Exposure Assessment for Early Childhood Education (ECE) Workers

Wai Ting Joycelyn Chui

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Public Health

University of Washington

2022

Committee:

Noah Seixas

Jennifer Otten

Program Authorized to Offer Degree:

Department of Environmental and Occupational Health Sciences

University of Washington

Abstract

Exposure Assessment for Early Childhood Education (ECE) Workers

Wai Ting Joycelyn Chui

Chair of the Supervisory Committee:

Noah Seixas

Department of Environmental and Occupational Health Sciences

Background: There are a little under a million U.S. early childhood education (ECE) workers in 2020, and the ergonomic risk factors pertinent in this workforce is understudied. The purpose of the study was to conduct detailed worksite observations to comprehensively describe prevalence, durations, and frequencies of workplace exposures.

Method: The study team developed a 29-item observation tool to systemically characterize the duration and frequency of four behavior classes (situation, behavior, point hazard, modifier). A 'situation' (e.g., meal time) was defined as the general activity that the ECE worker was engaged in at the time of observation. A 'behavior' (e.g., bent over) was defined as a posture or position that could expose workers to strains on selected body parts. Situations and behaviors are mutually exclusive and exhaustive as one cannot partake in more than one situation or posture at a time. 'Point hazard' (e.g., lift child) are momentary, rapid motions that can cause body strains and safety hazards registered as incidents. 'Modifiers' (e.g., carry/hold neutral) were used to refine a behavior or point hazard, therefore 'modifiers' must be associated with a behavior or

point hazard. Sixty-four observations were conducted at 8 selected ECE centers across Washington state in summer 2021. Descriptive analyses described observed exposures. Bivariate analysis and multiple linear regressions were used to analyze the relationship between center- and classroom-level variables and four ergonomic exposures.

Findings: Children's age appears to be a key contributor to the ergonomic exposures ECE workers experience due to children reaching different developmental stages and levels of mobility. Providers were observed to spend an estimated half a workday walking and standing and one-third of the time in sedentary postures on average. The three most prevalent instantaneous movements are rapid torso bending/twisting, lift child, and lift object. Workers caring for toddlers were estimated to lift, on average, about a total of 2,000 lbs in a workday, lifting is considered a 'hazardous' risk to ECE providers at the observed lifting frequency and weight.

Conclusion: Results did not only add to the limited body of research, but also underscored the gap in applicable ergonomic guidelines to the ECE workforce. Results from this study could improve the health, safety, and working conditions of ECE providers.

Introduction

A high quality early childhood education (ECE) workforce is critical for providing high quality childcare to support children's developmental, learning, and health outcomes (Committee on Early Childhood Care and Education Workforce et al., 2011; Gratz et al., 2002). Emerging research primarily defines the quality of the workforce in terms of ECE worker's education, job satisfaction, and turnover rate (Whitebook, 2014; Whitebook et al., 2014). However, relatively little is known about the health of the ECE workforce or how work environment and job demands influence workers' physical health.

Almost a million U.S. workers were employed in early childhood education (ECE) in 2020 (U.S. Bureau of Labor Statistics, 2022) and; they represent a highly vulnerable working population (Lessard et al., 2020; Linnan et al., 2017; Otten et al., 2019). The ECE workforce is overrepresented by young women of color, and those with low education and socioeconomic status (Lessard et al., 2020; Linnan et al., 2017; Otten et al., 2019). ECE workers commonly earn low to poverty-level wages with few benefits, such as health insurance, sick leave, and paid time leave (Otten et al., 2019), and as much as one-third of them are enrolled in public assistance programs (e.g., Medicaid or SNAP) (Whitebook et al., 2014). In 2021, ECE workers earned an average hourly wage of $13.22, and their annual median income was $27,490 (U.S. Bureau of Labor Statistics, 2022).

However, limited information is available on the health status of ECE workers, especially ergonomic exposure pertinent to this workforce. Workplace ergonomic exposure is defined as awkward postures workers hold for certain tasks they do (e.g., bend over a crib). Those positions are considered as risk factors because they can cause muscle fatigue and strains on certain body parts and can decrease the worker's capability to complete those tasks over time. In terms of ECE workers' overall health, previous studies revealed that they experience poorer health outcomes (i.e., hypertension, diabetes, asthma, migraine, lower back pain, obesity) compared to women in other occupations but with similar sociodemographic characteristics (Gratz & Claffey, 1996; Linnan et al., 2017; Whitaker et al., 2013). Workers also experience poorer mental wellbeing, such as depression and high levels of stress (Gratz & Claffey, 1996; Otten et al., 2019; Whitaker et al., 2013).

Although the ECE work environment is not historically considered 'dangerous', workers are exposed to potentially higher levels of multiple safety and health risks at their work environment, including infectious disease, musculoskeletal strain, high levels of stress, and toxic materials (Bright & Calabro, 1999; Calder, 1994). Specifically, ECE workers report high rates of injury and musculoskeletal disorders (MSDs) due to tasks that involve lifting and carrying, frequently in bent, stooping or squatting postures, and work in crowded active environments conducive to high spread of infectious disease (Bright & Calabro, 1999; Gratz et al., 2002). MSDs are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs. Lifting heavy objects, working in awkward postures, or performing repetitive tasks are a few examples of risk factors for developing MSDs or injuries (Bernard, 1997; Occupational Safety and Health Administration, n.d.). Prevalence of work-related MSDs is high among ECE workers as they

frequently lift and carry children and conduct other physically demanding activities. A study conducted in the United States found that 61% of ECE workers reported back pain and discomfort (Grant et al., 1995); a more recent study by Cheng et al. (2013) revealed that work-related ergonomic risk factors are highly associated with lower back, shoulder, and neck symptoms in ECE workers.

High prevalence in work-related MSD negatively impacts the ECE workforce both physically and financially (loss of work days) (Cheng et al., 2013; Holtermann et al., 2020; Horng et al., 2008). In the U.S., over 40% of all workers' compensable claims were due to work-related MSDs from 1999-2013 (Marcum & Adams, 2017; Washington State Department of Labor & Industries, 2019). Each back-related claim costs about $6,000. Lifting and holding/carrying objects made up 40% of job activities that caused compensable claims, while the top two most affected body areas were back and shoulder (Marcum & Adams, 2017). On average, workers are absent for 8-13 days for back-related MSD (U.S. Bureau of Labor Statistics, 2021a). In 2020, there were 2.7 in every 100 full-time workers across all industries who experienced a nonfatal work injury/illness. The educational services sector had fewer nonfatal work injuries/illnesses - 20,600 nonfatal work injuries happened in the same year, which was equivalent to one in 100 full-time workers (U.S. Bureau of Labor Statistics, 2021b). Specifically, the childcare/preschool/daycare workforce filed 700 cases of nonfatal occupational injuries that involved days away from work (absent work days) in 2020, in which 60 cases were related to back injury or illness (U.S. Bureau of Labor Statistics, 2021c).

Earlier research emphasized the importance of gaining a better understanding of physical health exposures that ECE workers face, specifically further analyzing specific child care tasks such as lifting, bending, kneeling (King et al., 2006). Studies that characterized the association between physical job demands and worker health are outdated or relied solely on self-report survey or questionnaire data (Gratz & Claffey, 1996; Whitaker et al., 2013). The only published U.S.-based ECE worksite analyses was conducted almost three decades ago (King et al., 1996). As a result, little is known about the prevalence, variability, and severity of physical and psychosocial hazards in ECE settings.

