

# Moderating and Mediating Effects of Over-Commitment on the Association Between Effort–Reward Imbalance (ERI) with Upper Back and Hand/Wrist Disorders in Municipal Solid Waste Collectors

Wen-Yu Lin <sup>1,2</sup>, Ching-Lan Yang<sup>3</sup>, Wei-Ping Huang<sup>1</sup>, Po-Chang Tseng <sup>1,4</sup>, Hsien-Wen Kuo <sup>1,5</sup>

<sup>1</sup>Institute of Environmental and Occupational Health Sciences, National Yang Ming Chiao Tung University, Taipei, Taiwan; <sup>2</sup>Taiwan's Environmental Protection Agency, Taipei, Taiwan; <sup>3</sup>Occupational Medicine Department, Far Eastern Memorial Hospital, New Taipei, Taiwan; <sup>4</sup>Health Promotion Administration, Ministry of Health and Welfare, Taipei, Taiwan; <sup>5</sup>Institute of Public Health, National Defense University, Taipei, Taiwan

Correspondence: Hsien-Wen Kuo, Institute of Environmental and Occupational Health Sciences, National Yang Ming Chiao Tung University, No. 155, Sec.2, Linong Street, Taipei, 112, Taiwan, Tel +886 2-28272294, Email hwkuo@ym.edu.tw

**Purpose:** Despite repetitive activities and the frequency of high workload for municipal solid waste (MSW) collectors, the risks of work-related stress on upper extremity pain are inconclusive. The objective of this study is to assess the moderation and mediation effect of effort–reward imbalance (ERI) and over-commitment (OC) on upper back and hand/wrist disorders in MSW collectors.

**Methods:** A cross-sectional study was conducted with MSW collectors from two cities in Taiwan. Each participant was asked to anonymously fill out a structured questionnaire. Work-related stress, including ERI and OC, was assessed by a Chinese version of the Job Content Questionnaire (C-JCL). Upper back and hand/wrist disorders were assessed using the Nordic musculoskeletal questionnaire. Multivariate analysis was used to assess moderation and mediation effect of OC and ERI on upper extremity pain.

**Results:** The moderation effect of ERI and OC on upper back and hand/wrist disorders in MSW collectors was found. Disorders were higher in the group with both ERI  $\geq 1$  and high OC (OR (odds ratio) = 3.25 and OR = 3.00) than in the group with ERI  $\geq 1$  and low OC (OR = 2.66 and OR = 1.87) and in the ERI  $< 1$  and high OC group (OR = 2.27 and OR = 1.26). Synergy indexes were 0.77 and 1.77, respectively. Using multivariate analysis after adjusting for covariates, the mediation effect of OC was significant for the association between ERI and upper back and hand/wrist pains. The indirect effects of OC for upper back and hand/wrist pains accounted for 35% and 42%, respectively, and OC appears to mediate the relationship between ERI and upper back and hand/wrist disorders in MSW collectors.

**Conclusion:** Work-related stress measured ERI and OC may play a role in moderating and mediating effects on upper extremity pain. Encouraging provisions of work modification and stress management is needed to mitigate the occurrence of upper extremities pain in MSW collectors.

**Keywords:** effort–reward imbalance, ERI, over-commitment, upper back, hand/wrist disorders, municipal solid waste collectors, mediation effect

## Introduction

Since the policy of “keeping trash off of the ground” was launched in Taiwan, garbage/trash has been directly brought to a trash truck at designated times and locations rather than leaving it on the ground randomly. As a result, municipal solid waste (MSW) collectors are required to assist citizens collecting household waste, involving repeated heavy physical activity during a short time period. Consequently, MSW collectors are frequently exposed to repetitive motions, awkward working positions, forceful hand exertion, and frequent manual handling, recognized as high risk to occupational diseases

and injuries commonly occurring at upper back and hand/wrist disorders. Besides, it is well known that heavy workload is a risk factor for musculoskeletal disorders (MSDs), and high psychosocial job stressors also contribute to the frequencies and intensities of MSDs. Since MSW collectors are frequently exposed to psychological demands and work postures involving elevated arms, they often have high upper back and shoulder pain. High point prevalence rates in municipal solid waste collectors were 89.1% for upper back pain, 80.9% for shoulder pain, 78.7% for wrists/hands, and 67.8% for neck pain, respectively.<sup>1</sup> In contrast, a study in Egypt found that in 60.8% of musculoskeletal complaints, the lower back was the most frequently affected body region among MSW collectors.<sup>2</sup>

