



Using the Rapid Upper Limb Assessment to examine the effect of the new Hotel Housekeeping California Standard

Cristiane K. Brazil^{a,*}, Timothy A. Pottorff^b, Merl Miller^c, Malgorzata J. Rys^a

^a Industrial and Manufacturing Systems Engineering, Kansas State University, 1701B Platt St., Manhattan, KS, 66506, United States

^b QP3 ErgoSystems, 2926 Carrington Court, West Dundee, IL, 60118, United States

^c Performance Ergonomics, 2454 E. Glencove Street, Mesa, AZ, 85213, United States

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ABSTRACT

A housekeeper's job includes a variety of repetitive and strenuous tasks, which can put workers at high risk for musculoskeletal disorders. In 2018, a new standard was implemented in California aiming to prevent work-related injuries of hospitality industry workers. This paper assesses California housekeepers performing regular work tasks during their shifts from 2018 to 2020. Rapid Upper Limb Assessments (RULA) after the standard was implemented found average right-arm scores for scrubbing tasks ($M = 6.93$, $SD = 0.00$), vacuuming ($M = 6.27$, $SD = 0.45$), and trash-collecting ($M = 4.48$, $SD = 0.50$). Forces to move housekeeping carts were also evaluated, with 98% of pushing forces and 73% of turning forces observed within the accepted range. Results show that RULA scores remain high even after the implementation of the standard, with improvements only seen in tasks that required just changing of the method.

1. Introduction

Housekeepers play a vital role in the Hospitality Industry. Their work is critical in maintaining the hotel's overall cleanliness and appearance, as well as making sure guests are stocked with necessary supplies for their stay. Room attendants and housekeepers constitute approximately 23.5% of hotel employees, with an annual mean wage of \$27,420 in 2020 (U.S. Bureau of Labor Statistics, 2020). Majority of these workers are females (86.3%), with 54.2% White (29.4% Non-Hispanic and 24.8% Hispanic), and 18.9% Black, with an average age of 44.7 years for female housekeepers (Maids, 2019). Low-wage jobs that are usually performed by minorities were found to put workers at high risk for injuries and disability (Krause et al., 1997)–(Young and Rischitelli, 2006), which represents a risk for this occupational sector.

Common housekeeping tasks when cleaning bathrooms include cleaning the shower and bathtub, scrubbing and disinfecting the toilet bowl, cleaning, and sanitizing the toilet seat, lid, and handle, cleaning mirrors, cleaning the vanity top and the sink, and cleaning floor tiles and grout. Other common tasks include vacuuming, changing linens, collecting trash, sweeping, dusting, and pushing and turning carts between rooms. Although different types of tasks are performed, which in turn makes housekeepers constantly change their body positions (Liladrie,

2010), their job is still reported as repetitive and labor intensive (Blangsted et al., 2000), (Faulkner and Patiar, 1997). Luxurious hotels require even more from housekeepers to maintain hotel standards with bigger rooms and heavy furniture (Liladrie, 2010), and with increased guests' expectations resulting in greater performance demands from workers (Bernhardt et al., 2003).

There is a prevalence of musculoskeletal disorders of housekeepers in multiple settings and affecting different body regions (Bell and Steele, 2012)–(SotrateGonçalves and de Oliveira Sato, 2020). The most common health issue associated with housekeepers worldwide are occupational injuries, with past research reporting workers experiencing pain in the lower back, upper back, neck, hips, shoulder, hand/wrist, and legs/feet (Zock, 2005). Occupational accidents are also common when trying to reach and clean high objects or slipping on wet floors (Zock, 2005).

Studies have been analyzing the effects of managing housework on experiencing musculoskeletal symptoms, with women reporting more musculoskeletal disorders and engagement in domestic work (Ahlgren et al., 2012). People who are responsible for doing housework are more likely to develop upper limb repetitive stress injuries (Yang and Cheung,

* Corresponding author.

E-mail addresses: cristianebrasil@ksu.edu (C.K. Brazil), t.pottorff@qp3ergosystems.com (T.A. Pottorff), mmiller@performance-ergonomics.com (M. Miller), malrys@ksu.edu (M.J. Rys).

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2016). Ironing, cleaning floors and cleaning kitchen countertops were found to have the highest biomechanical risk amongst common house chores, but all other common tasks put the worker at risk when performed for 4 h in a day (Sala et al., 2007). For housekeepers working longer shifts, the risk can be even higher, and, indeed, work-related musculoskeletal disorders (WMSDs) are a common burden of housekeepers which can affect the lower back, calf muscles and knee joints (Parmar and Dalal, 2017).