There were two studies conducted in more recent years. Labaj et al. (2016) focused on lifting postures among Canadian ECE workers. Their posture analysis revealed that on average, workers moderately and severely flexed their trunk at angles greater than 55. While their lifting analysis revealed that workers did 0.25 lifts/minute and lifted a total weight of 501 kg over about three hours. However, ergonomic risk factors other than lifting were not studied by Labaj et al. (2016). Holtermann et al. (2020) conducted systematic in-person observations to assess the physical work demands of Danish childcare workers handling children ages 0–3 years old. Based on the 722 total hours of workplace observations, ECE workers from 16 Danish nurseries spent about half of the workday (44.8% of working hours) being sedentary, and the remainder of the workday was spent quite evenly between standing (22.8% of working hours) and dynamic activities (e.g., moving, walking) for 27.6% of working hours, with low exposures to carrying children (1.8% of working hours). Specifically, Holtermann et al. noted that ECE workers spent 4.1% of their workday in knee straining postures such as kneeling and squatting, which could

increase the risk of MSD. Though, only workers handling children ages 0-3 were observed in Holtermann et al. (2020)'s study; this presents a gap in research and their data may not apply in the U.S. because U.S. ECE workers care for children up to 5 years old. The physical demands and ergonomic exposures of working with children ages above three is unknown.

This study aimed to address a critical research gap by carrying out detailed worksite observations to characterize physical health and safety risks, describe ergonomic exposures faced by ECE workers comprehensively, and understand how these exposures differed by key aspects including children ag, center size, child to worker ratio, provider age, and subsidy enrollment. Even though this study heavily focused on ergonomic exposures, there was a minor focus on infectious disease (e.g., COVID-19) and toxic materials exposures by examining ECE workers' masking behaviors and use of cleaning products. This exposure assessment was a part of a larger study to conduct a comprehensive assessment of ECE workers' health and working conditions in Washington State. The long-term impact is to improve the health, safety, and working conditions of ECE providers, and to contribute to the healthfulness and quality of ECE environments where young children grow and learn.

Methods

The study team developed an observation tool to systemically characterize the duration and frequency of four ergonomic behavior classes (situation, behavior, point hazard, modifier) since there were no available tool that fits our study goals entirely. A 'situation' (e.g., meal time) was defined as the general activity that the ECE worker was engaged in at the time of observation. A 'behavior' (e.g., bent over) was defined as a posture or position that could expose workers to strains on selected body parts. Situations and behaviors are mutually exclusive and exhaustive as one cannot partake in more than one situation or posture at a time. 'Point hazards' (e.g., lift child) are momentary, rapid motions that can cause body strains and safety hazards and are registered as incidents. 'Modifiers' (e.g., carry/hold neutral) were used to refine a behavior or point hazard, therefore 'modifiers' must be associated with a behavior or point hazard.

Three observers were trained to conduct thirty-minute live observation sessions without filming at 8 selected ECE centers across Washington state in summer 2021. Collected data were analyzed in R (version 4.0.2) and Stata (version 14.0) for descriptive analyses and multiple linear regression modeling. The study team ran the model to understand whether four ergonomic exposures differed by five independent variables: age of children in the classroom, center size, classroom child-to-worker ratio, provider age, and subsidy enrollment.

Observation Tool Development

Our observation tool was developed using the Behavioral Observation Research Interactive Software (BORIS v. 7.12.2) (Friard & Gamba, 2016), a free and open-source software for coding live observations. BORIS were loaded into Microsoft Surfaces for convenient on-site observations for this exposure assessment. Based on the literature, the study team focused on types of exposures that are easily observable, particularly ergonomic and safety related postures/behaviors. The team developed the observation tool with goals to characterize postures in a reliable and accurate manner, as well as quantify the frequency and duration of postures in an unbiased manner while observing ECE workers carry out their work over time.

A similar tool, TRACK (observaTion woRk demAnds Childcare worK), was developed by Svendsen et al. (2020) for an ECE observation study led by Holtermann et al. (2020) in Denmark. Grounding in the TRACK tool, the team developed a list of 29 items categorized among four behavior classes – situations, behaviors, point hazards, and modifiers (appendix A). We created a list of possible 'situations' because an exposure is related to the type of activity/task taking place at the time. Situations (e.g., child activity) were mutually exclusive and exhaustive as one cannot partake in more than one situation at a time, and both the count of their occurrence and their duration could be tracked. We also listed possible 'behaviors' of the provider being observed (e.g., kneeling) which were ergonomic exposures largely related to postures causing strain on selected body parts. 'Behaviors' were also mutually exclusive and exhaustive, and their occurrence and duration could be tracked. Some strain-causing postures and safety hazards are momentary, and it is the frequency of those incidents that cause risk. Thus, we also created 'point hazards' (e.g., quick lean/twist) which were registered simply as an occurrence when observed. Providers could hold a secondary or 'add-on' posture while doing a primary behavior. The upper and lower part

of their body could be engaged in two different postures. For example, providers could carry a child in their arms while sitting on a chair. Sitting on a chair is the primary behavior, while carrying a child is an 'add-on'. We came up with a list of 'modifiers' (e.g., carry/hold awkward) to describe providers' behaviors comprehensively. Modifiers were registered with a behavior or point hazard.

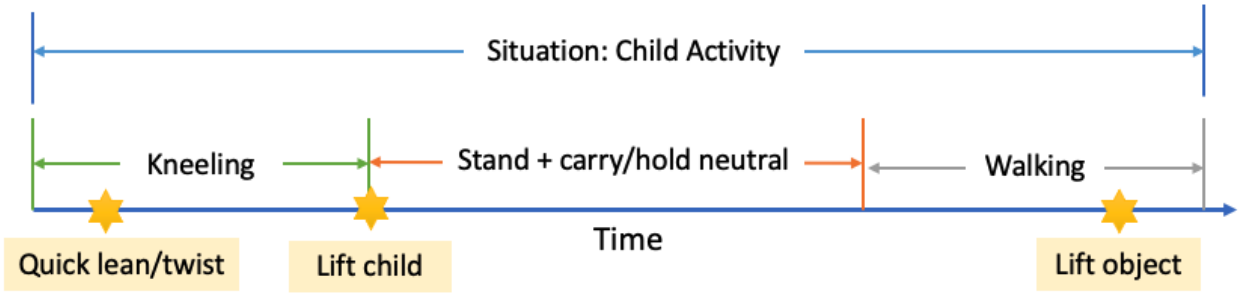


Figure 1 - Sample timeline displaying four behavior classes and types of data collected.

Figure 1 depicts the timeline of an observation period as an illustration. Child activity situation was recorded with a count (incident) and number of minutes (duration). In Figure 1, the provider did three behaviors – kneeling, standing, and walking. Behaviors were also recorded with a count and duration. Standing has a modifier, carry/hold neutral, indicating that the provider held a child or object in a neutral position while standing. There were three point hazards (depicted by the stars) – quick lean/twist, lift child, and lift object. Instantaneous occurrences of observed point hazards were recorded as counts.

A key piece of the tool development was to identify (functional and/or logistical) problems with applying the definitions through many rounds of iterations, then come to consensus on the final set of definitions. The team took an interactive approach to finetune the observation tool and evaluate feasibility by going through approximately 200 minutes of video practice and then conducting team debriefs and comparing observation results, resulting in 22 iterations of tool definitions. The team also pilot tested the tool at a local ECE center.

For instance, it took multiple rounds of iterations for observers to come to a consensus on 'quick lean/twist' (point hazard) and 'bent over' (behavior) due to their similar definitions. We defined 'Quick lean/twist' as an instantaneous back bend over 30° and/or rapidly twisting the torso in an unsupported manner for less than 10 seconds, e.g., picking up toys on the ground. This motion introduces uneven forces on the back, and the greater the twist, the more physically stressful it is on the back. 'Bent over' is defined as standing bent over for 10 seconds or longer, for example, bending over a crib. The deeper the bend, the more stressful it is on the low back. It was challenging for observers to distinguish between the two at first since it is impossible to guess which posture a worker would do until observers saw it happen and providers could bend rapidly or hold the bent position for longer periods of time. Therefore, any 'bent over' behavior under 10 seconds were recoded as 'quick lean/twist' during the data cleaning phase.

