



Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.org

Original Article

Workplace Accidents and Work-related Illnesses of Household Waste Collectors



Byung Yong Jeong*, Sangbok Lee, Jae Deuk Lee

Department of Industrial and Management Engineering, Hansung University, Seoul, Republic of Korea

ARTICLE INFO

Article history:

Received 30 October 2015

Received in revised form

25 November 2015

Accepted 27 November 2015

Available online 18 December 2015

Keywords:

accident analysis

accident prevention

household waste collector

work-related injury

ABSTRACT

Background: Household waste collectors (HWCs) are exposed to hazardous conditions. This study investigates the patterns of workplace injuries and work-related illnesses of HWCs.

Methods: This study uses cases of workplace injuries and work-related illnesses of HWCs that occurred between 2010 and 2011. We analyzed 325 cases of injuries and 36 cases of illnesses according to the workers' age, length of employment, size of workplace, injured part of body, day and month of injury, type of accident, agency of accident, and collection process.

Results: There were significant differences in the effect of workers' length of employment, injured part of body, type of accident, agency of accident, and collection process. Results show that most injuries occur in workers in their 50s and older. This study also shows that 51.4% of injuries occur at businesses with 49 employees or fewer. Injuries to waste collectors happen most often when workers are electrocuted after slipping on the ground. The second most prevalent form of injury is falling, which usually happens when workers hang from the rear of the truck during transportation or otherwise slip and fall from the truck. Work-related illnesses amongst waste collectors are mostly musculoskeletal conditions due to damaging postures.

Conclusion: These findings will be instructive in devising policies and guidelines for preventing workplace injuries and work-related illnesses of HWCs.

Copyright © 2015, Occupational Safety and Health Research Institute. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

According to Korea Standard Industry Code (KSIC) [1], the waste management industry includes traditional services such as collecting waste from households, public spaces, and businesses, and then transporting them to recycling, incineration, or landfill. The waste management services industry has multiple areas: collection and transportation of waste materials; treatment of waste materials; recycling; cleaning business facilities, and industrial supplies. The waste collection and transportation industry is further classified into: collection and transportation of nontoxic waste from households and businesses; collection and transportation of toxic waste from industrial sites which require special handling; and collection of transportation of waste from construction sites (e.g., disassembled building material). The treatment industry is further classified into: treatment of nontoxic waste by containment in

landfills or incineration; treatment of toxic waste such as biological or medical waste matter; and treatment of construction industry waste. The recycling industry is classified into: recycling waste matter into metal materials; and recycling waste matter into nonmetal materials.

Meanwhile, the Korean Standard Classification of Occupations [2] classifies waste collection occupations into: sanitation workers; collectors of recycled matter; and others. Waste management occupations are classified into: recycling equipment operators, incinerator operators, and others.

In the waste management industry, the accident rate has increased from 1.27 to 1.37 from 2010 to 2011, and the fatality rate has actually increased from 2.57 to 2.67 during the same period [3]. It is known that waste collectors are exposed to various accidental risks, such as traffic accidents by waste vehicles, caught in and between the trash compressor, cut/puncture by sharp waste

* Corresponding author. Department of Industrial and Management Engineering, Hansung University, 116 Samseongyoro-16Gil, Seongbuk-Gu, Seoul, 02876, Republic of Korea.

E-mail address: byjeong@hansung.ac.kr (B.Y. Jeong).

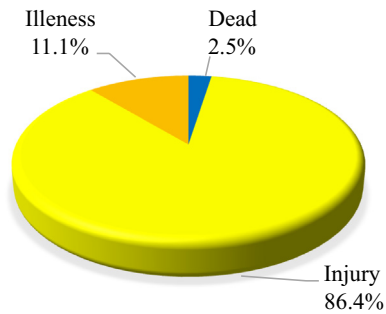


Fig. 1. Distribution of injuries and illnesses.

materials, slipping, or falling down [4–6]. In addition, garbage collectors repeatedly bend over to lift and deliver heavy wastes, thus, it is associated with a high prevalence rate of musculoskeletal disorders [7].