The awkward working postures necessary for cleaning hotel rooms put workers at high-risk levels for injuries (Yusof et al., 2021). Most housekeepers can also experience severe back or neck pain that are strongly associated with physical workload demanded by commonly performed tasks (Krause et al., 2005). When looking directly at cleaning tasks such as scrubbing, they are usually associated with high muscle load levels, putting pressure on upper body muscles (Blangsted et al., 2000). Pushing and turning tasks put workers at risk for low back and shoulder injuries, with a need for guidelines to determine appropriate forces to reduce the risk of WMSDs (Snook and Ciriello, 1991). Vacuuming can also put workers at high-risk for WMSDs regardless of the type of equipment used (back-pack or canister machine) (Bell and Steele, 2012).

Not all cleaning equipment is specially designed for someone in a cleaning occupation such as a housekeeper, and research has pointed to the importance of design improvements in this area (Schwartz et al., 2019), along with evaluations of available tools (Yang et al., 2022). Ergonomic analysis of available tools included important design modifications recommendations such as lighter tools with different lengths and handle sizes (Woods and Buckle, 2005). Indeed, having adjustable tools has showed to decrease the physical load of cleaning tasks (Öhrling et al., 2012), but properties need to provide not only the appropriate equipment, but also ergonomic training (Öhrling et al., 2012), (Lim et al., 2022).

Being exposed to various ergonomic risks, it is necessary to further assess physical risk factors of commonly performed housekeeping tasks. To evaluate the risk of tasks with high upper-body demand performed by housekeepers, a reliable method must be used to know if workers are exposed to WMSD risk factors during their shifts. A study among janitors identified and analyzed eight common tasks (emptying trash cans of less than 25 pounds; emptying trash cans of more than 25 pounds; mopping/sweeping; vacuuming; dusting; cleaning mirrors; cleaning sinks; and cleaning toilets), finding all of them in a high-risk category for WMSDs and were positively correlated to injury occurrence (Schwartz et al., 2019). This type of analysis should be also extended to other types of workforces such as housekeepers.

Previous studies evaluating cleaning tasks have selected different analysis techniques including direct measurement, observational measures, and self-reports (Lee et al., 2022). Each technique has its own pros and cons, and its selection depends on multiple variables. The lower cost and higher dimensionality of observational techniques such as the Rapid Upper Limb Assessment (RULA) is an alternative to evaluate housekeeper's work (Villalobos and Mac Cawley, 2022)– (Keester and Sommerich, 2017).

Multiple studies have selected RULA as their method of evaluating manual labor types of work. Research also pointed to RULA as being a more sensitive system for assessing risk for WMSDs over the Ovako Working Posture Analysis System (OWAS) and the Rapid Entire Body Assessment (REBA) (Kee, 2021), (Kee and Karwowski, 2007).

Objective measures have been commonly used to evaluate occupational pushing and pulling cleaning tasks (Laursen et al., 2003), (Søgaard et al., 2001). Biomechanical forces must be compared to the recommended force limits to protect workers from injuries in those types of tasks (Weston, Aurand, Dufour, Knapik, Marras).

In 2018, California implemented the Cal-OSHA 3345 Hotel Housekeeping Musculoskeletal Injury Prevention Standard (California Code of Regulations, 2018) after the State Department of Labor categorized hotel housekeepers as a “High Hazard Occupation”. The Standard

requires every company in the state that rents rooms, whether a hotel, resort, inn, bed & breakfast, or short-term room or house rental property, fulfill multiple obligations including: a written program with specific requirements that is updated annually; annual workplace assessments of all housekeeping tasks being performed, and identifying specific, prescribed risk factors within those tasks; completing annual training for all housekeepers (and separate training for housekeeping management teams) regarding the findings of the assessments, the situations that cause work-related musculoskeletal disorders, key elements of the program, and how to report issues; and making improvements to housekeeping tasks and tools based on the findings of the assessments.

To the authors knowledge, no research so far has directly evaluated the effect of the promulgation of the new Standard. Therefore, this study assessed if implementing the 3345 Hotel Housekeeping Musculoskeletal Injury Prevention Standard reduced the risk for WMSDs. We compared work postures (scrubbing tasks, vacuuming, and collecting trash) from before and after the standard implementation using the Rapid Upper Limb Assessment, and high-risk for upper body WMSDs from pushing and turning carts.