Modifiers 'carry/hold in a neutral position' and 'carry/hold in an awkward position' were tricky to differentiate as well. The rule of thumb for observers was to see whether the provider held a child or object close to their torso or had another supportive mechanism. For example, 'carry/hold neutral' would be holding a child on their lap (sitting) or in a carrier or at waist height. Holding a child or object away from their torso would be unsupported and awkward. Additionally, using one arm to hold up the child's head/torso while feeding was considered 'carry/hold awkward' if it was unsupported (I.e., not resting on the arm of a chair).

A few non-ergonomic risk factors were observed as well, such as masking and using cleaning products. Due to COVID-19 guidelines in place at the time of observation, the team also collected data on providers' mask wearing behaviors (item 19 in appendix A). 'Mask-off' was coded when the provider did not wear mask or wore their mask improperly. 'Cleaning product use' was a point hazard that represented workers' interaction with cleaning supplies (e.g., cleaners, disinfectants, dish soaps, homemade solutions/unknowns).

Inter-observer Agreement

To evaluate inter-observer consistency among three observers, they simultaneously conducted three 30-minutes observations at a local childcare center in May 2021. A graphical method was utilized to determine level of agreement among observers (appendix B). Three sets of clustered bar graphs in appendix B show the level of agreement among three observers. Each bar represents an observer, hence there are three bars per behavior. Each set of bar graphs consists of (a) 'state behaviors' (i.e., behaviors) recorded in duration in minutes or proportion of time and (b) 'point behaviors' (i.e., point hazards) recorded in sum of occurrences.
Overall, the results showed agreement between three observers (appendix B). Some behaviors were not observed hence not all behaviors were listed on graph. The graphs showed that there was consensus that certain behaviors did not occur among observers. Stand and walk behaviors (state behaviors) in observation 2 showed some disagreements, proportion of time recorded as standing and walking varied between observers A and J. Walking was then re-defined to providers at least taking five steps. Transferring weight between two legs while standing or taking a couple of steps no longer constitute as walking. Quick lean/twist (point behavior) in observations 2 and 3 also showed a large degree of disagreement. Observers then redefined quick lean/twist to be under 10 seconds and utilized the 10-second threshold during the data cleaning phase to reach a higher consistency level.

Center Eligibility and Recruitment

The research team identified representative ECE centers based on the following two sets of selection criteria:
Strategic selection criteria:

- Only licensed, center-based centers were chosen.
- Mix of centers based on size to maximize comparison.
- Centers that serve all ages were preferred. Washington State Department of Children, Youth, and Families defines infants as 0-11 months old, toddlers as 12-29 months old, and preschoolers as 30 months – 6 years old.

Feasibility selection criteria:

- Centers located in western and central Washington were chosen for ease of travel during the COVID-19 pandemic.
- Only centers that regularly screen for COVID-19 were eligible.
- Only centers that gave oral consent were included.

The research team recruited ECE centers from the pre-identified list via email and phone calls. Once centers were identified, screened for eligibility, selected, and gave oral consent, the team scheduled observation dates for data collection and asked about key pieces of information to use in planning observations (e.g., number of classrooms and teachers at the center). The team relied on center directors to pre-identify ECE providers who were eligible and willing to participate in the study. Providers had to be at least 18 years old, interact with children, and proficient in English for meaningful oral consent. Nine ECE centers (one for inter-observer agreement, 8 for data collection) across Washington State were identified and recruited in spring - summer 2021. Centers that participated in the study received a $100 gift card as compensation.

Data Collection and On-site Observation Protocol

Observation data was collected from August - September 2021 in 8 ECE centers in Washington state. Each observation period was designed to be 30 minutes, with an expectation that sessions can range from 10-35 minutes depending on the circumstances, such as major interruptions or transitions. The 30-minute duration was chosen to balance feasibility and minimize classroom disruption.

Observers paired up to conduct observations at each center. Precautions were taken for COVID-19, such as masking, social distancing, testing, and vaccinations. Prior to starting on-site observations in classrooms, observers and center directors reviewed the observation plan (e.g., which rooms, providers). Two observers aimed to conduct a total of 8 observations per site, ideally with 8 individual providers. Observers conducted observations individually in separate classrooms, observing only one provider per observation session despite there were multiple providers working in the same room.

Before the observation started, observers were instructed to seek oral consent from providers being observed and explain the purpose of the observation. Observers highlighted the fact they were not there to judge providers' quality of care, and providers shouldn't alter any tasks while being observed. Observers chose an advantageous location to observe without being an obstacle. Observers first recorded classroom-level data (e.g., number of children and workers in the room, age and years of experience of provider) then started the live, visual observations. There was no video recording to comply with human subjects' research guidelines.

If providers were unable to be observed for a longer time, observers used "unable to observe" situation. If the entire class moved to another area, observers followed the provider. Observers aimed to continue coding despite brief interruptions (e.g., child interrupts) and used "unable to observe" if necessary. Details of the observation protocol are in appendix C.

Center Director Survey

ECE Center Directors were invited to participate in a survey either over phone or in-person on the day of observations. The survey was developed to better understand their center's operations in terms of information on their workers, wages, safety and benefits policies (including those related to the COVID-19 pandemic), center size (e.g., number of staff and enrolled children), and number of children enrolled in local or state subsidies. Survey results were entered into RedCap and summarized (appendix D).

Data Analyses

Data from BORIS were imported into statistical software - R (version 4.0.2) (R Core Team, 2022) and Stata (version 14.0) (StataCorp, n.d.) for data analyses. Any observations that were less than 10 minutes were excluded from analyses. The "bent over" behavior was recoded to be "quick bend/twist" if it was under 10 seconds. Observations that had an indoor/ outdoor transition were split into two separate observations, with one observation covering the indoor period and one covering the outdoor time. The goal was to keep an entire observation completely indoors or outdoors for further analyses. Point hazard occurrences were standardized to 30 minutes by computing the rate of point hazards per observation period, then multiply by computing the rate of point hazards per observation period, then multiply by 30 minutes. The mean and standard deviations were calculated for both durations and frequencies across all observations. Observation results were stratified by behavior class (situation, behaviors, point hazards), children age, indoor or outdoor.

The study team ran a multiple linear regression model to examine whether four ergonomic exposures differed by five independent variables: age of children in the classroom, center size, classroom child-to-worker ratio, provider age, and subsidy enrollment. The four ergonomic exposures were: lean rate (number of instantaneous bending per 30 minutes), lift rate (number of lifts per 30 minutes), percent time kneeling (proportion of minutes in kneeling posture), and percent time in back risk postures (proportion of minutes in back straining postures). These ergonomic exposures were selected as they represent different types of ergonomic risks on various body parts. Lift rate predicts lifting operations performed by providers, including lifting children and objects. Back risk postures include sitting in kid-size furniture, sitting on the floor, bending over to reach below waist. Such postures increase providers' exposure to low back pain.

Bivariate analyses were conducted to test for statistical significance between four ergonomic exposures and five independent variables. Children age and center size were primary independent variables included by study design, and were used for a base model. Using a step-wise selection with $P < 0.1$, we tested for additional contribution from child to worker ratio, provider age, and subsidy enrollment. Finally, four ergonomic exposure models were run, including children age, center size, and significant contributors.

Results

Sixty-four in-person observations were conducted in eight ECE centers in central and western Washington in Summer 2021 (Table 1). Each observation was for one provider, so a total of 64 ECE providers were observed caring for 553 children. On average, ECE Providers were 31.6 years old with 6.1 years of experience. Observation durations ranged from 10-35 minutes with a mean of 25.7 minutes. Only three centers had all three age groups of children. The rest only served toddlers and preschoolers. One center placed toddlers, and preschoolers in the same classroom, hence observers noted that as “mixed” or “combined age group”. Two of the eight centers had over 75% of children enrolled in state or local subsidies. For example, center 2 is a large center with high subsidy enrollment. At this center, eight observations were conducted with an average duration of about 30 minutes per observation.

