling for long durations have been identified as facing the risk of developing MSDs [8–10]. So far, very few studies have been conducted among street sweepers and hardly any study has thoroughly assessed the risk of MSDs among street sweepers. Past studies conducted among street sweepers have predominantly focused on eye, skin and respiratory morbidities in India [4,11–14]. The present study, in contrast, aimed to

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3 assess the occupational exposure of sweeping to the development of MSDs as well as  
4 disabilities. Additionally, the study tried to identify the individual risk factors leading to the  
5 development of MSDs and disabilities among street sweepers.  
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13 **MATERIAL AND METHODS**  
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15 **Study design and participants**  
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18 The study applied a cross-sectional design to assess the prevalence of musculoskeletal disorders  
19 and related disabilities among street sweepers compared to a comparison group. A street sweeper  
20 sweeps assigned areas – such as roads, residential areas, markets, public parks, and open  
21 settlements – using a long-handle broom and a wheelbarrow to deposit the collected waste in  
22 nearby community dustbins. Sweepers work eight hours daily in pairs. A group of municipal  
23 workers not exposed to sweeping – including employees associated with fogging and pesticide  
24 spraying and peons having similar socioeconomic conditions – were selected as the comparison  
25 group. These employees were basically field workers of the MCGM, working continuously in  
26 the field, performing heavy physical tasks such as carrying necessary equipment/machines. Their  
27 work load was more or less similar to that of the sweepers.  
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31 The present study was primarily conducted to examine the major morbidities, including MSDs,  
32 among municipal street sweepers. The estimated sample size was 180 with a prevalence rate of  
33 30 and a design effect of 1.25 [11]. Applying stratified systematic random sampling design, the  
34 required sample was collected randomly from 6 out of 24 municipal wards of the MCGM based  
35 on the proportion of the slum population to the total population. At the first stage, all 24  
36 municipal wards were arranged in the ascending order of their slum population and divided into  
37 three strata, that is, low, moderate and high. At the second stage, two wards were randomly  
38 selected from each stratum. Based on the list of employees provided by the Municipal  
39 Corporation, a representative sample of 60 employees from each ward (that is 30 sweepers and  
40 30 non-sweepers) was selected through systematic random sampling. Finally, a sample of 180  
41 street sweepers and 180 non-sweepers were interviewed at the workplace from March to  
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## Measurements

A modified Standardized Nordic Questionnaire was adopted to assess the musculoskeletal disorders [15]. A diagram, with labels and arrows clearly indicating the different musculoskeletal regions, was used for the assessment of MSDs during the 12 months and the 7 days preceding the survey. The interview schedule collected information on the MSDs along with demographic, socio-economic, and occupational characteristics. Specifically, the schedule covered age, years of work, substance use, anthropometric measurements, job satisfaction, caste, and mental health.

## Variables

### Outcome variables

The respondents who reported pain in 9 anatomical regions – namely neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles – during the 7 days and 12 months prior to the survey were considered to be morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the preceding 12 months were classified and recoded as disabled.

### Exposure classification

Age and years of working are significant predictors of development of MSDs among solid waste collectors, with the risk of MSDs increasing with increasing age and years of working [5]. Past studies have concluded that overweight and obesity are positively associated with MSDs because of the pressure exerted on the weight-bearing joints [16,17]. Symptoms of worry, tension, anxiety, work stress, and low mood too have a correlation with musculoskeletal pain [18–20]. The prevalence of MSDs and disabilities can vary between groups of workers sharing different cultural characteristics [21]; therefore, caste of the workers was also considered.

Job satisfaction of employees also influences the prevalence of MSDs [22]. Job satisfaction is measured on a scale of 1-5, with 1 being very bad and 5 being very good. In the present study, the responses were scored as 1, 2, 3 in place of being measured using the Likert scale of 1-2-3-4-5 to eliminate any biases which might result from the respondents choosing responses 1 and 2 or 4 and 5 respectively. Finally, the responses were recoded as low, medium and high. Past studies

show that psychosocial factors, such as mental health and job satisfaction, may increase or decrease the prevalence of MSDs among the street sweepers too [21].

The quantum of work that sweepers have to do in low or high slum concentration areas too may affect the prevalence of MSDs and related disabilities among them. Since sweeping in the slum areas is a more rigorous task due to unorganized garbage disposal, overflowing community dustbins, and defecation by the children on the footpaths, the workload can be higher. Therefore, the location of work was considered to be one of the risk factors. Based on the proportion of the slum population to the total population, the wards were divided into three, that is, low, moderate and high. Job satisfaction, location of work, and mental health of sweepers were considered to be effect modifiers.