Currently, two theoretical models of job stress including the Job-Demand-Control (JDC) model<sup>3</sup> and Effort–Reward-Imbalance (ERI) model<sup>4</sup> are frequently used to measure levels of job-related stress in different workplace features. The ERI model attributes stress to an inequitable balance between job demands and rewards, whereas individuals with high ERI together with over-commitment (OC) may interact to increase their risk of poor physical or mental health. The ERI model separates extrinsic and intrinsic components, the former refers to imbalance between effort and reward at work, while the latter reflects the need for control and a desire for approval.<sup>4–6</sup> A systematic review<sup>7</sup> indicated 13 out of 19 studies showed statistically significant associations between MSDs and ERI with a moderate level of evidence. However, the evidence for the role of OC and for its interaction with ERI was rated as inconclusive. Although incident and prevalent MSDs have been found to co-occur with psychosocial job stress, impacts of independent and interactive effects from different job-related stress are unknown. Herr et al<sup>8</sup> assessed three job stress models (ERI, job strain, and organizational justice) associated with MSDs in blue- and white-collar workers and found ERI influences pain symptoms in both occupational groups, but organizational justice was an independent significant predictor only among white-collar workers and job strain had additive predictive utility exclusively among blue-collar workers. Therefore, authors suggest simultaneous exposure to multiple job stress factors appeared to synergize MSDs reporting. In addition, ERI and OC at work are determinants of burnout and the inverse association of OC with professional efficacy in police officers.<sup>6</sup> Obviously, high work-related stress and extreme involvement in work may negatively affect work efficiency and health status. Moreover, limited evidence has shown psychological stress associated with MSDs in MSW collectors. Work-related stress measured by ERI and OC's contribution to the independent, moderation, and mediation effects on upper extremity pain is inconclusive. The objective is to assess the moderation and mediation effects of ERI and OC on upper extremity pain in MSW collectors. Therefore, there are four hypotheses of ERI and OC in association with upper extremity pain in MSW collectors. These include 1) the extrinsic hypothesis: ERI is positively associated with upper extremity pain, 2) the intrinsic hypothesis: OC is positively associated with upper extremity pain, 3) the moderation effect: MWCs reporting both high levels of extrinsic ERI and intrinsic OC have greater prevalent upper extremity pain, and 4) the mediation effect: OC acts as a mediator on the association between ERI and upper extremity pain.

## Methods

### Study Population

Our protocol was reviewed and approved by the institutional review board (IRB) in Yang Ming University (ID: YM106062EF). A cross-sectional study was conducted among 622 MSW collectors (including drivers, waste collectors, and others) who voluntarily enrolled from Keelung city and Yilan county located northern Taiwan. The overall response rate was 85%, the reasons for non-response included vacations, requested time off, or having limited time to fill out the questionnaire. Each employee signed an informed consent at the time of the study and anonymously filled out a structured questionnaire.

### Measurement

The structured questionnaire included demographic data, job characteristics (job title, job schedule, and work duration), psychological risk factors (ERI and OC), and musculoskeletal disorders (MSDs). ERI was measured using the Chinese-version Job Content Questionnaire (C-JCL).<sup>9</sup> Detailed information on measurement of ERI and OC was described in our previous study.<sup>10</sup> The ERI model is based on theories on social exchange and stress, which the core of the theory considers “Reciprocity”.<sup>4,5</sup> Three scenarios of an imbalance occurs when 1) workers do not have or have fewer opportunities at workplace; 2) workers accept non-reciprocity for strategic career reasons, or 3) persons are

overcommitted. Therefore, over-commitment plays a special role in the ERI model. The higher the ERI or OC, the worse are employees' health. ERI was measured by a modified questionnaire, which contained three items for measuring effort and seven items for measuring reward. The ERI ratio for each study participant was computed using the sum scores for efforts as the numerator (Effort) and the sum scores for rewards as the denominator (Reward) multiplied by a correction factor of 0.43 [(Effort/3)/(Reward/7)]. An ERI ratio  $\geq 1$  indicated an exposure to a high ERI at work, which constitutes as a perceived job-related stress. Cronbach's alpha coefficients for effort, reward, and OC were 0.74, 0.83, and 0.88, respectively, which is consistent with Siegrist's study of 0.61–0.91.<sup>4</sup> An ERI ratio  $\geq 1$  indicated an exposure to high psychological stress at work. OC is measured using the sum of six items with a Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). Levels of OC were classified into two groups: the high OC group ( $\geq 75\%$ ) and the low OC group ( $< 75\%$ ).