Table 1- Summary of observations conducted, observed number of children and providers, providers' age, and years of experience in WA ECE Centers by age groups, Summer 2021.

Center Size [a]	Center Number	Subsidy Enrollment [b]	Age Group	Mean Number of Children (SD)	Mean Number of Staff (SD)	Ratio of Children to Provider [c]	Mean Age of Provider (SD)	Mean Providers' Years of Experience (SD) [d]	Number of Observations	Mean Observation Duration in Minutes (SD)
Large	2	High	Total	N=86	N=12	7.17	32.75 (16.31)	4.69 (6.79)	8	29.78 (3.80)
			Infant	8.00 (0)	2.00 (0)	4.00	21.00 (1.41)	0.75 (0.35)	2	29.38 (2.72)
			Toddler	6.00 (0)	1.00 (0)	6.00	44.50 (24.75)	3.00 (2.83)	2	27.3 (5.97)
			Preschooler	14.50 (5.20)	1.50 (0.58)	9.50	32.75 (15.22)	7.50 (9.06)	4	31.23 (3.52)
Large	9	High	Total	N=45	N=9	5.00	34.67 (11.73)	4.56 (3.08)	9	25.37 (4.54)
			Toddler	4.62 (1.85)	1.00 (0)	4.00	34.88 (12.52)	4.50 (3.28)	8	24.77 (4.46)
			Preschooler	8.00 (NA)	1.00 (NA)	8.00	33.00 (NA)	5.00 (NA)	1	30.15 (NA)
Large	5	Low	Total	N=50	N=20	2.50	34.50 (15.36)	12.56 (8.54)	8	24.82 (5.11)
			Infant	3.00 (0.82)	2.50 (0.58)	1.50	37.75 (22.47)	12.75 (11.76)	4	27.09 (6.02)
			Toddler	7.67 (0.58)	2.67 (0.58)	2.67	30.33 (4.62)	13.17 (6.64)	3	22.78 (3.98)
			Preschooler	15.00 (NA)	2.00 (NA)	7.50	34.00 (NA)	10.00 (NA)	1	21.83 (NA)
Large	6	Low	Total	N=70	N=28	2.50	26.60 (7.75)	5.97 (8.59)	10	23.21 (7.39)
			Infant	7.00 (NA)	3.00 (NA)	2.33	26.00 (NA)	3.50 (NA)	1	28.45 (NA)
			Toddler	5.17 (2.48)	3.17 (2.4)	2.67	28.17 (9.97)	7.62 (11.16)	6	19.47 (7.39)
			Preschooler	10.67 (2.52)	2.00 (0)	5.50	23.67 (1.15)	3.50 (0.50)	3	28.95 (2.02)
Large	7	Low	Total	N=43	N=11	3.91	34.83 (11.91)	6.17 (2.99)	6	25.22 (3.24)
			Toddler	2.50 (2.12)	1.50 (0.71)	2.00	38.50 (16.26)	9.50 (0.71)	2	26.02 (1.02)
			Preschooler	9.50 (2.89)	2.00 (0)	3.50	33.00 (11.6)	4.50 (1.91)	4	24.82 (4.06)
Small	3	Low	Total	N=85	N=13	6.54	26.83 (4.79)	1.42 (1.77)	6	28.88 (3.45)
			Mixed [e]	14.17 (0.41)	2.17 (0.41)	6.54	26.83 (4.79)	1.42 (1.77)	6	28.88 (3.45)
Small	4	Low	Total	N=130	N=37	3.51	25.90 (6.71)	4.50 (3.21)	10	23.10 (7.44)
			Toddler	13.00 (0)	4.00 (0)	3.25	28.00 (5.66)	5.00 (4.24)	2	32.85 (3.59)
			Preschooler	13.00 (2.67)	3.62 (0.52)	3.75	25.38 (7.19)	4.38 (3.25)	8	20.66 (5.95)
Small	8	Low	Total	N=44	N=14	3.14	39.86 (12.76)	8.64 (8.05)	7	27.73 (6.61)
			Toddler	4.50 (1.73)	2.00 (0)	3.00	40.00 (12.00)	4.12 (7.25)	4	30.09 (0.42)
			Preschooler	8.67 (2.31)	2.00 (0)	5.00	39.67 (16.50)	14.67 (4.51)	3	24.58 (10.24)
Total				553	144	3.84	31.62 (11.80)	6.09 (6.53)	64	25.73 (5.87)

[a] Center size was based on staff capacity at each center. Large centers had >40 staff, small center had <14 staff.

[b] Percent of children enrolled in state or local subsidies. >75% of children enrolled in subsidy is high enrollment, <10% is low enrollment. Data is from director survey results.

[c] Ratio was calculated based on the number of children per provider in each observation, aggregated by age group.

[d] Providers who worked less than a year were assumed to have worked half a year.

[e] Mixed age group had toddlers, and preschoolers in the same classroom.

In total, 53 of 64 observations were indoor observations and 11 were outdoor observations. Providers spent most of their time on child activity - interacting with children, such as story or craft time (Table 2). About three-quarters of outdoor time was spent interacting with children. 63.2% of indoor time was spent on child activity, followed by preparing for meal time and assisting with feeding at 16.6%, and helping children take naps at 8.7%. Providers in infant rooms spent 80% of their time interacting with infants, while around 12% of the time was spent almost equally on feeding infants and putting them to sleep. When comparing across age groups, providers spent less time interacting with children and more time on other situations, (e.g., preparing for meal time and assisting with feeding and helping children take naps) as children grow older.

Table 2 - Indoor and outdoor situations observed by age group.

	Infants		Toddlers		Preschoolers		Combined Age Group [a]		Total		
Situations	Mean # of occurrences/ Observation [b]	Mean % of time (SD) [c]	Mean # of occurrences/ observation	Mean % of time (SD)	Mean # of occurrences/ observation	Mean % of time (SD)	Mean # of occurrences/ observation	Mean % of time (SD)	Mean # of occurrences/ observation	Mean % of time (SD)	Range (Min-Max)
Indoor	N=7		N=24		N=17		N=5		N=53		
Child Activity	2.0	80.0 (34.1)	1.4	66.7 (42.4)	1.2	51.1 (45.3)	1	63.7 (41.7)	1.4	63.2 (42.3)	0 - 99.9
Clean/Preparation	0.7	3.2 (8.3)	0.4	9.3 (25.1)	0.4	5.7 (11.9)	0.2	6 (13.4)	0.4	7.0 (18.7)	0 - 99.5
Meal	0.1	6.1 (16.1)	0.6	13.9 (27)	0.7	25.4 (35.9)	0.2	13.9 (31.2)	0.5	16.6 (29.5)	0 - 99.9
Nap Help	0.1	6.4 (16.9)	0.2	8.2 (24.7)	0.5	12.8 (28.6)	0	0 (0)	0.3	8.7 (23.9)	0 - 99.9
Other Situation	0.7	3.3 (8.6)	0.4	0.9 (2.5)	0.4	1.8 (5.1)	0	0 (0)	0.4	1.4 (4.5)	0 - 22.8
Pickup/Dropoff	0	0 (0)	0	0 (0)	0	0 (0)	0.4	13.9 (22.4)	0.0	1.3 (7.4)	0 - 51.6
Outdoor			N=3		N=7		N=1		N=11		
Child Activity	NA	NA	1	77.5 (37.8)	2	68.8 (47.1)	1	99.3 (NA)	1.6	74.0 (41.2)	0 - 99.6
Meal	NA	NA	0	0 (0)	1.4	11.4 (29.9)	0	0 (NA)	0.9	7.3 (23.9)	0 - 79.3
Other Situation	NA	NA	0	0 (0)	0.3	0.3 (0.8)	0	0 (NA)	0.2	0.2 (0.7)	0 - 2.2

[a] Combined age group is equivalent to the "mixed" age group in table 1. I.e., the classroom had toddlers, and preschoolers.