The mental health of sweepers was analyzed by applying the General Health Questionnaire of 12 items (GHQ-12) [23]. The workers were asked whether they had experienced any positive or negative emotions in the previous month. Each negative response was coded 1, while the absence of it was coded 0. The items were summed to a score for each respondent. The higher the score was from 0 to 12, the more severe the mental health problem was considered to be. Further, the score was divided into three categories, namely low, medium and high. The mental health scale has acceptable internal consistency ( $\alpha=0.97$ ) [24].

**Statistical Analysis**

The data was entered in the CSPro.06 software and analyzed using the STATA13 [25] software. Descriptive statistics were used to understand the socioeconomic and occupational characteristics. Differences in the prevalence of MSDs and the related disabilities were tested using the Chi-square test. The differences in groups were tested using independent sample t-test.

While assessing the exposure of the occupation of sweeping to the development of MSDs, the study adopted the nearest neighbourhood method of propensity score matching (PSM) [26,27]. The method allowed assessment of the impact of exposure on the outcomes using cross-sectional survey data. The propensity score was estimated with the logistic regression analysis with the dichotomous exposure variable, for instance 1 = exposed to sweeping and 0 = unexposed to sweeping, using associated observed demographic and occupational characteristics and used as predictor variables. The principal assumption of the PSM is that the observable characteristics of

the exposed and the comparison groups have similar distributions. This assumption test was applied by using the 'p-score' command. The propensity score was calculated using the probability of exposure assignment given pre-exposure characteristics.

$$p(x) \equiv \text{prob}(D = 1|x_i) = E(D|x_i),$$

where  $D = \{0, 1\}$  is the indicator of exposure and  $x$  is the multidimensional vector of pre-exposure characteristics.

The average exposure effect among the exposed (AEEE) is defined as the conditional expectation of difference in the exposure effect for the exposed units only. After matching the propensity scores of exposed and counterfactual scores of comparison group, we compared the outcomes between the groups.

$$AEEE = E(\Delta | p(x), D=1) = E(y_1 | p(x), D=1) - E(y_0 | p(x), D=1)$$

To calculate the impact of street sweeping on the development of MSDs and related disabilities during the previous 12 months, the average effects in both the groups were weighted by the proportion of respondents in the two groups. Further, to understand the individual risk factors for MSDs and disabilities among sweepers, multiple logistic regression analysis was applied.

## Ethical considerations

As the study involved government employees, permission to conduct the primary survey was obtained from the MCGM. Ethical clearance was obtained from the Student Research Ethics Committee of the International Institute for Population Sciences, Mumbai prior to data collection. The informed consent of the participants was obtained in the local language, and the respondents were assured that the information would be confidential and used for research purposes only.

## RESULTS

### Characteristics of the study population

The socioeconomic and occupational characteristics of the street sweepers and the comparison group have been depicted in Table 1. There was a small difference in the mean age of the street sweepers (37 years, SD  $\pm$  9.12) and that of the comparison group (38 years, SD  $\pm$  7.39). A similar pattern was observed while looking at the years of working of the street sweepers (11 years, SD  $\pm$  8.30) and those of the comparison group (11 years, SD  $\pm$  6.35). Substance use, such as



alcohol consumption, smoking, and chewing tobacco, was higher among the sweepers compared to the comparison group. For instance, nearly 70% of the sweepers reported using at least one type of substance. A little less than one-third reported using two or more types of substance. The corresponding figure for the comparison group was 19%. Further, 17% of the street sweepers reported that they were not satisfied with their occupation, and 8% of the comparison group did so.

**Table 1 Descriptive statistics of the study groups**

Background Characteristics	Street Sweeper N=180	Comparison group N=180
<b>Workers' Age</b>	(t= -0.952; p=0.3416 )	
19-34 years	45.5	34.4
35 & above	54.4	65.5
Mean age ± SD	37.3 ± 9.1	38.1 ± 7.4
<b>Years of Working</b>	(t = -1.123; p= 0.261)	
Below 10	67.8	51.1
10 or more	32.2	48.9
Mean ± SD	10.6 ± 8.3	11.4 ± 6.3
<b>Substance use</b>		
No Addiction	33.3	53.3
Any one	68.6	46.6
Two or more	32.2	19.4
<b>Mental Health (GHQ-12)</b>		
Good	47.2	35.6
Intermediate	21.7	28.9
Poor	31.1	35.6
<b>Job Satisfaction</b>		
Good	17.8	30.5
Average	65.0	61.1
Bad	17.2	8.3
<b>BMI</b>		
<25	65.6	51.7
>25	34.4	48.3
Mean BMI±SD	23.6 ± 1.4	25.1 ± 3.3
<b>Caste</b>		
SC/ST	85.6	51.7
Others	14.4	48.3