Domestic waste management services are generally provided by local government authorities. In Republic of Korea, household waste collectors are employed by private consignment companies, which are commissioned by local government, while street cleaners are involved in local government agencies. As household commodities come in various types and materials, the types and quantities of waste vary. There is little awareness or attention for waste-collection workers while the social and public role of them expands [8,9]. Furthermore, under the international agreements on recycling, intermediate treatment and selection of the waste gets complicated [10]. Therefore, a general purposed preventive plan is required [9], based on analyzing accidents and injuries-related data for waste-collection workers. This study aims to investigate the characteristics of occupational accidents and work-related injuries of household waste collectors.

2. Materials and methods

2.1. Definition and data collection

The term household waste, refers to municipal solid wastes from houses, which are very often the responsibility of municipal or other governmental authorities. In this paper 'household waste collectors' are people who collect the standard plastic garbage bag, excluding those who collect food waste and recyclable waste.

This study investigated 325 male workers who have suffered injury or illness while collecting waste between 2010 and 2011. Our focus was on workers who lost > 4 days of work due to illness or injury. Fig. 1 shows the distribution of these workers: 2.5% suffered fatalities, 86.4% suffered injuries, and 11.1% suffered work-related illnesses.

2.2. Data analysis

Accident data for injured persons were analyzed in terms of their age and length of employment, injured part of body, accident type, operating process, and agency of accident. The independent variables of the study include age, length of employment, size of workplace, day and month of injury, type of injury, agency of accident, operating process, and physical location of injury. The dependent variable is the distribution of injuries and illnesses incurred by workers. In order to see whether the distribution of injuries and illnesses vary according to the explanatory variables, we used SPSS (SPSS Inc., Chicago, IL, USA) to run a Chi-square test, considering p values < 0.1 as statistically significant.

Table 1
Distribution of injuries and illnesses by length of employment

Length of employment (y)	Injury		Illness		Total	
	No.	%	No.	%	No.	%
< 1	77	26.6	6	16.7	83	25.6
1–5	73	25.3	8	22.2	81	24.9
5–10	65	22.5	15	41.7	80	24.6
≥ 10	74	25.6	7	19.4	81	24.9
Total	289	100	36	100	325	100

3. Results

3.1. Characteristics of injured persons

3.1.1. Distribution by length of employment

Table 1 shows the distribution by worker's length of employment. It shows the length-distributions between injured and ill persons are different with confidence level 0.1 ($\chi^2 = 6.636$, $p = 0.084$). From Table 1, there is less difference in accident rates according to work experiences, because this job may not require complicated techniques. Meanwhile, the rate of work-related illnesses varies along with the work experiences. A total of 41.7% of the illnesses occurred in workers with 5–10 years of experience.

3.1.2. Distribution by age

Fig. 2 shows the distribution of the ages of workers who incurred injury or illness. Men in their 50s were the most common (46.7%), followed by men in their 40s (28.0%) and 60s and over (14.2%). Men in their 50s or older are 60.9% of the total. It implies that older workers are vulnerable to accidents because the workers have to keep moving around, work on their feet all day, and hold plastic garbage bags, which are not easy to handle. These cause tiredness and loss of concentration. There was no particular difference in the effect of age on injuries and illnesses ($\chi^2 = 5.686$, $p = 0.128$).

3.1.3. Distribution by size of employment

Fig. 3 shows the distribution by size of employment. Workplaces employing > 100 employees were most common (30.8%), followed by workplaces employing 10–29 people (27.7%), then workplaces employing 50–99 people (17.8%). There was no significant effect of workplace size on the distribution of illnesses and injuries ($\chi^2 = 1.197$, $p = 0.751$). Household waste is collected and transported by businesses to which the responsibility has been outsourced by municipal governments, and it seems that small businesses with < 50 employees are not educated properly in safety precautions and measures. This is an area in need of improvement.