## Outcome Measurement

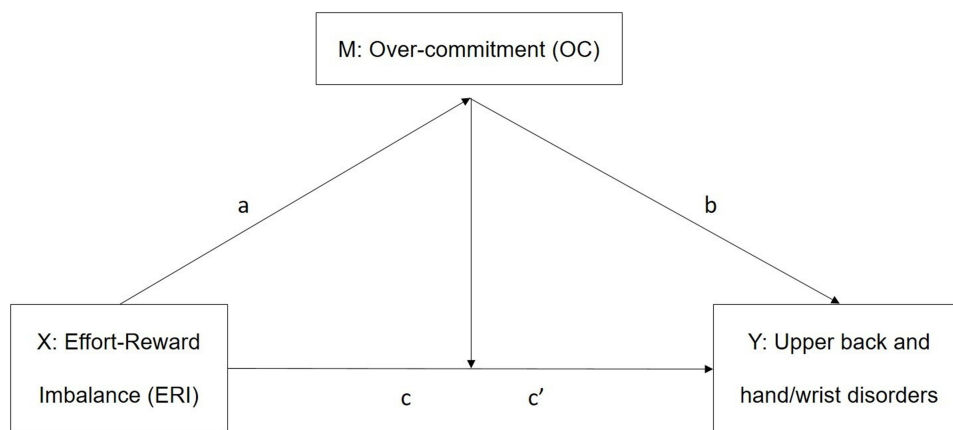
Since MSW collectors occupationally collect solid waste by hand or wrist to immediately throw into a compact truck, they are frequently exposed to a high workload of manual hazards. Consequently, MSW collectors in Taiwan reported high frequency of symptoms of upper back and hand/wrist pains. Each MSW collector self-reported upper extremity pain using the Chinese version of the Nordic musculoskeletal questionnaire (NMQ) to assess symptoms of numbness or pain over the previous year in an upper extremity location including upper back and hand/wrist.<sup>11</sup> In addition, each employee was asked about the onset and treatment of the upper extremity pain, which was checked by a physician to maintain high consistency. Point prevalence rates of upper extremity pain among MSW collectors were calculated.

## Statistical Analysis

The SPSS 24 package was used to perform descriptive analysis for demographic data. The Chi-square test was used to examine the prevalence of upper back and hand/wrist pain associated with demographics and job characteristics. The odds ratios (ORs) in the high and low groups of ERI and OC examined the moderation effect on prevalent upper extremity pain using multivariate analysis after adjusting for gender, educational level, marital status, and job title. Synergy index was used to assess the interaction effect of ERI and OC using a dichromatic scale on upper extremity pain. The association between ERI and prevalent upper back and hand/wrist pain mediated by OC was also tested using Hayes's model 4 based on the PROCESS macro for SPSS.<sup>10</sup> The goal of a simple mediation model 4 analyses is to establish the extent to which the predictor (ERI) influences outcome (upper extremity pain) through one mediator variable (OC), which are conceptualized as the mechanism through which the predictor (ERI) influences outcome (upper extremity pain). The bias-corrected 95% confidence interval (CI) was calculated with 5000 bootstrapping resamples. In OLS regression (as used in Hayes Process Macro), an effect tells us about the association between variables. If the predictor (ERI) has a *positive* direct effect on outcome (upper extremity pain), it appears that higher levels of the predictor (ERI) are associated with higher levels of the outcome (upper extremity pain). In [Figure 1](#), a simple mediation model indicates whether variation in the predictor (ERI) is associated with variation in the mediator (OC), which in turn is associated with variation in the outcome (upper extremity pain). Assessing the mediator (OC) allows for assessment of the mechanisms that contribute to an association between the predictor (ERI) and the outcome (upper extremity pain).<sup>12</sup>