The prevalence of MSDs and related disabilities during the previous 12 months in various musculoskeletal sites has been presented in Table 2 both for the street sweepers and for the comparison group. The results show that the street sweepers were at a significantly higher risk of developing MSDs compared to the comparison group, specifically for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%). These figures were 11%, 19%, 9%, and 11% respectively for the comparison group. Similarly, the street sweepers differed significantly from the comparison group in terms of disabilities suffered during the previous 12 months. For instance, the percentage of sweepers who suffered disability due to pain in the lower back, upper back, wrists/hands, shoulders, elbows, and hips/thighs was 27%, 27%, 26%, 24%, 23%, and 17% respectively. In the case of the comparison group, the corresponding figures were 18%, 19%, 13%, 9%, 6%, and 8% respectively. Additionally, the incidence of MSDs during the previous 7 days was significantly higher among the sweepers, particularly for the upper back (19%), wrists/hands (17%), hips/thighs (17%), elbows (16%), lower back (15%), and shoulders (11%) compared to the comparison group (4%, 3%, 7%, 4%, 9%, and 4% respectively).

**Table 2 Prevalence and incidence of musculoskeletal disorders and disabilities among the study groups in the past 7 days and 12 months**

Body regions	Street Sweeper N=180	Comparison group N=180	X <sup>2</sup> test
<b>Neck</b>			
Past 12 months	16.7 %	10.6 %	X <sup>2</sup> = 2.858; p = 0.091
Disabled in past 12 months	10.6 %	9.4 %	X <sup>2</sup> = 0.123; p = 0.725
7 days	6.7 %	4.4 %	X <sup>2</sup> = 0.847; p = 0.357
<b>Shoulders</b>			
Past 12 months	31.7 %	11.1 %	X <sup>2</sup> = 22.616; p = 0.000
Disabled in past 12 months	24.4 %	9.4 %	X <sup>2</sup> = 14.388; p = 0.000
7 days	10.6 %	4.4 %	X <sup>2</sup> = 4.844; p = 0.028
<b>Elbows</b>			
Past 12 months	26.7 %	8.9 %	X <sup>2</sup> = 19.459; p = 0.000
Disabled in past 12 months	23.3 %	5.6 %	X <sup>2</sup> = 23.017; p = 0.000
7 days	16.1 %	4.4 %	X <sup>2</sup> = 13.284; p = 0.000
<b>Wrists/ Hands</b>			
Past 12 months	29.4 %	18.9 %	X <sup>2</sup> = 5.471; p = 0.019
Disabled in past 12 months	26.1 %	13.3 %	X <sup>2</sup> = 9.281; p = 0.002
7 days	16.7 %	2.8 %	X <sup>2</sup> = 19.780; p = 0.000
<b>Upper Back</b>			

Past 12 months	33.9 %	27.2 %	$X^2 = 1.885$ ; $p = 0.170$
Disabled in past 12 months	26.7 %	18.9 %	$X^2 = 3.095$ ; $p = 0.079$
7 days	18.9 %	3.9 %	$X^2 = 20.065$ ; $p = 0.000$
<b>Lower Back</b>			
Past 12 months	33.3 %	29.4 %	$X^2 = 0.632$ ; $p = 0.427$
Disabled in past 12 months	26.7 %	17.8 %	$X^2 = 4.114$ ; $p = 0.043$
7 days	15.6 %	8.9 %	$X^2 = 3.728$ ; $p = 0.053$
<b>Hips/Thighs</b>			
Past 12 months	26.7 %	20.0 %	$X^2 = 2.236$ ; $p = 0.135$
Disabled in past 12 months	16.7 %	7.8 %	$X^2 = 6.628$ ; $p = 0.010$
7 days	17.2 %	6.7 %	$X^2 = 9.534$ ; $p = 0.002$
<b>Knees</b>			
Past 12 months	1.7 %	3.9 %	$X^2 = 1.6457$ ; $p = 0.200$
Disabled in past 12 months	0.6 %	3.3 %	$X^2 = 3.6423$ ; $p = 0.056$
7 days	1.7 %	0.6 %	$X^2 = 1.0112$ ; $p = 0.315$
<b>Ankles/Feet</b>			
Past 12 months	3.9 %	2.2 %	$X^2 = 0.8440$ ; $p = 0.358$
Disabled in past 12 months	1.7 %	2.2 %	$X^2 = 0.1457$ ; $p = 0.703$
7 days	2.2 %	0.6 %	$X^2 = 1.8254$ ; $p = 0.177$