3.1.4. Distribution by injured part of body

Table 2 shows the distribution of the physical locations of injuries. Multiple injuries denote any case in which there were

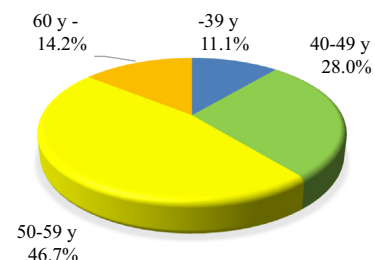


Fig. 2. Distribution of injuries and illnesses by age.

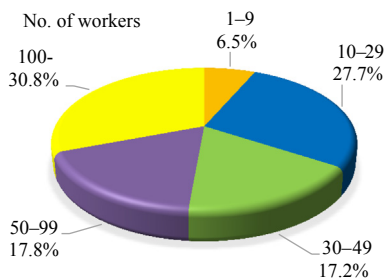


Fig. 3. Distribution of injuries and illnesses by size of employment.

injuries in more than one location. Overall the location most prevalently injured was legs/knees/feet (23.1%), followed by waist/torso (15.4%), and hand/fingers (12.9%).

There is a significant difference in distribution between illnesses and injuries. Injuries were most common in the legs/knees/feet (25.3%) and hands/fingers (14.5%). This is in agreement with Robazzi [11], who shows a large number of injuries occurred on legs and arms. Most illnesses occurred to the waist/torso (69.4%) and shoulder/arms (19.4%), and this result is consistent with previous results [12,13], which state waste collection workers have more musculoskeletal illnesses on the waist, knees/feet, and hands.

3.2. Characteristics of day of accidents

3.2.1. Distribution by month

Fig. 4 shows the distribution by month of injury and illnesses. September was most common (10.8%), followed by August (9.8%), and January (9.5%). There was no significant difference in distribution between injuries and illnesses ($\chi^2 = 8.939, p = 0.628$). Ivens [12] states the accident rate decreases in wintertime because the workers are more cautious at that time. In Republic of Korea, however, it is shown that March and July are marked with lower numbers.

3.2.2. Distribution by week

Fig. 5 shows the distribution by day of injury. Monday was most common (22.6%), followed by Tuesday (17.8%), and Wednesday (16.3%). We can see that the prevalence of injury gradually decreases between Monday and Sunday. The reason why there are more injuries on Mondays is that it takes a longer time to collect the waste, which has accumulated over the weekend. The workers rush their work and consequently, it causes more injuries [7,8]. There was no significant difference in distribution between injuries and illnesses depending on the day ($\chi^2 = 6.510, p = 0.369$).

3.3. Characteristics of accidents

3.3.1. Distribution by type of accident

Table 3 shows the distribution of injuries by type of accidents, and slips are most common (25.8%), followed by falls from a height

Table 2
Distribution by injured part of the body

Physical location	Injury		Illness		Total	
	No.	%	No.	%	No.	%
Head/face/neck	18	6.2	1	2.8	19	5.8
Waist/torso	25	8.7	25	69.4	50	15.4
Shoulder/arm	23	8.0	7	19.4	30	9.3
Hand/finger	42	14.5			42	12.9
Leg/knee/foot	73	25.3	2	5.6	75	23.1
Composite	18	6.2			18	5.5
Unknown	90	31.1	1	2.8	91	28.0

Composition ratio (%)

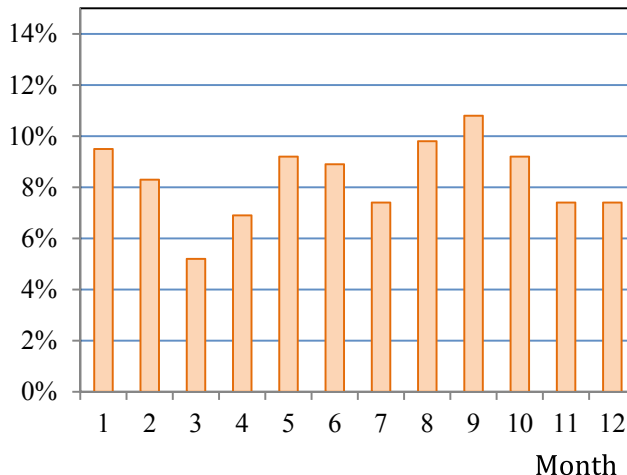


Fig. 4. Distribution of injuries and illnesses by month.