2. Materials and methods

2.1. Data availability

Data was collected as part of inspections conducted at different hotel properties in California. The 2018 Cal/OSHA Hotel Housekeeper Musculoskeletal Injury Prevention Program (MIPP) Standard required hotels and other lodging establishments to prepare for audits, and some took the initiative to hire certified ergonomic consultants to conduct such evaluations as a part of yearly inspections. A different number of properties were analyzed at each year as it depends on properties' outreach. Twenty-seven assessments were made in 2018, seven in 2019, and twenty in 2020.

2.2. Participant selection and data observations

Several workers for different tasks were assessed due to the applied nature of the compliance assessments. It was not possible to observe the same worker for each consecutive year in the analysis due to staff changes since about 6% of housekeepers leave the job every month (U.S. Bureau of Labor Statistics, 2021). Bias should be minimized by CAL/OSHA requirements, as the assumption is that every new employee should go through an ergonomics training, which was available by video for the assessed properties.

To minimize Hawthorne Effects of being observed and possibly changing cleaning behaviors (McCambridge et al., 2014), the ergonomist in charge of the assessment kept some distance from the housekeepers and observed the tasks *in situ*. Therefore, photographs of each worker were taken while performing routine tasks without giving them any instructions or coaching.

2.3. Scrubbing tasks, vacuuming and trash-collecting

Four common fixtures in each room require repetitive scrubbing motions: sink, mirrors, tub and shower, and the toilet. The number of fixtures cleaned per shift varies depending on the type of cleaning required per room (deep cleaning after checkout versus daily room-service). Vacuuming and emptying trash cans were also analyzed. Housekeepers were observed and photographed while performing the above-mentioned tasks at the initial posture housekeepers assumed as they began each scrubbing task (Table 1).

These postures were selected based on frequency as they are part of the standard cleaning procedure of those specific bathroom fixtures e.g., cleaning the bottom of the tub, the entire sink bowl, and the rim area of the toilet are tasks normally done at every cleaned room. Bathroom mirrors are usually at 86-inches height, making housekeepers often

Table 1
Postures selected for RULA analysis in each scrubbing task.

Scrubbing Task	Selected posture
Mirror	Highest point of the mirror that the housekeeper could reach when cleaning it, standing on the floor
Tub/Shower	Cleaning the bottom of the tub
Toilet	Cleaning with a brush or sponge to the area just below the rim
Sink	Cleaning the bottom of the bowl

stretch their bodies to reach as high as possible and even stand on one foot. Other cleaning postures related to those tasks might depend on housekeeper's preference and specific hotel procedures.

Postures for trash collection were selected during the period housekeepers changed the waste basket liners, which is also standard procedure for each cleaned room. Postures for vacuuming were taken while employees were holding vacuums in anterior directions while in an open floor, and only the hand used to vacuum was evaluated. Photographs were taken to observe trunk flexion in the sagittal plane at approximately 4–5 feet distance.

2.3.1. RULA analysis

The selected methodology to evaluate scrubbing task was assessed for each housekeeper at each fixture and task using the Rapid Upper Limb Assessment (RULA), as these tasks required extensive use of the upper extremities (McAtamney and Corlett, 1993).

The RULA technique evaluates required body postures, forces, and repetitions for each performed task. Scores are based on deviation from neutral body positions. Separate scores are combined to find the overall Arm and Wrist Score and Neck, Trunk, and Leg Score. A final RULA scoring ranging from 1 to 7 is calculated based on these two sub-scores. Scores ranging from 1 to 2 are classified as acceptable, 3–4 require further investigation with change may needed, 5–6 require further investigation with changes needed soon, and a score of 7 meaning investigate and implement changes immediately (McAtamney and Corlett, 1993).

A post-hoc analysis used the photographs to estimate the RULA scores. A Baseline XTender 12-1034HR Goniometer was utilized to aid the measure of trunk angles by drawing straight lines following the trunk and its angle in relation to the ground. Other sub scores of the RULA were estimated based on the photographs and its approximate observed angle ranges by an experienced ergonomist. The analysis was performed by a single certified ergonomist with over 20 years of practical experience to avoid inter-observer bias. The RULA Smart Form was utilized to calculate scores (McAtamney and Corlett, 1993).