Street sweeping augments the MSDs

In order to assess the effects of sweeping on the development of MSDs, the PSM method was employed. The results have been exhibited in Table 3 in terms of the average exposure effect among the exposed (AEEE) for MSDs and disabilities during the previous 12 months. The results of the AEEE highlighted that the occupation of sweeping raised the episodes of MSDs, particularly for the shoulders (17%), wrists/hands (14%), elbows (13%), upper back (12%), neck (10%), and hips/thighs (9%). A similar pattern was observed for MSD led disabilities, which were significantly higher for the shoulders (16%), lower back (14%), wrists/hands (14%), upper back (13%), elbows (13%), and hips/thighs (12%). In a nutshell, the results of the PSM demonstrated that the occupation of sweeping significantly enhanced MSDs and disabilities.

Table 3 Average exposure effect among exposed (AEEE) to the street sweeping occupation on developing MSDs and disabilities for various body regions in the past 12 months				
Body regions	MSDs		Disability# due to MSDs	
	Coef.	95% CI	Coef.	95% CI

Neck	0.10**	(0.02 to 0.19)	0.02	(-0.05 to 0.09)
Shoulders	0.17***	(0.07 to 0.27)	0.16***	(0.07 to 0.24)
Elbows	0.13***	(0.05 to 0.21)	0.13***	(0.06 to 0.19)
Wrists/hands	0.14***	(0.06 to 0.22)	0.14***	(0.07 to 0.21)
Upper back	0.12***	(0.04 to 0.21)	0.13***	(0.05 to 0.22)
Lower back	0.08*	(-0.02 to 0.18)	0.14***	(0.05 to 0.23)
Hips/thighs	0.09**	(0.00 to 0.18)	0.12***	(0.05 to 0.18)

\*\* $p < 0.05$ , \*\*\* $p < 0.01$ , \* $p < 0.1$ ; # Prevented normal activity at home or away from home due to MSDs

### Factors associated with MSDs

The individual risk factors enhancing MSDs among the sweepers in the previous 12 months were identified after adjusting for the workers' age, BMI, and caste. The results for the same have been presented in Table 4. The results exhibited that years of working emerged as a significant predictor of development of MSDs. For instance, the sweepers working for 10 or more years were significantly 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;  $p < 0.01$ ), and hips/thighs (OR=4.49;  $p < 0.01$ ) as compared to the sweepers working for less than 10 years. Job satisfaction and MSDs were also found to be significantly correlated as the sweepers who were not satisfied with their job were more likely to have suffered from the MSDs in the wrists/hands (OR=11.43;  $p < 0.01$ ), hips/thighs (OR=5.42;  $p < 0.01$ ), upper back (OR=4.52;  $p < 0.05$ ), and lower back (OR=3.91;  $p < 0.05$ ) as compared to the sweepers who reported to be satisfied with their jobs.

The location of work too was found to be a significant predictor of developing MSDs. Sweepers working in high slum concentration areas were more likely to get MSDs in the hips/thighs (OR=10.64;  $p < 0.01$ ), lower back (OR=5.22;  $p < 0.01$ ), and elbows (OR=0.23;  $p < 0.01$ ) as compared to those working in the low slum concentration areas.

Table 4 Odds ratio showing individual risk factors for MSDs among street sweepers (past 12 months)							
	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Hips/thighs
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more yrs.	5.41*** (1.60 to 18.26)	6.40*** (2.45 to 16.73)	10.79*** (3.49 to 33.38)	6.08*** (2.31 to 15.99)	6.06*** (2.42 to 15.19)	2.96*** (1.23 to 7.09)	4.49*** (1.69 to 11.91)
<b>Job satisfaction</b>							
High ®							
Medium	0.53 (0.15 to 1.85)	2.16 (0.74 to 6.30)	2.55 (0.70 to 9.26)	6.41** (1.32 to 31.11)	5.13*** (1.49 to 17.66)	1.58 (0.58 to 4.26)	2.58 (0.77 to 8.63)
Low	2.19 (0.55 to 8.63)	1.89 (0.52 to 6.84)	2.38 (0.53 to 10.68)	11.43*** (2.04 to 64.08)	4.52** (1.11 to 18.42)	3.91** (1.19 to 12.83)	5.42*** (1.33 to 21.94)
<b>Mental health</b>							
Low ®							
Medium	0.22 (0.02 to 2.11)	0.24* (0.05 to 1.17)	0.21* (0.04 to 1.15)	0.30* (0.07 to 1.32)	0.78 (0.22 to 2.68)	0.84 (0.24 to 2.88)	0.31 (0.56 to 1.77)
High	1.15 (0.43 to 3.05)	1.83 (0.81 to 4.14)	1.57 (0.63 to 3.87)	1.30 (0.53 to 3.17)	1.90* (0.83 to 4.37)	1.28 (0.56 to 2.94)	1.70 (0.68 to 4.22)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.43 (0.14 to 1.32)	0.93 (0.38 to 2.26)	0.96 (0.38 to 2.41)	1.06 (0.42 to 2.68)	2.04 (0.82 to 5.06)	2.18* (0.86 to 5.51)	4.12*** (1.30 to 13.01)
High	0.40* (0.13 to 1.16)	0.77 (0.32 to 1.87)	0.23*** (0.08 to 0.66)	0.44* (0.16 to 1.15)	2.13* (0.86 to 5.27)	5.22*** (2.10 to 12.95)	10.64*** (3.48 to 32.50)
® Reference category; ***p<0.01, **p<0.05, *p<0.1; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers' age, BMI and caste							