(16.6%), traffic accidents (13.6%), and musculoskeletal disorders (11.1%). There seems to be a slight difference from the sanitation industry, in which slips are most common (27%), followed by falls from a height (17.2%), musculoskeletal disorders (11.6%), traffic accidents (10.6%), and collisions (8.6%). The HSE reported that 'slips and trips' are the major cause of the accidents in garbage collecting [4], which is the same as our results. Meanwhile, Robazzi [11] mentions 'cut/pricked' is most common in Brazil because they do not wear an appropriate work suit. As Robazzi pointed out, it is also important to have appropriate safety wear in order to secure safety.

3.3.2. Distribution by agency of accident

Table 4 shows the distribution by agency of accident. Mode of transportation was most prevalent (40.3%), followed by waste bags or pouches (20.6%), ground conditions and speed bumps (19.7%), glass, trees, fluorescent lights (10.8%), and miscellaneous (8.6%). There was a difference in distribution between injuries and illnesses ($\chi^2 = 155.895, p < 0.001$). Injuries were most often due to mode of transportation (45.3%) and ground conditions and speed bumps (22.2%) which collectively made up 67.5%, whereas illnesses were most often due to handling of waste bags or pouches.

Composition ratio (%)

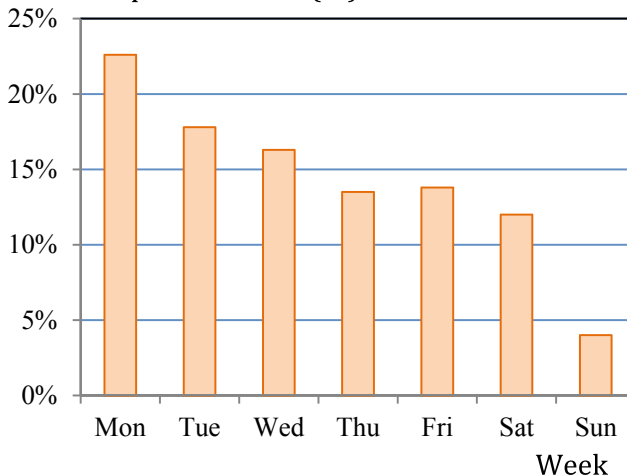


Fig. 5. Distribution of injuries and illnesses by week.

Table 3
Distribution of injuries and illnesses by type of accident

Type	Total	
	No.	%
Slips	84	25.8
Falls from a height	54	16.6
Traffic accidents	44	13.6
Musculoskeletal disorders	36	11.1
Cut/puncture	29	8.9
Caught in and between	33	10.2
Other	45	13.8

3.3.3. Distribution of injuries and illnesses by collection process

Table 5 shows the distribution of injuries and illnesses by collection process. Waste collection was most prevalent (42.8%), then loading of waste disposal (29.5%), and transportation during waste collection (11.4%). This is because the incidence of electrocution was high during waste collection, and because there is handling of heavy equipment during waste disposal.

There was also a significant difference in distribution between injuries and illnesses ($\chi^2 = 30.947, p < 0.001$). Injuries were due to waste collection (43.9%), loading of waste disposal (24.9%), and transportation during waste collection (12.8%).

However, illnesses were due to loading of waste disposal (66.7%) and waste collection (33.3%). This implies bending and twisting of the body, in the middle of lifting to garbage-loading trucks and collecting of wastes, result in musculoskeletal illnesses [9,13,14].