2.4. Pushing and turning forces

Jobsite measurements of pushing and turning forces were taken using standard measuring tapes, an analog Amada Force Dial, and a SHIMPO Nidec digital force gauge. Measurements of reach distances were taken from the base of the shoulder to the point of operation of the hands and it accounted for forward leaning when housekeepers were reaching for the cart's handle. Measurements of work heights were taken from the floor surface to the point of operation of the hands. No accommodations were made for footwear.

Push/pull and turning force measurements of housekeeping carts were taken from the handle end of each housekeeping cart. Force measurements were taken at various times during the housekeeping shift. Housekeepers frequently refilled their carts with additional linens and supplies, and filled the dirty linen and trash receptacles, thus the carts were rarely fully empty at any point during the shift.

To interpret risk, push and turn force values will be compared with objective guidelines (Weston et al., 2018) using a standard hand height of 38 inches for housekeeper carts. The most protective push force,

which protects more than 80% of the population, is of 44 lbs. or less for the standard height of assessed carts (Weston et al., 2018).

3. Results

This section presents results of the observed scrubbing, trash-collecting, and vacuuming tasks using the Rapid Upper Limb Assessment, followed by the observed biomechanical forces used to push and turn housekeeping carts. Data collected in 2018 was prior to the new standard, and therefore is considered as the “before” data. Data collected in 2019 and 2020 was combined to evaluate postures after the standard was implemented.

3.1. Scrubbing tasks

A total of 178 scrubbing postures were analyzed using the RULA technique, with scores differentiated by left and right arms/hands for each observed task. Results are summarized in Table 2.

Mean results for all RULA scores demonstrated that housekeepers who perform the task of scrubbing are at risk of work-related upper-limb musculoskeletal injury, with all average scores above 6, mainly due to very high trunk scores. Two observations had a score of 4 for the left-arm, being the lowest observed scores. Right-arm evaluations all had scores of either 6 or 7, for which is recommended further investigation and soon or immediate changes.

A two-factor ANOVA table was used to simultaneously compare different tasks and left/right arm/hand scores. There was a significant difference between fixtures being scrubbed ($p < .01$), as well as right versus left arm ($p < .01$). Right-arm RULA scores were significantly higher than left-arm scores, but both still qualified as high-risk for work-related upper limb disorders.

Table 3 summarizes individual criterion scores for the four analyzed tasks for all the available data (before and after the standard was implemented). Values were normalized as a percentage of the possible score range to investigate worst scores. Cleaning mirrors resulted in high upper (average = 4.61, SD = 0.83) and lower arm scores (average = 2.17, SD = 0.44). Data of the height of each mirror was collected for the analysis, and the reach distance had an average of 78.6 inches, with values ranging from 65 to 92 inches. To clean vanity mirrors, housekeepers usually must bend their trunk over the sink and hold their neck in extension (Fig. 1).

Fig. 2 shows the awkward body positions for cleaning the tub/shower using a regular sponge for scrubbing. Worst trunk scores were seen during the toilet and tub/shower cleaning, which included bending angles in the 20 to 60-degree range (yielding a RULA score of 4) and not well-supported leg postures.

It was also investigated if there were differences in RULA scores between 2018 (before standard) and 2019/2020, after the CAL-OSHA regulation was already implemented in California. It was expected that the RULA scores would decrease after the CAL-OSHA standard 3345 was implemented. Table 4 has the average scores for each year combining data from all four analyzed tasks. Two-Sample T-Tests evaluated the effect of the standard on average RULA scores. There was a significant difference in scores after the standard was implemented for the left-arm score ($t(132) = -5.82, p < .01$) with higher scores in 2019/2020 data. There was not a significant difference between the right-arm analysis ($t(132) = -0.78, p = .43$), with scores significantly higher in

Table 2
RULA summary for the four analyzed scrubbing tasks.

Scrubbing Task	Average Left-Arm Score	Average Right-Arm Score
Mirrors (n = 41)	6.37 (SD = 0.83)	6.98 (SD = 0.15)
Sink (n = 40)	6.02 (SD = 0.66)	6.62 (SD = 0.49)
Toilet (n = 48)	6.54 (SD = 0.58)	7.00 (SD = 0.00)
Tub/Shower (n = 49)	6.67 (SD = 0.59)	7.00 (SD = 0.00)

Table 3

Average scores for each individual RULA criterion (L = Left-Arm, R = Right-Arm) and its reference percentage of highest possible score. M = Mirrors, S = Sink, T = Toilet, T/S = Tub/Shower.