**Table 5 Odds ratio showing individual risk factors for disabilities due to MSDs among street sweepers (past 12 months)**

	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Hips/thighs
<b>Years of working</b>							
Below 10 yrs. ®							
10 & more yrs.	6.38** (1.16 to 34.91)	3.13*** (1.22 to 8.05)	8.12*** (2.62 to 25.13)	4.98*** (1.86 to 13.33)	4.40*** (1.66 to 11.62)	3.45*** (1.33 to 8.91)	6.27*** (2.00 to 19.60)
<b>Job Satisfaction</b>							
High ®							
Medium	0.28* (0.06 to 1.27)	1.30 (0.44 to 3.82)	1.85 (0.50 to 6.76)	4.78** (0.96 to 23.68)	3.37** (0.99 to 11.47)	1.33 (0.46 to 3.86)	1.75 (0.46 to 6.59)
Low	1.32 (0.26 to 6.66)	0.73 (0.18 to 2.90)	1.98 (0.44 to 8.93)	7.66** (1.33 to 43.87)	2.93 (0.71 to 12.11)	4.08** (1.16 to 14.35)	1.80 (0.37 to 8.62)
<b>Mental health</b>							
Low ®							
Medium	0.37 (0.35 to 3.86)	0.18 (0.02 to 1.49)	0.29 (0.05 to 1.56)	0.43 (0.10 to 1.87)	1.12 (0.30 to 4.13)	0.88 (0.22 to 3.48)	0.31 (0.03 to 3.00)
High	1.10 (0.32 to 3.72)	1.85 (0.79 to 4.29)	1.67 (0.67 to 4.18)	1.65 (0.67 to 4.08)	2.77** (1.17 to 6.55)	1.05 (0.43 to 2.58)	1.49 (0.53 to 4.16)
<b>Location of work based on proportion of slums</b>							
Low®							
Moderate	0.03*** (0.00 to 0.34)	0.56 (0.21 to 1.44)	0.93 (0.36 to 2.38)	0.88 (0.34 to 2.28)	2.58* (0.95 to 6.97)	2.45* (0.83 to 7.23)	7.31*** (1.39 to 38.24)
High	0.25** (0.07 to 0.85)	0.6 (0.25 to 1.53)	0.22*** (0.07 to 0.65)	0.37** (0.13 to 1.00)	3.20*** (1.21 to 8.48)	7.79*** (2.76 to 21.99)	16.17*** (3.30 to 79.22)
® Reference category; *** $p < 0.01$ , ** $p < 0.05$ , * $p < 0.1$ ; 95% confidence interval in parenthesis. The full model is additionally adjusted for workers' age, BMI and caste							

An inquiry was also made to identify the individual factors enhancing the risk of disabilities during the previous 12 months. The results of the inquiry depicted in Table 5 – suggested that the number of years of working is significantly correlated with disabilities. More specifically, the sweepers working for 10 and more 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 to those working for less than 10 years. Job satisfaction and mental health were not found to be significantly correlated with disabilities among the sweepers. The sweepers working in the high slum concentration areas were significantly more likely to develop disabilities in the hips/thighs (OR=16.17;  $p<0.01$ ), lower back (OR=7.79;  $p<0.01$ ), upper back (OR=3.20;  $p<0.01$ ), and elbows (OR=0.22;  $p<0.01$ ), as compared to the sweepers working in the low slum concentration areas.