## Results

[Table 1](#) shows demographic information in MSW collectors associated with upper back and hand/wrist disorders. Results indicated 83% from Yilan county collectors and 81.6% for male collectors. Regarding job characteristics, 75.8% of the participants were waste collectors and 73% had worked the job for less than 20 years. In the demographic information, a high percentage of upper back disorders were in Yilan county (22.8%), drivers (28.8%), and work duration between 25 and 239 months (28.4%). Hand/wrist disorders were only significantly associated with location but not associated with gender, job title, and work duration. However, the prevalence of upper back and hand/wrist disorders were consistently associated with the ERI  $\geq 1$  group (33.5% and 28.7%) and the high OC group (41.2% and 39.4%).



**Figure 1** Over-commitment (OC) acts a modifier and/or mediator for the association between ERI and upper back and hand/wrist disorders. [(a) the path from X to M; the relationship between the predictor and the mediator; (b) the path from M to Y; the relationship between the mediator (M) and the outcome (Y); (c) the direct effect [X to Y], the relationship between X-Y]; (c') the direct effect [X to Y], the relationship between X-Y without mediation].

Table 2 indicates job-related stress measured by ERI and OC associated with upper back and hand/wrist disorders in MSW collectors using univariate and multivariate analysis for hypothesis 1 and 2. Based on multivariate analysis after adjusting for age, education, marital status, and job title, upper back and hand/wrist disorders were significantly higher in the ERI  $\geq 1$  group (OR (odds ratio) = 2.27 and OR=2.40, respectively). Similarly, results show the high OC group with

**Table 1** Demographic Information Associated with Upper Back and Hand/Wrist Disorders

	<b>N=594 n (%)</b>	<b>Upper Back n (%)</b>	<b>Hand/Wrist n (%)</b>
Location			
Keelung city	101 (17.0)	15 (14.9)	128 (26.0)
Yilan county	493 (83.0)	23 (22.8)	173 (35.1)
<i>p</i>		0.017	0.016
Gender			
Male	499 (81.6)	115 (23.0)	166 (33.3)
Female	90 (18.4)	27 (30.0)	29 (32.2)
<i>p</i>		0.156	0.846
Job title			
Cleaner	448 (75.8)	111 (24.8)	157 (35.0)
Driver	73 (12.2)	21 (28.8)	20 (27.4)
Other	71 (12.0)	9 (12.7)	19 (26.8)
<i>p</i>		0.048	0.210
Work duration (months)			
$\leq 24$	53 (15.2)	5 (9.4)	15 (28.3)
25–239	204 (58.5)	58 (28.4)	68 (33.3)
$\geq 240$	92 (26.4)	18 (19.6)	24 (26.1)
<i>p</i>		0.009	0.421
ERI			
<1	400 (67.3)	78 (19.5)	116 (29.0)
$\geq 1$	194 (32.7)	65 (33.5)	80 (41.2)
<i>p</i>		<0.001	<0.001
Over-commitment			
Low	343 (57.7)	71 (20.7)	97 (28.3)
High	251 (42.3)	72 (28.7)	99 (39.4)
<i>p</i>		<0.001	<0.001

**Table 2** Job-Related Stress Measured by ERI and OC Associated with Upper Back and Hand/Wrist Disorders Using Univariate and Multivariate Analysis After Adjusting for Age, Education, Marital Status, and Job Title

			Crude OR (95% CI)	Adjusted OR (95% CI)
	ERI <1	ERI ≥1		
	(N=400) n (%)	(N=194) n (%)		
Upper back	78 (19.5)	65 (33.5)	2.08** (1.41–3.06)	2.27** (1.30–3.95)
Hand/Wrist	116 (29.0)	80 (41.2)	1.72** (1.20–2.46)	2.40** (1.45–3.95)
	Low OC	High OC		
	(N=343) n (%)	(N=251) n (%)		
Upper back	78 (19.5)	65 (33.5)	1.54* (1.06–2.25)	2.14** (1.24–3.70)
Hand/Wrist	116 (29.0)	80 (41.2)	1.65** (1.17–2.33)	1.80* (1.11–2.94)

Note: \*p<0.05 \*\*p<0.01.