[b] Mean number of occurrences / observation was calculated by taking a mean of occurrences by situations from all observations then stratify by age group.

[c] Mean percent time per situation was calculated by computing the percent time spent on a situation in each observation session, then take the mean across all observations per situation, and summarize by age group.

Providers' behaviors diversified as children's age increased. Providers spent about a quarter of their time walking and standing indoors and outdoors, equivalent to about half of the observation duration (Table 3.1). Providers were rarely observed carrying or holding children while walking or standing (Tables 3.2, 3.3). Providers were observed walking and standing more in classrooms with older children. Providers stood the most in preschooler rooms and the least in infant room.

Sitting in a chair was the third most prevalent observed indoor behavior. 'Sit chair' means sitting on a child-size chair by default. For about 10% of their time, providers (across all age groups) were observed sitting in kid-size chairs (Table 3.2). Providers in infant rooms did not sit in kid-size chairs at all. Instead, about a third (31.2%) of the observation time was providers holding infants in a neutral position in an adult-size chair (Table 3.2). That is equivalent to a-third of their workday sitting and carrying infants neutrally. Providers in indoor toddler rooms spent slightly more time sitting on the floor rather than in a chair (Tables 3.1, 3.2). Overall, providers in the infant room spent the most time in a sitting (chair and floor) posture compared with providers that cared for older children.

Bent over was another frequently observed behavior. Providers spent 7.4 % of their time bending over indoors and 6.6% of their time bending over outdoors on average (Table 3.1). Providers seldom carried or held children/objects while bending over in our observations. On the other hand, providers spent 4.2% and 7.2% of the observation time kneeling indoor and outdoor respectively (Table 3.1). While providers were not kneeling and carrying or holding most of the time, providers were observed awkwardly carrying/holding while kneeling outdoors for a short amount of time (3.4%, Table 3.3). We observed three providers who cared for toddlers outdoors (Table 2), they spent 20.4% and 16.8% of observation time in kneeling and squatting positions, respectively (Table 3.3). Kneeling and squatting outdoors were observed more frequently and for longer durations than indoors.

Table 3.1 - Mean number of behaviors recorded per observation and mean percent time ECE providers were involved in either an indoor and outdoor behavior by age group.

Behavior	Infants		Toddlers		Preschoolers		Combined Age group		Total		
	Mean number of behavior/ observation	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Range
Indoor	N=7		N=24		N=17		N=5		N=53		
Sit chair	0.5	7.3 (20)	0.4	3.1 (8.6)	0.2	2.3 (9.5)	0.5	3.5 (6.9)	1.9	17.1 (23.9)	0 - 91.9
Sit floor	1.4	7 (13.4)	0.8	5.8 (13.5)	0.2	2.1 (8.6)	0.8	3.8 (8.7)	2.2	13.7 (20.3)	0 - 72.3
Stand	2.5	5.9 (10.9)	3.2	7.9 (15.9)	4.6	10.8 (18.4)	1.7	4.5 (11.8)	10.3	24.8 (19.4)	0 - 77.3
Walk	4.3	6 (7.6)	5.5	8.3 (13)	5.7	8.9 (14.4)	5.0	13.3 (18.5)	16.1	25.9 (15.3)	2.6 - 71.8
Bent over	0.1	0.2 (1.1)	2.2	2.5 (5.2)	2.7	3.7 (9.8)	1.3	1.6 (4.1)	6.0	7.4 (10.3)	0 - 61.4
Kneel	0.6	1.3 (4)	0.7	1.7 (4.5)	0.4	1.2 (4.1)	0.4	0.8 (2)	1.6	4.2 (6.3)	0 - 26.0
Squat	0.2	0.3 (0.7)	1.0	1.9 (3.8)	1.0	2.0 (4.8)	1.0	1.8 (2.7)	1.8	3.4 (4.9)	0 - 26.3
Lie down	0.1	0.2 (0.5)	0.1	0.1 (0.6)	0	0 (0)	0.2	0.2 (0.5)	0.1	0.1 (0.5)	0 - 2.9
In motion	0	0 (0)	0.1	0.2 (0.8)	0.2	0.2 (0.8)	1.4	4.3 (7.2)	0.2	0.6 (2.4)	0 - 16.5
Unable to observe	0.7	0.7 (1.7)	1.2	0.7 (2.2)	1.2	1.2 (1.8)	1.4	2.2 (4.7)	1.1	1.0 (2.3)	0 - 10.6
Outdoor			N=3		N=7		N=1		N=11		
Sit chair	NA	NA	0	0 (0)	0.3	3.3 (10.1)	0	0 (0)	1.1	10.4 (18.3)	0 - 49.5
Sit floor	NA	NA	0	0 (0)	0.2	2.7 (7.9)	2.7	22.9 (39.7)	1.2	11.5 (21.7)	0 - 68.8
Stand	NA	NA	1.7	5.7 (9.7)	5.5	9.4 (13.5)	0.3	0.2 (0.4)	12	22.7 (15.7)	0.7 - 55.0
Walk	NA	NA	3.8	13.2 (21.9)	6.1	8 (13.1)	3.0	7 (11.2)	15.6	27.9 (15.1)	8.9 - 52.3
Bent over	NA	NA	0.6	0.6 (1.3)	3.0	3.1 (7.1)	0.3	0.3 (0.5)	6.3	6.6 (8.7)	0 - 29.9
Kneel	NA	NA	1.0	8.1 (19.4)	0.2	0.2 (1)	1.0	0.5 (0.8)	1.5	7.2 (21.1)	0 - 70.7
Squat	NA	NA	3.2	8.4 (14.1)	2.2	3.8 (7.1)	1.0	3.1 (4.4)	4.7	10 (11)	0 - 33.7
In motion	NA	NA	0	0 (0)	0.1	0 (0.1)	0	0 (NA)	0.1	0 (0.1)	0 - 0.2
Unable to observe	NA	NA	0.7	0.1 (0.1)	2.7	4.6 (7.1)	1.0	0.6 (NA)	2	3.0 (5.9)	0 - 19.7

Table 3.2 - Reporting mean number of behaviors recorded per observation and mean percent time ECE providers were involved in an indoor behavior by modifiers and age group.