DISCUSSION

Sweepers work for long hours in public places using long-handle brooms along with wheelbarrows. This repetitive, rigorous occupation increases the prevalence of MSDs and related disabilities among the street sweepers as compared to the comparison group. The results of bivariate analysis showed that the prevalence of MSDs among the street sweepers was significantly higher for the shoulders (32%), wrists/hands (29%), and elbows (27%) as compared to the comparison group during the previous 12 months. Field observation suggested that this may be because of continuous sweeping with long-handle brooms and carrying collected waste in the wheelbarrows to the community dustbins manually in an unvarying posture. MSDs among street sweepers were also found to be significantly higher for the lower back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) as compared to the comparison group over the previous 12 months.

The results of the PSM method revealed that the average exposure effect among the exposed (AEEE) to the sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulders (17%), wrists/hands (14%), elbows (13%), and upper back (12%). A similar pattern was observed in case of disabilities, particularly for those of the shoulders (16%), wrists/hands (14%), lower back (14%), elbows (13%), and upper back (13%). After adjusting for the age, the BMI and the caste of the street sweepers, the results of the multivariate logistic regression model



revealed that years of working, job satisfaction and location of work were significantly correlated with pain in the shoulders, elbows, wrists/hands, lower back, upper back, and hips/thighs.

The location of work emerged as a significant predictor of increased likelihood of MSDs and related disabilities among the street sweepers due to the higher quantum of work in the high slum concentration areas. In the absence of any studies on MSDs among the street sweepers, the results of the present study are comparable with the other studies conducted among the solid waste workers except in the case of knee and ankle disorders [3,4,11,28,29]. This may be because the street sweepers are not engaged in lifting heavy loads continuously or for carrying them for long duration, as a result of which they do not put as much pressure on the knees and ankles as those engaged in solid waste collection. A cross-sectional study conducted in Iran among 217 municipal solid waste workers showed a higher prevalence of the MSDs for lower back (45%), knees (29%), shoulders (24%), upper back (23%), and neck (22%) as compared to the comparison group [5]. A similar study conducted in India among 313 waste workers concluded that the prevalence of MSDs was higher among the solid waste workers, particularly for the knees (39%), lower back (33%), shoulders (30%), elbows (27%), ankles (22%), wrists (21%), and neck (17%) [11]. These findings are in tune with the present study in offering the evidence that workers associated with municipal solid waste management have higher MSDs compared to the general population. The results of the study may be generalized for the street sweepers of India and other developing countries where sweeping is carried out manually.

Past meta-analysis studies have indicated that substance use – such as alcohol consumption, smoking, and chewing tobacco – affects the physical capacity for work and causes musculoskeletal pain [30,31]. We observed that seven out of ten sweepers were using at least one substance (tobacco, smoking, or alcohol) and that around one-third of them were using two or more substances.

The occupational structure in India is influenced by the social structure and the caste system. The Scheduled Caste communities, that is, communities which were previously considered untouchable and were economically the weakest were historically assigned cleaning or menial work and were discriminated against [32]. Today, things have not changed much and it is seen that the majority of the employees working in solid waste management belong to the Scheduled

Castes (SCs). The present study shows that more than 86% of the sweepers belong to the Scheduled Castes and that only a marginal proportion come from the other caste groups.

**Limitations of the Study**

In the present study, biases might have occurred due to subjectivity in the response since the severity of MSDs was not quantified. We have adopted the standard tool to assess the self-reported MSDs and validated methods which helped us to avoid biases. Moreover, the chances of misreporting are low as the study guaranteed confidentiality and assurance. The cross-sectional survey method used for data collection may have under or over-estimated the actual prevalence of MSDs and related disabilities due to a year long reference period, which may have led to recall bias. Additionally, the cross-sectional study design has a limitation of conducting survey at one time point and therefore it gives no indication of the sequence of events [33]. There may also be seasonal variations in the prevalence rate of MSDs among sweepers. For instance, the prevalence of MSDs may increase during the rainy season because of the waste getting wet and therefore requiring extra energy for sweeping than in the other seasons. Previous studies have revealed a significant relationship between seasonal variations in the work environment and the health risk posed to the workers associated with waste collection [34]. Since the survey for the present study was carried out at a specific point in time, seasonal variations in the prevalence of MSDs were not covered. This study was conducted among municipal street sweepers sweeping public places; the results may be generalized with caution.

Past studies have demonstrated that job rotation between waste collectors, street sweepers and drivers helps to reduce the workload as well as the risk of MSDs [35]. Sweepers sweeping in high slum concentration areas may be shifted to low slum concentration areas since the workload varies by place of work. Job rotation and change in the place of work may reduce the risk of MSDs and related disabilities. The burden of disabilities may be reduced by taking curative measures at an early stage and by providing proper treatment.

**Acknowledgement**

The authors acknowledge the English editing services of Ms. Shailja Thakur.