**Table 3** Interaction Effect of ERI and OC on Upper Back and Hand/Wrist Disorders Using Multivariate Analysis After Adjusting for Covariates

		Upper Back	Hand/Wrist
ERI	OC	OR (95% CI)	OR (95% CI)
<1	Low	1	1
≥1	Low	2.66* (1.12–6.33)	1.87 (0.85–4.11)
<1	High	2.27* (1.07–4.81)	1.26 (0.63–2.52)
≥1	High	3.25** (1.61–6.53)	3.00** (1.63–5.52)
Synergy index		0.77 (0.43–1.39)	1.77 (0.69–4.58)

Note: \*p<0.05 \*\*p<0.01.

OR=2.14 and OR=1.80 higher than those in the low OC group. Compared to the effects of OC, work-related stress measured by ERI had considerably high associations with upper back and hand/wrist disorders.

The moderation effect of ERI and OC on upper back and hand/wrist disorders is shown in Table 3. Using multivariate analysis after adjusting for age, education, marital status, and job title, both ERI ≥1 and high OC group had the highest ORs (OR=3.25 and OR=3.00) on upper back and hand/wrist disorders, followed by the ERI ≥1 and low OC group (OR=2.66 and OR=1.87) and lower ORs in the ERI <1 and high OC group (OR=2.27 and OR=1.26). For hypothesis 3, the synergy index was respectively 0.77 and 1.77 to assess the moderation effect of ERI and OC on upper back and hand/wrist disorders but were not significant.

Table 4 and Figure 1 show the standardized coefficients of OC for the association between ERI and upper back and hand/wrist disorders in MSW collectors using mediation analysis after adjusting for age, education, marital status, and job title. In Figure 1, upper back and hand/wrist disorders were directly affected by ERI and indirectly affected by ERI to OC. In addition, there is a moderation effect of ERI and OC on upper back and hand/wrist disorders. A simple mediation

**Table 4** Standardized Coefficients of OC for the Association Between ERI and Upper Back and Hand/Wrist Disorders Using Mediation Analysis After Adjusting for Covariates

	Direct Effect (c) (95% LLCI-ULCI)	Indirect Effect (c') (95% LLCI-ULCI)	Total Effect (95% LLCI-ULCI)	Mediated Effect (%)
Upper back	0.097* (0.002–0.193)	0.051** (0.014–0.108)	0.147** (0.058–0.236)	35%
Hand/Wrist	0.066 (–0.042–0.174)	0.054** (0.014–0.120)	0.129** (0.031–0.228)	42%

Note: \*p-value < 0.05; \*\*p-value < 0.01.

model examines how the effect of the predictor (X: ERI) on the outcome (Y: upper back and hand/wrist disorders) is partitioned into two paths: 1) the direct effect; predictor–outcome and 2) the indirect effect; predictor–mediator–outcome. For hypothesis 4, if the direct effect of ERI (X) on upper back pain (Y) is 0.097 (95% CI: 0.002–0.193); however, the LLCI & ULCI do not include zero, then the direct effect of ERI (X) on upper back pain (Y) is significant. However, If the indirect effect of OC (M) on the association between ERI (X) and upper back pain (Y) is 0.051 (95% CI: 0.014–0.108); the LLCI & ULCI do not include zero, so the indirect effect of OC (M) on between ERI (X) and upper back pain (Y) is significant, which is accounted for 35% of variance was explained by mediator (M). Similarly, the hand/wrist pains were significantly associated with ERI directly and OC indirectly. Percentages of the indirect effect of OC on hand/wrist pains accounted for 42%, revealing the mediating effects of hand/wrist disorders through OC.