4. Discussion

This study has investigated the patterns of illness and injuries that occur in waste collectors. Based on our findings, we have devised a set of illness and injury prevention guidelines and safety and health recommendations.

First, we can observe that most injuries occur in workers in their 50s and older. It is inevitable that workers' physical abilities decline with age, but in addition to these physical changes, there is also mental stress related to aged vision, auditory, and mobile capabilities. Therefore, we can infer that there needs to be a focus on elderly and senior workers with regard to injury and illness prevention [15]. However, because the sanitation industry that employs waste collectors mostly consists of small businesses, there is a lack of organized health and safety protocols. This study also shows that 51.4% of injuries occur at businesses with 49 employees or fewer, indicating that there is a need for support and management of workplace safety at these small businesses. Choi et al. [8] have already pointed out the need for health and safety education at businesses with > 50 employees, so on the whole there is a need for systematic education with regards to injury prevention of waste collectors. This is all the more important when taking into account the public benefit of proper waste collection.

Table 4
Distribution of injuries and illnesses by agency of accident

Agency of accident	Injury		Illness		Total	
	No.	%	No.	%	No.	%
Mode of transportation	131	45.3			131	40.3
Waste bags or pouches	31	10.7	36	100	67	20.6
Ground conditions and speed bumps	64	22.2			64	19.7
Glass, trees, fluorescent lights	35	12.1			35	10.8
Other	28	9.7			28	8.6

Table 5
Distribution of injuries and illnesses by collection process

Cause	Injury		Illness		Total		
	No.	%	No.	%	No.	%	
During workplace movement	22	7.7			22	6.8	
Transportation during waste collection	37	12.8			37	11.4	
Waste collection	Waste collection	127	43.9	12	33.3	139	42.8
	Loading of waste disposal	72	24.9	24	66.7	96	29.5
	Machine operation	15	5.2			15	4.6
	Subtotal	214	74.0	36	100	250	76.9
Working inside garbage collection place	16	5.5			16	4.9	

Injuries to waste collectors happen most often when workers are electrocuted after slipping on floors. In order to prevent slips on floors, workers must be provided with work shoes equipped with proper traction on the soles. For senior workers, eyesight is the first to deteriorate after the age of 40, with their field of vision increasingly narrowing with age, and contracting pupils unable to transmit as much light as before. Therefore, when work conditions provide insufficient natural lighting (such as early morning or nighttime labor), waste collectors should be provided with lighting equipment and waste collection vehicles should be equipped with lighting capabilities, in order to ensure that there is enough visibility to prevent injuries.

The second most prevalent form of injury is falling, which usually happens when workers hang from the rear of the truck during transportation or otherwise slip and fall from the truck. Waste collection vehicles must be driven at low speeds, and it needs to be reiterated to workers that there is a high risk of falling when the vehicle is driving at high speeds or passes over a speed bump, and prevent them from hanging from the back of the vehicle when it is being driven at high speeds. Proper lighting is also necessary to prevent injuries by traffic accidents, and workers must be properly outfitted with reflective gear and safety harnesses.

Work-related illnesses amongst waste collectors are mostly musculoskeletal conditions due to damaging postures; therefore, it is important that vehicles be provided with lifts and other necessary apparatus to handle heavy loads. These musculoskeletal conditions are due to handling of heavy waste bags and bins, and repetitive push/pull motions that accompany such tasks; workers must be educated in the proper methods of handling such heavy loads. There may also be a need to restrict the size of waste bags in order to prevent them from becoming too heavy when filled with waste. Awkward postures can be reduced by improving inappropriate work methods or tools [16]. Thus, as Jung et al [14] pointed, an integrated remedy such as providing ergonomically designed work-tools can reduce or prevent musculoskeletal disorders.