**a. Contributors**

Pradeep Salve contributed to the conceptualization, design and data analysis.  
Praveen Chokhandre led the conceptualization, data analysis and writing.

- Both the authors have read and approved the final manuscript.
- b. **Competing interests:** None declared.
  - c. **Funding:** This research work received no specific grant from any funding agency in the public, commercial or not-for-profit sector.
  - d. **Ethics approval:** The study was approved by the institute's research committee.
  - e. **Data sharing statement:** There is no additional data available.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	<p>(a) Assessing the exposure of street sweeping and potential risk factors for developing musculoskeletal disorders and related disabilities: a cross-sectional study</p> <p>(b) <b>Objective</b> This study aims to assess the exposure of those involved in street sweeping to the development of musculoskeletal disorders (MSDs) and related disabilities and tries to identify the individual risk factors leading to the development of MSDs and related disabilities among street sweepers.</p> <p><b>Methods</b> A cross-sectional survey was conducted with a comparison group. A modified Standardized Nordic Questionnaire was adopted to measure MSDs and related disabilities. The impact of the occupation of sweeping on the development of MSDs and related disabilities was assessed using the propensity score matching (PSM) method. A multivariate logistic regression model was employed to identify the individual risk factors.</p> <p><b>Participants</b> Street sweepers (n=180) and a comparison group (n=180) working for at least a year were randomly selected from six municipal wards, all of them being formal employees of the Municipal Corporation of Greater Mumbai.</p> <p><b>Results</b> The prevalence of the MSDs was significantly higher among the sweepers for the shoulders (32%), wrists/hands (29%), elbows (27%), and neck (17%) compared to the comparison group, in which the prevalence was 11%, 19%, 9%, and 11% respectively. Similarly, the disabilities among the street sweepers were significantly higher for the lower back (27%), upper back (27%), wrists/hands (26%), shoulders (24%), and elbows (23%) compared to the comparison group, for which the figures were 18%, 19%, 13%, 9%, and 6% respectively. The PSM method highlighted that the occupation of sweeping raised the risk of developing MSDs as well as disabilities particularly those of the shoulders (17-16%), wrists/hands (14% each), elbows (13% each), and the upper back (12-13%). After adjusting the workers' age, body mass index (BMI) and caste the number of years of engagement in street sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities.</p> <p><b>Conclusion</b> The study concluded that the occupation of street sweeping raises the risk of MSDs and musculoskeletal disabilities. Results from the study recommend preventive and curative measures to abate episodes of MSDs among street sweepers.</p>
Introduction		
Background/rationale	2	Study assessed the MSDs among street sweepers, whereas all past studies primarily focused on the occupational related morbidities other than MSDs among street sweepers.
Objectives	3	Study aims to assess the exposure of sweeping occupation on developing the MSDs as well as the disabilities. Additionally, the study tried to identify the individual risk factors leading to develop the MSDs and disabilities



among street sweepers.

Methods		
Study design	4	The study applied cross-sectional design to assess the prevalence of musculoskeletal disorder and related disabilities among street sweepers compared to comparison group
Setting	5	A group of municipal employees of MCGM engaged in street sweeping were selected as cases and another group of municipal employees non-exposed to sweeping consists of employees associated with fogging, pesticide spraying and peons in offices having similar socioeconomic condition were selected as a comparison group. The data was collected during March to September 2015.
Participants	6	Workers who were engaged in the occupation at-least for a year were selected as participants for the study. Applying stratified systematic random sampling design, the required sample was collected randomly from six out of 24 municipal wards of the MCGM based on the proportion to the slum population. The sample for case-comparison group is 1:1.
Variables	7	<b>Outcome variables:</b> The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled. <b>Exposure:</b> The location of work, job satisfaction and mental health state of the sweepers were considered as effect modifier. Potential Confounders: The workers age, caste, BMI; years of engagement in the street sweeping and their location of work were consider potential individual risk factors for developing the MSDs and thereby disabilities
Data sources/ measurement	8*	Primary data was collected for the present study. Chi-square method and multivariate logistics regression was used to assess the association and correlation between potential risk factors and MSDs; disability. Additionally, the propensity score matching method was applied to assess the impact of sweeping occupation on developing the MSDs and disabilities.
Bias	9	<b>Subjectivity:</b> Biasness might have occurred due to the subjectivity in response but there was less chance of false reporting as the study was guaranteed confidentiality.
Study size	10	The estimated sample size was 180 with p-value 0.30 and design effect 1.25. Finally, the data collected from 180 street sweepers and 180 comparison group of MCGM.
Quantitative variables	11	Appropriate variables were recoded as per the requirement of applied methods such as, age, year of working, BMI, job satisfaction, and mental health. The details of considered variables for analysis discussed in methods section.
Statistical methods	12	<b>Chi-square Test:</b> Differences in prevalence of the MSDs and the disabilities were tested by Chi-square test. <b>Multivariate Regression:</b> The multivariate logistic regression analysis was performed to assess the correlation between individual characteristics with the MSDs and thereby disabilities.