## Discussion

The ERI model used in the study consists of three components: effort, reward and over-commitment. Over-commitment is defined to be “a set of attitudes, behaviors and emotions reflecting excessive striving in combination with a strong desire of being approved and esteemed high-cost/low gain-working conditions.” However, the moderation of OC and ERI has often been neglected.<sup>5</sup> As a result, our study not only demonstrated the moderation effect of ERI and OC on MSDs but assesses the mediating effect of OC for the association between ERI and MSD. We indicated that ERI and OC were independently associated with upper back and hand/wrist disorders in MSW collectors. In addition, the moderation effect of the group with both  $ERI \geq 1$  and high OC had a synergy index with 0.77 and 1.77, but they are insignificant. However, the mediation effect for upper back and hand/wrist pains accounted for 35% and 42%. It appears OC significantly mediated the association between ERI and upper back and hand/wrist disorders in MSW collectors. A previous study has stated OC could be interpreted as a mediator between ERI and mental health. A longitudinal study<sup>13</sup> for German employees aged 40–54 years indicated that there was no association between ERI and mental health that was independent of OC. It explained that OC is a risk factor not only for an employee’s health but also for increasing the risk of perceived adverse job strain factors in the working environment. As a result, overcommitted employees tended to maintain their level of involvement, which predicted later experiences of high effort, low reward, and high ERI. Each MSW collector understands the collection of municipal solid waste is a public service that has important impacts on public health and the appearance of cities. When MSW collectors in Taiwan have had to frequently cope with the ever-increasing quantities of waste and challenge with the diversity of materials in the waste, there may be ambitions for approval and esteem by citizens, and they are often willing to contribute extra effort to their work. Significant risk factors for MSDs among MSW collectors were longer duration of employment, low decision latitude, lifting, pulling, pushing/carrying loads >20 kg, and walking for long periods of time.<sup>12</sup> As could be expected, highly overcommitted MSW collectors underestimate challenging situations and overestimate their own capacity, consequently, thereby adding to already prevalent upper back and hand/wrist pains. Consistent with previous studies,<sup>14–16</sup> it is indicated that the high OC group has been found to be associated with insomnia, poor self-rated health, and emotional exhaustion at work. Obviously, over-commitment can affect the perception of efforts and rewards and consequently cause health effects. In this study, a mediation effect is proposed in which OC would mediate the relationship between ERI and upper back and hand/wrist disorders in MSW collectors.

Besides, evidence has shown that the risk factors of MSDs in MSW collectors included individual factors (age, body weight, and work duration), physical demands (lifting bags/buckets, pulling/pushing waste containers, walking along with a bag/bucket carriage, and jumping up/down on the garbage truck), and organizational demands (low vacation and high decision authority).<sup>1,2,17</sup>

The process of municipal waste collection greatly varies globally, especially for low-/middle-income countries where it is known as a stressful and physically demanding job. The study highlights the psychological factors associated with upper back and hand/wrist pain in MSW collectors in Taiwan. Ever since the “Solid Waste Disposal Act” was launched in 1974, Taiwan’s government sustainably promoted the reduce, reuse, and recycle (3R) principles. Based on the policy of “keeping trash off of the ground” in Taiwan, garbage/trash must be directly brought to a trash truck at designated times and locations rather than being left on the ground randomly. Each citizen is also expected to comply with a pay-by-bag collection fee system and is encouraged to participate in mandatory waste sorting, versatile usage of kitchen waste, multi-

purpose usage of bulk waste, and reuse of household renovation waste. Consequently, Taiwan has had outstanding performance in its resource recycling promotion plan for solid waste. In Taiwan's annual EPA report, the daily amount of MSW collected per person for disposal in 1998 was 1.14 kg and was reduced to 0.41 kg in 2019, the resource recovery rate increased from 5.8% to 56.4%, the proper trash treatment rate was approximately 99%, and initial MSW disposal problems in the early days had been rectified.<sup>18</sup> This success was reliant upon the empowerment of civic engagement and community participation in the frames of lifestyle movements in Taiwan. For the sake of collecting solid waste during limited periods of time, MSW collectors efficiently and promptly help citizens at designated times and locations. Thus, MSW collectors perform repetitive movements of lifting, pulling, pushing/carrying loads, and walking for long periods of time contributing to high prevalence of neck, upper back, and hand/wrist disorders. The prevalence of these is explained by the elevating of arms in these work postures may accelerate the degeneration of shoulder tendons through impairment of circulation due to static tension and humeral compression against the coracoacromial arch.<sup>19</sup> Consequently, MSW collectors working tasks with repetitive arm movements may evoke shoulder tendinitis or tendovaginitis. Therefore, there needs to be a prompt development and implementation of a targeted approach to mitigate the ergonomic hazards in MSW collectors.