Values	M	%	S	%	T	%	T/S	%	Grand Total	%
Upper Arm L	2.29	26%	2.38	28%	2.10	22%	3.00	40%	2.46	29%
Upper Arm R	4.61	72%	2.48	30%	2.58	32%	4.35	67%	3.51	50%
Lower Arm L	1.68	23%	1.80	27%	1.60	20%	1.78	26%	1.71	24%
Lower Arm R	2.17	39%	1.95	32%	1.94	31%	2.12	37%	2.04	35%
Wrist L	1.61	15%	1.70	18%	1.52	13%	1.63	16%	1.61	15%
Wrist R	2.12	28%	2.05	26%	1.98	24%	2.06	27%	2.05	26%
Wrist Twist R	1.51	51%	1.58	58%	1.52	52%	1.55	55%	1.54	54%
Wrist Twist L	1.02	2%	1.28	28%	1.02	2%	1.06	6%	1.09	9%
Neck	3.05	34%	2.13	19%	2.17	19%	2.80	30%	2.53	26%
Trunk	2.46	24%	2.18	20%	3.69	45%	3.18	36%	2.93	32%
Leg	1.07	7%	1.03	2%	1.02	2%	1.35	35%	1.12	12%

**Fig. 1.** Housekeeper cleaning a mirror.**Fig. 2.** Housekeeper cleaning the sides and bottom of a tub/shower.

both scenarios.

3.2. Vacuuming and trash-emptying

A total of 52 housekeepers were observed vacuuming and their postures were analyzed using the RULA technique and all used the right-hand to vacuum. Only the right-arm RULA score was considered for this analysis. Scores for vacuuming before the standard went from 6.95 (SD = 0.21, n = 22) to 6.27 (SD = 0.45, n = 30) for the right-arm.

Mean results for RULA scores demonstrated that housekeepers are at risk of work-related upper-limb musculoskeletal injury when vacuuming, with average scores over 5, meaning that the task requires further investigation and changes should be made soon. Fig. 3 shows the before and after training postures for vacuuming. A Two-Sample T-Test was used to evaluate the effect of the standard on average RULA scores.

Table 4

Average RULA scores before and after standard implementation (all scrubbing tasks combined).

Values	2018 (n = 72)	2019/2020 (n = 106)
Average RULA score (Left-Arm)	6.08 (SD = 0.70)	6.66 (SD = 0.58)
Average RULA score (Right-Arm)	6.89 (SD = 0.31)	6.92 (SD = 0.27)

There was a significant difference in scores after the standard was implemented for the right-arm scores ($t(44) = 7.32, p < .01$) with lower scores in 2019/2020 data.

Similar results were seen for trash-collecting tasks. Fig. 4 demonstrates the key difference between before and after the ergonomic training part of the Standard's requirements. Initially, housekeepers would remove the trash and add a new liner whilst the trashcan



Fig. 3. Vacuuming task before and after ergonomics training (modification to the technique).



Fig. 4. Trash-collecting task before and after ergonomic training, with modifications in its technique.

remained on the floor during the entire process. After training, the procedure changed to lifting the trashcan at a higher surface and then removing the trash and replacing the liner before placing it back on the floor.

The change in posture significantly improved trunk scores for the trash-collecting task. Table 5 analyzes the differences in posture seen in Fig. 4, with an example of a reduction from 5 to 3 in the RULA.

Average RULA scores for trash-collecting for both left and right-arms went from 5.00 (SD = 0.00) in 2018 ($n = 11$) to 4.48 (SD = 0.50) in 2019/2020 ($n = 25$). Most recent scores had an average of less than 5, which would still require further investigation of the tasks with them possibly needing changes. The Two-Sample T-Test was also used to compare trash-emptying scores, with a significant difference in scores after the standard was implemented for both the left and right-arm scores ($t(24) = 5.09, p < .01$).

Table 5

Example of RULA score calculation for the left side of the body from a trash-collecting task before training (2018) and after training (2020) as seen in Fig. 3.