**Propensity score matching (PSM):** To examine the impact of street sweeping occupation on the MSDs and the disabilities, propensity score matching method was applied.

Continued on next page

**Results**

Participants	13*	The cases (n=180) and comparison group (n=180) were considered throughout the analysis.
Descriptive data	14*	There was a small difference in the mean age of the street sweepers (37 years, SD ± 9.12) and that of the comparison group (38 years, SD±7.39). A similar pattern was observed while looking at the years of working of the street sweepers (11 years, SD±8.30) and those of the comparison group (11 years, SD±6.35). Similarly, substance use, such as alcohol consumption, smoking, and chewing tobacco, were higher among the sweepers compared to the comparison group. For instance, nearly 70 percent of the sweepers were using at least one type of substance. A little less than one-third were using two or more types of substance. The corresponding figure for the comparison group was (19%). Further, 17% of the street sweepers reported that they were not satisfied with their occupation compared to 8% of the comparison group.
Outcome data	15	The respondents who reported pain in 9 anatomical regions, viz. neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles during the previous 7 days and 12 months were considered as morbid with MSDs. The sweepers who were prevented from doing normal day-to-day activities at home or away from home due to the MSDs in the past 12 months were classified and recoded as disabled.
Main results	16	The street sweepers significantly have higher prevalence of MSDs and disabilities for shoulders, wrists/hand and elbow compared to the comparison groups. Similarly, street sweepers were more significantly disabled than comparison group for lower back, wrists/hand, shoulders, elbow and hips/thigh. The number of years of engagement in street sweeping and the location of work emerged as potential risk factors in the development of MSDs and, thereby, related disabilities. The PSM method highlighted that the occupation of sweeping significantly raised the risk of developing MSDs as well as disabilities particularly for shoulders, wrists/hands, elbows, and upper back.
Other analyses	17	No

**Discussion**

Key results	18	The results of bivariate analysis showed that the prevalence of the MSDs among the street sweepers was significantly higher for the shoulders (32%), wrists/hands (29%), and elbows (27%) as compared to the comparison group during the previous 12 months. Similarly, MSDs were found to be significantly higher among the street sweepers for the lower back (27%), wrists/hands (26%), shoulders (24%), elbows (23%), and hips/thighs (17%) as compared to the comparison group over the previous 12 months. The results of PSM method revealed that the average exposure effect among exposed (AEEE) to the sweeping occupation significantly enhanced the prevalence of the MSDs for the shoulders (17%), wrists/hands (14%), elbows (13%), and upper back (12%). A similar pattern was observed in case of disabilities, particularly for the shoulders (16%), wrists/hands (14%), lower back (14%), elbows (13%) and upper back (13%).
Limitations	19	<b>Subjectivity:</b> Biases might have occurred due to subjectivity in the response since the severity of MSDs was not quantified. However, the chances of false reporting are

low as the study guaranteed confidentiality.

**Cross-sectional:** Cross-sectional study design has a limitation of time period, however, by the fact that study carried out at one-time point and give no indication of the sequence of events.

**Seasonal variation:** There may be seasonal variations in the prevalence rate of MSDs. For instance, the prevalence of the MSDs may increase during the rainy season because wet waste requires extra energy for sweeping. This study has not considered the seasonal variation because the data collection for this study is not done in rainy season.

Interpretation	20	The results of bivariate analysis showed the higher prevalence of MSDs among the street sweepers compared to comparison group. Field observation suggested that this may be because of the continuous sweeping with the long-handle broom and carrying of the collected waste in the wheelbarrow to the community dustbins manually in an unvarying posture. The location of work emerged as a significant predictor of increased likelihood of MSDs and related disabilities among the street sweepers. It may be due to the higher quantum of work in the high slum concentrated areas.
Generalisability	21	In absence of any studies based on the MSDs among the street sweepers, the results of present study are comparable with other studies conducted with solid waste workers except knee and ankle disorders. This may be so because the street sweeper were not engaged in lifting heavy loads continuously as well as carrying it for long duration which might not put pressure on the knee and ankles as compared to the workers associated with the solid waste collection.
<b>Other information</b>		
Funding	22	The present study is a part of PhD work and does not receive any funding neither for the paper nor for the original study.

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).