This study has the following limitations: (1) minor accidents are not included in the analysis because we used data of industrial accidents, which needs > 4 days' convalescence; and (2) due to the limitations of our dataset, the analysis does not cover accidental characteristics or evaluation of accidental risks in the middle of collecting wastes. Thus, a further study regarding evaluation of accidental risks based on frequencies and severities of accidents is necessary. Nevertheless, despite these limitations, this study put its significance on thorough analysis on waste collectors' characteristics regarding to accidents and job-related illnesses' specifications. This work can be used as basis for developing preventive plans for waste collectors.

Conflicts of interest

All authors declare that there are no conflicts of interest.

Acknowledgments

This research was financially supported by Hansung University, Seoul, Republic of Korea.

References

- [1] Statistics Korea. Korean Standard Industrial Classification [Internet]. 2008 [cited 2015 Oct 30]. Available from: http://kostat.go.kr/e_book/kssc/KSIC08/EBook.htm. [in Korean].
- [2] Statistics Korea. Korean Standard Classification of Occupations [Internet]. 2007 [cited 2015 Oct 30]. Available from: http://kostat.go.kr/e_book/kssc/KSCO07/EBook.htm. [in Korean].
- [3] KOSIS. Report on the Service Industry Survey (2012 yearly base) [Internet]. 2013 [cited 2015 Feb 1]. Available from: <http://kosis.kr/> [in Korean].
- [4] HSE. Health and hazardous substances in waste and recycling [Internet]. 2014 [cited 2014 Jan 28]. Available from: <http://www.hse.gov.uk/pubns/waste27.htm>.
- [5] Krajewski JA, Tarkowski S, Cyprowski M, Szarapinska-Kwaszewska J, Dudkiewicz B. Occupational exposure to organic dust associated with municipal waste collection and management. *Int J Occup Med Environ Health* 2002;15:289–301.
- [6] Kuijer PPFM, Sluiter JK, Frings-Dresen MH. Health and safety in waste collection: towards evidence-based worker health surveillance. *Am J Ind Med* 2010;53:1040–64.
- [7] Poulsen OM, Breum NO, Ebbehoj N, Hansen AM, Ivens UI, van Lelieveld D, Malmros P, Matthiasen L, Nielsen BH, Nielsen EM, Schibye B, Skov T, Stenbaek EI, Wilkins CK. Collection of domestic waste. Review of occupational health problems and their possible causes. *Sci Total Environ* 1995;170:1–19.
- [8] Choi ES, Sohn SY, Yi KH. A study on types of municipal sanitation workers' occupational accident by work type. *Korean J Occup Health Nurs* 2011;20:172–84. [in Korean].
- [9] Kim SB, Ryu SH, Park DU, Lee YK. Strategies for protecting waste collectors' health and safety. *Korean J Environ Health Sci* 2010;36:247–53.
- [10] Jonsson PO. Trends in waste management in relation to increased recycling. *Ann Agric Environ Med* 1997;4:3–6.
- [11] Robazzi ML. Garbage collectors: occupational accidents and coefficients of frequency and severity per accident. *Ann Agric Environ Med* 1997;4:91–6.
- [12] Ivens UI, Lassen JH, Kaltoft BS, Skov T. Injuries among domestic waste collectors. *Am J Ind Med* 1988;33:182–9.
- [13] ILO. Domestic Waste Collection – ILO Encyclopedia of Occupational Health and Safety [Internet]. 2011 [cited 2011 Mar 28]. Available from: <http://www.iloencyclopaedia.org/component/k2/item/838-domestic-waste-collection>.
- [14] Jung S, Lee KS, Jung MC, Lee I, Jung-Choi K, Bahk J, Kim H. Relationship between prevalence of musculoskeletal symptoms and occupational and personal factors among street cleaners. *J KOSOS* 2010;25:171–81.
- [15] Gao C, Abeysekera J. A systems perspective of slip and fall accidents on icy and snowy surfaces. *Ergonomics* 2004;47:573–98.
- [16] Gallagher S. Physical limitations and musculoskeletal complaints associated with work in unusual or restricted postures: A literature review. *J Saf Res* 2005;36:51–61.