RULA scores	Before Training	After Training	Difference
Upper Arm L	2	2	0
Lower Arm L	1	1	0
Wrist L	1	1	0
Wrist Twist L	1	1	0
Neck	2	2	0
Trunk	4	1	-3
Leg	1	1	0
Muscle	1	1	0
Force	0	0	0
Final Score L	5	3	-2

3.3. Pushing and turning carts

Pushing data was collected from 50 carts. The average push force was of 28.38 lbs. (SD = 10.15 lbs.). Values were converted as a ratio of the recommended maximum of 44 lbs. to protect more than 80% of the population (Weston et al., 2018), which represented an average of 53% (SD = 18.8%) of the maximum recommended. Only one observed force (58 lbs.) exceeded the recommended guidelines and fell into the least protective category with less than 50% of the population protected, with immediate changes to the task being recommended.

Turning forces were measured from 41 carts. Forces were converted to turning torque by multiplying the maximum hand force (in lbs.) by respective moment arm (in feet), which was of 38" or 3.2 feet from center of object. Using the hand height of 40 inches, which is the standard height for housekeeper carts, the most protective limit is of 73 ft-lbs. or less. Average turning force was of 59.08 ft-lbs. (SD = 22.74), which represents an average of 81% (SD = 31%) of the maximum recommended for highest protection. In this turning analysis, 10 observations surpassed the recommended turning torque limits. Table 6 summarizes results for the pushing and turning analysis.

Housekeepers keep their carts fully stocked for most of their shift to ensure not needing to restock meanwhile. Although the carts are heavy, pushing forces were not at high risk for WMSDs and majority (98%) were within acceptable exertions for over 80% of the population. Turning forces were only acceptable for 73% of observed tasks.

4. Discussion

RULA scores for all four different scrubbing tasks, vacuuming, and trash-collecting indicate at least further investigation of the tasks and changes to be done. In exception of one measured push force, overall push forces needed to operate carts are not at high risk for lower back and shoulder injuries. This technique does not consider the duration of the task and available recovery time, which was not analyzed in this paper. Higher RULA scores for the right hand/arm were also expected as majority of the population is right-handed and most scrubbing tasks would be performed with the dominant hand.

RULA scores for vacuuming were slightly better than previously reported data, with scores going from of 6.54 (SD = 0.509) (Bell and Steele, 2012) to 6.27 (SD = 0.45) in this analysis, but still remain at the highest RULA risk category as seen in other studies (Schwartz et al., 2019). Toilet scrubbing and high level cleaning have been also previously reported as high risk using RULA (Yusof et al., 2021). Results were also in line with REBA scores from common tasks between janitors and housekeepers such as toilet cleaning, emptying a small trash can (<25lbs), mirror cleaning, sink cleaning, and vacuuming - all with high risk scores - requiring immediate investigation and changes to be implemented (Schwartz et al., 2019).

Although newly implemented regulations for Housekeepers in California took effect in 2018, a comparison between data collected from 2018 to 2019/2020 (after the CAL-OSHA) did not demonstrate improvements to the scrubbing tasks. Scores were not statistically significantly different for right-arm RULA assessments, and scores slightly increased for left-arm RULA assessments. One possible factor contributing to this increase could be the greater performance demands from

housekeepers in the hospitality industry to meet guests' expectations (Bernhardt et al., 2003). Differences in scores might also be attributed to different housekeepers being assessed throughout the three analyzed years, which is an uncontrolled study limitation: annual turnover rates of the hospitality industry in the United States are as high as 73.8% per year, with around 6% of staff leaving every month (U.S. Bureau of Labor Statistics, 2021), making it extremely challenging to re-evaluate the same employee at the same specific property. Constant changes in staff also contribute to difficulties related to training employees. Training and assessment of housekeepers in properties to comply with the new regulation should be conducted on annual basis. It is unknown if the properties are committed to maintain appropriate training to new staff throughout the year, or if hotel management implemented recommended changes.

During the assessments, ergonomic training might be done to change the technique used to perform a specific task and improve overall body posture. Ergonomic training for housekeeping vacuuming tasks includes walking with the vacuum instead of reaching with it, reducing trunk flexion and hand-arm extension (Fig. 3). Same applies for collecting trash bins, with recommendations to place bin on a taller surface and then collecting the trash and adding a new trash-bag (Fig. 4). This reduces the amount of time spent with a flexed trunk position and highlights the importance of developing more ergonomic techniques along with more ergonomic tools (Öhring et al., 2012).