	Infants		Toddlers		Preschoolers		Combined age group		Total		
Behavior and modifiers	Mean number of behavior/ observation	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Range
	N=7		N=24		N=17		N=5		N=53		
Sit chair [a]	0	0 (0)	1.2	9.6 (13.3)	0.9	9.6 (18.8)	1.8	9.9 (7.5)	1	8.4 (14.2)	0 - 73.3
adult size chair	0.1	0.1 (0.2)	0.5	2.8 (8.6)	0.1	0.3 (1.4)	0	0 (0)	0.3	1.4 (5.9)	0 - 39.2
carry/hold awkward, adult size chair	0.4	5.1 (13)	0	0 (0)	0	0 (0)	0	0 (0)	0.1	0.7 (4.8)	0 - 34.7
carry/hold neutral	0.1	0 (0.1)	0.1	0.6 (2.9)	0	0 (0)	0.8	7.6 (10.7)	0.1	1.0 (4.1)	0 - 22.9
carry/hold neutral, adult size chair	1.7	31.2 (35.1)	0.2	2.3 (7.8)	0.2	1.6 (6.5)	0	0 (0)	0.4	5.7 (16.9)	0 - 91.1
Sit floor	2.7	13.1 (16.4)	2.1	13.6 (18.1)	0.6	5.8 (14.3)	1.6	8.7 (14)	1.6	10.6 (16.3)	0 - 60.6
carry/hold awkward	0.3	1.8 (4.8)	0	0 (0)	0	0 (0)	0.2	0.2 (0.3)	0.1	0.3 (1.8)	0 - 12.8
carry/hold neutral	1.1	6 (15)	0.5	3.8 (11.6)	0.1	0.4 (1.8)	0.6	2.5 (4.2)	0.5	2.9 (9.6)	0 - 50.8
Stand	5.7	14.1 (16)	9.3	22.3 (20.8)	13.5	32.2 (18)	4.8	13.2 (18.5)	9.8	23.5 (19.8)	0 - 77.3
carry/hold awkward	1.1	2.7 (4.2)	0.2	0.4 (2.2)	0.1	0.1 (0.4)	0.2	0.3 (0.6)	0.3	0.6 (2.2)	0 - 12
carry/hold neutral	0.7	0.8 (1.7)	0.2	1.1 (4.4)	0.1	0.1 (0.3)	0	0 (0)	0.2	0.6 (3)	0 - 21.4
Walk	8.1	11.8 (9.4)	15.4	23.4 (12.5)	15.1	24.7 (15.4)	11.8	32.9 (20.8)	14.0	23.2 (14.6)	0 - 68.7
carry/hold awkward	3.9	5.7 (5.3)	0.6	0.8 (1.9)	1.4	1.6 (3.4)	3.2	7.1 (3.8)	1.5	2.3 (3.8)	0 - 13.5
carry/hold neutral	0.9	0.5 (0.9)	0.6	0.6 (2.2)	0.6	0.4 (0.8)	0	0 (0)	0.6	0.4 (1.5)	0 - 10.5
Bent over	0.4	0.7 (1.9)	6.2	7.2 (7)	7.7	10.7 (14.9)	3.8	4.7 (6.4)	5.7	7.2 (10.2)	0 - 61.4
carry/hold awkward	0	0 (0)	0	0 (0)	0.1	0.2 (0.9)	0	0 (0)	0	0.1 (0.5)	0 - 3.7
carry/hold neutral	0	0 (0)	0.3	0.2 (1)	0.2	0.1 (0.4)	0	0 (0)	0.2	0.1 (0.7)	0 - 4.9

Kneel	1.7	3.7 (6.6)	1.9	4.9 (6.7)	1.1	3.6 (6.6)	1.2	2.3 (3.1)	1.5	4.1 (6.3)	0 - 26
carry/hold awkward	0.1	0.1 (0.4)	0.1	0 (0.1)	0	0 (0)	0	0 (0)	0.1	0 (0.2)	0 - 1
carry/hold neutral	0	0 (0)	0	0.1 (0.5)	0.1	0.1 (0.4)	0	0 (0)	0	0.1 (0.4)	0 - 2.3
Squat	0.4	0.5 (0.9)	2.1	3.9 (4.6)	1.9	3.6 (6.4)	2	3.7 (2.8)	1.8	3.3 (4.9)	0 - 26.3
carry/hold neutral	0	0 (0)	0	0 (0)	0.2	0.3 (1.4)	0	0 (0)	0.1	0.1 (0.8)	0 - 5.7
Lie down	0.1	0.2 (0.5)	0.1	0.1 (0.6)	0	0 (0)	0.2	0.2 (0.5)	0.1	0.1 (0.5)	0 - 2.9
In motion	0	0 (0)	0.1	0.2 (0.8)	0.2	0.2 (0.8)	1.4	4.3 (7.2)	0.2	0.6 (2.4)	0 - 16.5
Unable to observe	0.7	0.7 (1.7)	1.2	0.7 (2.2)	1.2	1.2 (1.8)	1.4	2.2 (4.7)	1.1	1.0 (2.3)	0 - 10.6

[a] Default setting of sit chair is on child-size furniture.

Table 3.3 - Reporting mean number of behaviors recorded per observation and mean percent time ECE providers were involved in an outdoor behavior by modifiers and age group.

Behavior and modifiers	Toddlers		Preschoolers		Combined age group		Total		
	Mean number of behavior / observations	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Number of behaviors observed	Mean % of time (SD)	Mean number of behavior / observations	Mean % of time (SD)	Range
	N=3		N=7		N=1		N=11		
Sit chair	0	0 (0)	1	7.7 (15.6)	0	0 (NA)	0.6	4.9 (12.7)	0 - 42.7
adult size chair	0	0 (0)	0.4	6 (16)	0	0 (NA)	0.3	3.8 (12.8)	0 - 42.3
carry/hold neutral	0	0 (0)	0.3	2.6 (4.7)	0	0 (NA)	0.2	1.7 (3.9)	0 - 11.6
Sit floor	0	0 (0)	0.7	8.2 (12.5)	8	68.8 (NA)	1.2	11.5 (21.7)	0 - 68.8
Stand	4.7	14.7 (13.3)	15.9	24.9 (10.9)	1	0.7 (NA)	11.5	19.9 (13)	0.7 - 37.1
carry/hold awkward	0.3	2.3 (3.9)	0	0 (0)	0	0 (NA)	0.1	0.6 (2.1)	0 - 6.8
carry/hold neutral	0	0 (0)	0.7	3.4 (8.2)	0	0 (NA)	0.5	2.2 (6.6)	0 - 22
Walk	11.3	39.5 (18.7)	17.3	23.0 (13.3)	8	19.9 (NA)	14.8	27.2 (15.5)	7.3 - 52.3
carry/hold awkward	0	0 (0)	0.3	0.4 (0.6)	1	1.1 (NA)	0.3	0.3 (0.6)	0 – 1.4
carry/hold neutral	0	0 (0)	0.9	0.6 (0.8)	0	0 (NA)	0.5	0.4 (0.7)	0 - 2.1
Bent over	1.7	1.9 (1.7)	9	9.4 (10)	1	0.9 (NA)	6.3	6.6 (8.7)	0 - 29.9
Kneel	2.3	20.4 (33.4)	0.6	0.7 (1.8)	3	1.4 (NA)	1.3	6.2 (17.6)	0 – 59
carry/hold awkward	0.3	3.4 (5.9)	0	0 (0)	0	0 (NA)	0.1	0.9 (3.1)	0 - 10.2
carry/hold neutral	0.3	0.5 (0.9)	0	0 (0)	0	0 (NA)	0.1	0.1 (0.5)	0 - 1.5
Squat	6.3	16.8 (16.9)	4.4	7.6 (8.6)	2	6.3 (NA)	4.7	10 (11)	0 - 33.7
In motion	0	0 (0)	0.1	0 (0.1)	0	0 (NA)	0.1	0 (0.1)	0 - 0.2
Unable to observe	0.7	0.1 (0.1)	2.7	4.6 (7.1)	1	0.6 (NA)	2.2	3 (5.9)	0 - 19.7

The mean number of point hazards per standardized observation period (30 minutes) are reported in Tables 4.1 and 4.2. Quick lean/twist, lift child, and lift object were the most frequently observed indoor point hazards. Quick squat/kneel was recorded as the second most frequent outdoor point hazard. Quick lean/twist was the most prevalent point hazard in our study, both indoor and outdoor (Table 4.1). Specifically, providers were recorded leaning/twisting quickly 18.7 times every half-hour on average in indoor toddler room (Table 4.1).

Providers lifted children indoors 3.2 times on average every 30-minute standardized period (Table 4.1). Mainly younger children in infants, toddlers, combined age groups were lifted by providers indoors. Providers did not lift children outdoors as often. On average, providers lifted children

outdoors 0.5 times every half-hour (Table 4.1). Providers lifted objects around twice and 1.5 times every half-hour indoors and outdoors respectively (Table 4.1).

Providers were observed using cleaning product 0.4 times in every half-hour (Table 4.1). The two main cleaning products used were wiping (wet wipe) and spraying product, however, the contents of the wiping product or spray bottles were unrecorded (Table 4.2). Though director survey results (appendix D) revealed that centers generally use bleach, soap, "Ecolab" commercial cleaning and disinfecting products to clean, disinfect, and sanitize.

Table 4.1 - Table showing mean number of point hazards per observation that ECE providers did indoors and outdoors by age group.