An Indian study<sup>20</sup> for waste pickers in dumps showed the prevalence of MSDs was 79%, particularly for lower back (36–54%), knee (35–48%), upper back (21–40%), and shoulder (12–32%). Although workplace activities in waste pickers include repetitive lifting, carrying, pushing/pulling of heavy objects, prolonged standing and bending, their activities are not exactly the same as MSW collectors in Taiwan who are there to help citizens to toss their garbage into the yellow garbage trucks and perform waste recycling and separation on the basis of general refuse, raw food waste, cooked food waste, and other categories including plastic and paper in short periods at waste pickup spots. To increase work efficiency in waste collection, citizen use mobile apps that let them track the trucks and alert them whenever a garbage truck is nearby. MSW collectors in Taiwan not only help citizens to collect solid waste in waste pickup spots but also perform waste recycling and separation during these short periods of time. Consequently, high physical demands and psychological stress may contribute to high prevalence and incidence of MSDs among MSW collectors. Therefore, in view of these findings, potential interventions have to be implemented based on the nature of occupational hazards considering social, cultural, and organizational factors. A hierarchical framework for implementation of ergonomic interventions for hazard control and MSDs prevention among MSW collectors is proposed based on the National Institute for Occupational Safety and Health (NIOSH).<sup>21</sup> The priority of zero waste policies could be strengthened to require the cooperation and participation of a large proportion of citizens through public awareness and incentive motivation. Ergonomic interventions are broadly classified as engineering controls, behavioral interventions like ergonomic education/training, administrative controls like job rotation, and use of personal protective equipment, respectively.<sup>22</sup> Future research is needed to perform multiple interventions to alleviate occupational hazards and evaluate the synergistic effect of ergonomic interventions, focusing on the ergonomic design and development of personal protective equipment.

## Limitations

The study has several limitations. First, since our study is a cross-sectional design, we cannot establish causality on the effect of ERI and OC on upper back and hand/wrist pain. In addition, our findings may have underestimated the true prevalence of MSDs. Second, self-reported MSDs results from MSW collectors could be biased due to subjectivity in responses, as the severity of MSDs was not accurately quantified. Examinations need to be conducted to determine the consistency between study findings from both self-administered questionnaires and face-to-face physical assessments. Also, biological markers have been used to measure levels of work-related stress.<sup>23</sup> Finally, other covariates cannot completely be measured by questionnaire, such as organizational factors, intensity of biomechanics and psychophysics, and personality. Although the specific route by which psychological factors might cause risk of MSDs is a matter of debate, we propose both one-way and mutual causality. This is the first study in Taiwan to explore the moderation and mediation effects of psychosocial stress models on upper extremities pain among MSW collectors. Although it is well established that psychosocial work stressors relate to employees' work-related MSD symptoms, our results also demonstrate that ERI and OC independently or jointly contribute to high prevalent upper extremities pain. In addition, OC acts as a mediator for the association between ERI and upper back and hand/wrist pains, which accounted for 35%

and 42%. Consequently, we notified managers in MSW processes to perform multiple interventions to alleviate occupational hazards and evaluate the effect of ergonomic interventions, focusing on the significance of reducing effort and increasing rewards from encouragement and sponsorship provided by the organization.

## Conclusion

Psychological factors measured by ERI and OC were significantly associated with upper back and hand/wrist disorders in MSW collectors. The moderation effect of the group with both  $ERI \geq 1$  and high OC ( $OR=3.25$  and  $OR=3.00$ ) on upper back and hand/wrist disorders was higher than that of the other three groups, of which synergy indexes were 0.77 and 1.77, respectively, but they were not significant. However, the mediation effect of OC for the association between ERI and upper back and hand/wrist pains accounted for 35% and 42%, appearing OC would mediate the relationship between ERI and upper back and hand/wrist disorders in MSW collectors. Therefore, work-related stress measured ERI and OC may play a role in moderating and mediating effects on upper back and hand/wrist disorders. There is a need to encourage provisions for ergonomic control and stress management to mitigate the occurrence of MSDs in MSW collectors.

## Disclosure

The authors declare that they have no competing or potential conflicts of interests.

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