Recommendations for improvement usually include ergonomic work tools or best practices, which can improve some housekeeping tasks by reducing bending and turning and keeping bodies in more neutral positions (Yang et al., 2022), (Harris-Adamson et al., 2019), (Kumar et al., 2005). Simple solutions, such as longer toilet-cleaning tools, could significantly decrease the trunk's angle position, and tools with extendable handles for cleaning mirrors and tubs/showers can also improve overall posture when performing some scrubbing tasks. For mopping tasks, handle height recommendations can reduce poor working postures (Wallius et al., 2018), and different mopping systems have different impact on working postures, grip, and hand forces (Yang et al., 2022). More research should focus on efficient and ergonomic design of cleaning tools to aid housekeepers in their job (Kumar and Kumar, 2008).

Existing contracts with specific vendors of each property (or property management company or brand) that might not have the most ergonomic products available can make implementation of changes more challenging. Most assessments done after the standard implementation did not incorporate the tool and equipment recommendations from annual evaluations, which might explain the same or even worse RULA scores found for scrubbing tasks. Properties not only should invest into getting the proper tools to reduce possible work-related injuries, but housekeepers also need to adhere to using the new tools, which is a challenge when it comes to ergonomic education (Cheung et al., 2018). To authors' knowledge, only one assessed property purchased extended handle tools for scrubbing toilet and tub/showers after the standard was implemented. Future studies should identify optimal ergonomic guidelines for housekeeping tasks. Since most improvements might require investing in new tools and committing to regular training of employees, improving the working conditions of housekeepers needs to be a management priority. Supervisors need to take ownership of this training task and implementing recommendations as required by the CAL-OSHA regulation.

4.1. Study limitations

In this study, only one method was utilized to evaluate working postures. Since the focus was the upper limb assessment from scrubbing tasks, RULA was the selected tool. Repetition and other important risk factors for musculoskeletal disorders, although recommended (Lee et al., 2022), were not included in the analysis as it highly varies depending on

Table 6
Number of observations for pushing and turning torque at each action level.

Percentage of protected population	Interpretation	Pushing Forces	Turning Torque
> 80% protected	Acceptable exertion	49	30
50–80% protected	Changes recommended	0	7
< 50% protected	Immediate changes strongly recommended	1	4
Total Observed		50	41

multiple variables such as the length of the shift and property's demand and size. Objective measurements might provide an analysis with lower bias, but were not included in this study due to its costs and implementation difficulties including behavior modification and discomfort of participants (Fröhlich et al., 2018).

In addition, there was some possible loss in accuracy when evaluating each posture using the RULA, since the ergonomist kept a distance from the workers when collecting data and the differences in the bathroom layouts. Also, not all possible postures during each scrubbing task were analyzed as it depends on the technique and preference of each housekeeper, meaning that scores found in this analysis might not be the highest ones. Future research should evaluate which assessment tools work best when researchers require an unbiased work assessment (i.e., with no Hawthorn effects) with highly useable measuring tools.

5. Conclusion

This paper analyzed tasks performed by housekeepers from 54 different hotel assessments in California to evaluate the effect of implementing the new Standard. In line with past research, housekeepers' jobs are very demanding and can put them at risk for WMSDs. Workers are usually minorities and with low wages, putting them at high risk for occupational injuries which is supported by the RULA scores found. Average scores for all scrubbing, vacuuming, and trash-collecting tasks fell into the category of "requires changes", with tasks such as cleaning the tub/shower having unanimously the highest possible score of 7 at the selected postures. Effective ergonomic interventions are therefore needed to prevent injuries and increase productivity of housekeepers. Potential improvements for these tasks include training and better workplace tools to reduce reaching distances, trunk bending, and overall awkward positions. Forces required for pushing and turning carts fell mostly within acceptable ranges, but it could be improved if housekeepers reduce the amount of clean linens and supplies in their carts to reduce their weight.

Implementation of standard did not decrease RULA scores for scrubbing tasks, even though the regulation requires annual workplace assessments, completing annual training for all housekeepers, and making improvements to tasks and tools based on findings of each assessment. It is unclear if the cause for RULA scores remaining high is because of standard's limitations or if all aspects of the standard (California Code of Regulations, 2018) are being implemented by the properties. RULA scores for trash collecting and vacuuming improved, which could be attributed to the fact that those tasks can be done with better postures without the need of purchasing new tools. Without the right tools, it will be challenging to observe improvements for scrubbing tasks, and managerial support is necessary to implement recommended changes consistent with the new regulations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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