	Infants	Toddlers	Preschoolers	Combined age group	Total	
Point hazards and behaviors	Mean number of point hazards/observation (SD)				Mean number of point hazards/observation (SD)	Range
Indoor	N=7	N=24	N=17	N=5	N=53	
Quick lean/twist	12.8 (13.1)	18.7 (14.4)	14.6 (19.1)	14 (13.4)	16.2 (15.6)	0 - 82.4
Quick squat/kneel	1.5 (2.3)	0.8 (1.6)	0.7 (1.4)	0.9 (1.2)	0.9 (1.6)	0 – 6
Lift child	4.3 (3.5)	3.8 (5.1)	1.1 (3.0)	5.5 (4.1)	3.2 (4.4)	0 - 16.9
Lift object	1.9 (4.5)	2.5 (3.3)	3.5 (9.1)	1.5 (3.4)	2.6 (5.8)	0 - 36.3
Cleaning product use	0.2 (0.7)	0.6 (1.9)	0.1 (0.5)	0.2 (0.8)	0.4 (1.4)	0 – 12
Hand sanitizer	0 (0)	0 (0.2)	0 (0)	0.2 (0.4)	0 (0.2)	0 - 1.2
Wash hands	1.2 (1.4)	1.5 (2.1)	0.8 (1.2)	1.4 (3.1)	1.2 (1.8)	0 - 8.9
Biohazard	0.1 (0.3)	0.1 (0.5)	0 (0.2)	0.1 (0.3)	0.1 (0.4)	0 - 3.1
Diaper, toileting	0.2 (0.6)	0.5 (1.2)	0.3 (0.9)	0.6 (1.8)	0.4 (1.1)	0 - 6.5
Push or pull	0 (0)	1 (1.5)	0.3 (0.7)	1.7 (2.8)	0.7 (1.4)	0 - 6.6
Other hazard	0 (0)	0 (0.2)	0 (0)	0 (0)	0 (0.1)	0 – 1
Unexpected	0 (0)	0 (0)	0.1 (0.2)	0 (0)	0 (0.1)	0 - 0.9
Outdoor		N=3	N=7	N=1	N=11	
Quick lean/twist	NA	11 (5.2)	14.6 (14.0)	10 (NA)	13.2 (11.2)	3.9 - 44.1
Quick squat/kneel	NA	1.7 (1.5)	0.3 (0.6)	0.9 (NA)	0.8 (1.0)	0 - 2.6
Lift child	NA	1 (0.8)	0.2 (0.6)	0.9 (NA)	0.5 (0.7)	0 - 1.6
Lift object	NA	0 (0)	2.3 (3.6)	0 (NA)	1.5 (3.0)	0 – 10.0

Wash hands	NA	0.8 (1.4)	0 (0)	0 (NA)	0.2 (0.8)	0 - 2.5
Diaper, toileting	NA	0.2 (0.5)	0 (0)	0 (0)	0.1 (0.3)	0 - 1.2

Table 4.2 - Table showing mean number of point hazards per observation that ECE providers did indoors by modifiers and age group.

	Infants	Toddlers	Preschoolers	Combined age group	Total	
	Mean number of point hazards/observation (SD)				Mean number of point hazards/observation (SD)	Range
Point hazards and modifiers	N=7	N=24	N=17	N=5	N=53	
Quick lean/twist	12.8 (13.1)	18.7 (14.4)	14.6 (19.1)	14 (13.4)	16.2 (15.6)	0 - 82.4
Quick squat/kneel	1.5 (2.3)	0.8 (1.6)	0.7 (1.4)	0.9 (1.2)	0.9 (1.6)	0 - 6
Lift child	4.3 (3.5)	3.8 (5.1)	1.1 (3)	5.5 (4.1)	3.2 (4.4)	0 - 16.9
Lift object	1.9 (4.5)	2.5 (3.3)	3.5 (9.1)	1.5 (3.4)	2.6 (5.8)	0 - 36.3
Cleaning product use	0 (0)	0 (0.2)	0.1 (0.6)	0 (0)	0.1 (0.4)	0 - 2.4
glove use	0 (0)	0.1 (0.5)	0.1 (0.6)	0 (0)	0.1 (0.5)	0 - 2.4
spraying product	0.7 (1.3)	1.7 (3)	0.3 (0.9)	0.2 (0.4)	1 (2.2)	0 - 12
spraying product, glove use	0 (0)	0 (0)	0.1 (0.3)	0 (0)	0 (0.2)	0 - 1.3
wiping product	0.7 (1.3)	2.1 (3.2)	0.1 (0.3)	1.1 (2)	1.2 (2.4)	0 - 11.9
wiping product, glove use	0 (0)	0.1 (0.5)	0.1 (0.3)	0 (0)	0.1 (0.4)	0 - 2.1
wiping product, spraying product	0 (0)	0.2 (0.8)	0.1 (0.5)	0 (0)	0.1 (0.6)	0 - 3.9
Hand sanitizer	0 (0)	0 (0.2)	0 (0)	0.2 (0.4)	0 (0.2)	0 - 1.2
Wash hands	1.2 (1.4)	1.5 (2.1)	0.8 (1.2)	1.4 (3.1)	1.2 (1.8)	0 - 8.9
Biohazard	0.1 (0.4)	0.2 (0.7)	0.1 (0.2)	0.2 (0.4)	0.1 (0.5)	0 - 3.1
glove use	0 (0)	0 (0.2)	0 (0)	0 (0)	0 (0.1)	0 - 1.1
Diaper, toileting	0.4 (0.8)	0.2 (0.6)	0.3 (0.6)	1.1 (2.6)	0.3 (1)	0 - 5.7
glove use	0 (0)	0.8 (1.6)	0.3 (1.2)	0 (0)	0.5 (1.3)	0 - 6.5
Push or pull	0 (0)	1 (1.5)	0.3 (0.7)	1.7 (2.8)	0.7 (1.4)	0 - 6.6
Other hazard	0 (0)	0 (0.2)	0 (0)	0 (0)	0 (0.1)	0 - 1
Unexpected						
hit/kick	0 (0)	0 (0)	0.1 (0.2)	0 (0)	0 (0.1)	0 - 0.9

Table 5 presents the results of regression models considering factors contributing to ECE providers' four ergonomic exposures at work. Subsidy enrollment, child to worker ratio, and provider age were tested as secondary contributors to the models; only subsidy enrollment contributed to two of the four models significantly. Child to worker ratio and provider age did not contribute to any of the models.

In reference to an infant room in a large center, providers who cared for infants in a small center were predicted to lean (instantaneous bending the back at >30° and/or twisting the torso unsupported) about 25 times every 30 minutes. Providers who cared for infants in a small, low subsidy enrollment center were predicted to lift children/objects about the same times (13 times/30 minutes) as their counterparts in an infant room in a high subsidy enrollment large center. Providers were predicted to lift children/objects less in toddler and preschooler age groups, regardless of center size and subsidy enrollment.

The back risk postures model predicted the proportion of minutes that providers spend sitting in a kid-size chair and on the floor, and bending over without support. Child age appeared to be associated to ECE providers' ergonomic outcomes. Providers caring for preschoolers in a large center were predicted to spend half the time in back risk postures than providers caring for infants. With reference to an infant room in large center with high subsidy, providers in toddler and preschooler rooms were expected to spend 10-15% less time in back risk postures. Providers serving centers with low subsidy enrollment were predicted to spend 12% more time in back risk postures than those in high subsidy enrollment centers.

Table 5 - Effects of children age, center size, and subsidy enrollment on four ergonomic exposures. (N= 64)

Outcomes	Lean Rate [a]	Lift Rate [b]	Percent time in back risk postures [c]	Percent time kneeling [d]
Constant	12.8	6.2	58.0	3.8
Children Age (reference: Infants)				
Toddler	2.4 (6.2)	-1.1 (2.8)	-24.4 (9.8) *	3.5 (4.4)
Preschooler	-3.6 (6.5)	-3.4 (3.0)	-29.3 (10.3) **	-0.7 (4.7)
Mixed	-11.3 (9.2)	-2.9 (4.2)	-17.6 (14.5)	-1.0 (6.6)
Center Size (reference: Large)				
Small	11.8 (4.4) *	2.7 (2.0)	-0.9 (7.0)	-0.7 (3.2)
Constant		13.2	37.1	
Children Age (reference: Infants)				
Toddler		-1.8 (2.8)	-22.2 (9.8) **	
Preschooler		-3.9 (2.9)	-27.9 (10.0) **	
Mixed		-3.4 (4.1)	-15.9 (14.3)	
Center Size (reference: Large)				
Small		4.4 (2.1) **	-6.1 (7.6)	
Subsidy enrollment (reference: High)				
Low		-4.1 (2.0) **	12.23 (7.20) *	

Statistical significance indicated as: *p<0.1, **p<0.05

Infant is the reference category for children age. Large center is the reference category for center size. High subsidy enrollment is the reference category for subsidy enrollment. The base model used children age and center size as predictors. 'Mixed' refers to classrooms that combine children of all ages into the same space.

[a] Predicted rate of quick lean/twist per 30 minutes.

[b] Predicted rate of lifting per 30 minutes.

[c] Predicted proportion of minutes in kneeling postures.

[d] Predicted proportion of minutes in back postures that could contribute to low back pain – sitting in a kid-size chair, sitting on the floor, bending over.

Discussion

This study described ergonomic exposure of ECE workers who cared for children ages 0-6 in Washington State in 2021. Providers' situations, behaviors, and tasks diversified and became more dynamic as children's ages increased. This is likely attributed to children reaching different developmental stages and levels of mobility/activity. Based on our regression models, children's age groups appeared to be a key contributor to ECE workers' ergonomic exposures. Providers who care for infants are at higher risk. Providers caring for preschoolers were predicted to spend as much as 50% less time in back risk postures compared to those who care for infants.

Our observation results estimated that providers spent an estimated half (50.7%) of an eight-hour workday in walking or standing postures. In indoor classrooms, they spent almost a third (30.8%) of the time sitting in a chair or floor, particularly in infant rooms. That corresponds to four hours of standing and walking and about 2.5 hours of sitting in an 8-hour work day. Quick lean/twist was the most prevalent point hazard, which is an unsupported back bend forward or backwards for more than 30° and/or torso twisted for less than 10 seconds. On average, providers did quick lean/twist 19 times per 30 minutes outdoors, which is equivalent to over 300 quick lean/twists in an 8-hour work day.

Our study results largely agree with similar observation studies conducted by (Holtermann et al., 2020) and King et al. (1996). Holtermann et al. (2020) observed that Danish ECE workers who cared for children ages 0-3 years old spent about half of their workdays (45%) in sedentary postures (sit chair & floor), standing (23%), and walking (15%). These findings somewhat agree with our study results in infant and toddler age groups. Time spent walking in infant and toddler rooms (14%, Table 3.1) was almost identical to results from the study by Holtermann et al. (2020). Similarly, Danish and American providers spent the same proportion of their workdays in knee-straining postures (kneeling and squatting). Both Holtermann et al. (2020) and our study reported 4% of observation time in kneeling.

King et al. (1996) conducted a detailed worksite analysis in Wisconsin for ECE providers who cared for children from 6 weeks old – 11 years old. King et al. (1996) noted that "lifting and carrying children diminished with children over age three as would be developmentally expected", which aligns with our study findings. We observed providers' situations and behaviors diversified as children grow.

Our study revealed very different results in terms of time spent sitting in kid-size furniture or on the floor as to results from King et al. (1996). King et al. (1996) observed that providers regularly sat on child-size furniture (83%) and spent most of the day sitting on the floor (60%). Whereas our results indicated that providers only spent about a-tenth of their workday sitting in child-size furniture or on the floor (Tables 3.2, 3.3). Providers in infant room exclusively sat in adult-size chairs. On the other hand, providers mostly used child-size furniture in toddlers and preschooler rooms. It is important to note that the study was conducted almost 30 years ago. Observing infant room providers using adult-size furniture exclusively in our study could mean improvements in workplace safety awareness.

Lifting is associated with MSDs and is one of the most performed behaviors by ECE workers. We observed providers lifting children across age groups about 6 times/hour (i.e., 3 times per half-hour in Table 4.1), which is in agreement with lifting frequencies reported in prior studies conducted in Japan and Sweden – 6-9 lifts/hour (Kumagai et al., 1996; Shimaoka et al., 1997). However, our observation results appeared to have much lower lifting frequencies when compared to a Canadian study that reported similar lifting frequencies by children age. Labaj et al. (2016) found lifting frequencies of 18 lifts/hour, 20 lifts/hour, and 9 lifts/hour in the infant, toddler, and preschool groups respectively; while our study observed 9 lifts/hour, 8 lifts/hour, and 2 lifts/hour in infant, toddler, and preschooler groups respectively. These differences might be due to varying methods between the studies. Labaj et al. (2016) were able to film providers' during their observations and observed for longer periods (3.5 hours/session). Their team coded providers' postures after completing the observation based on the recordings, while our study relied on observers to code in real time. That might have contributed to the accuracy of the data collected.

Adequacy of guidelines

Overexerting oneself by lifting heavy weights frequently increases risk of developing MSD. ECE providers caring for toddlers need to have the physical endurance because, not only do they lift children frequently, lifting is also more challenging with this age group because of their weight (Gratz et al., 2002; King et al., 1996). We observed providers lifting toddlers almost 4 times/30 minutes (Table 4.1), that equals to 64 times in an 8-hour workday. Although we did not measure the weight of the children during observations, a three-year-old toddler weighs about 31 lbs (Centers for Disease Control and Prevention, 2019), a provider is estimated to lift a total of almost 2,000 lbs throughout an 8-hour workday.

Existing publicly available ergonomic-related workplace safety tools were applied to better understand and contextualize the ergonomic exposures faced by the ECE workforce. Washington State Department of Labor & Industries (n.d.-a, n.d.-b) has Caution and Hazard Zone Checklists to assist individuals in identifying activities on the job that can cause strains. The caution zone checklist states that lifting objects weighing more than 25 pounds above the shoulders, below the knees or at arm's length more than 25 times per (8-hour) day can cause sprains and strains. Providers often lift children from below the knees. In fact, providers were estimated to lift toddlers 64 times/day, exceeding suggested guidelines by more than double. The Hazard Zone Checklist has a lifting operations analysis calculator to perform simple ergonomic risk assessments on a wide variety of manual lifting and lowering tasks. At the frequency (64 times/day), weight lifted (30 lbs toddlers), and distance away from body (16" away) that providers are lifting, it is considered a 'hazardous' lifting risk to ECE providers (appendix E).

Providers frequently pick up children from floor level or knee height to waist height, and that puts workers at higher risk for low back pain or increased risk for back-related MSD. Lifting from floor level has 1.9 times higher risk than lifting at waist height, while lifting from knee height is 1.3 times higher risk (Washington State Department of Labor & Industries, n.d.-c). Moreover, guidelines referenced the weight of inanimate objects instead of wriggly children. Lifting a dynamic load could easily have more ergonomic risks associated, e.g., using awkward positions

or having to engage more muscles for stability. Also, those two guidelines do not distinguish between gender; hence they may not be fully protective for the ECE workforce that is overrepresented by women.

Ergonomic exposures and reproductive health

The ECE workforce that consists of over 90% female, particularly young women at childbearing age. They are more vulnerable to workplace ergonomic exposures. Pregnant ECE workers are more prone to injury from lifting children or objects (University of Washington & Safety and Health Investment Projects, 2021) as they have more elastic ligaments during pregnancy. Lifting and bending frequently, and standing for long periods of time are prominent risk factors and workplace hazards to pregnant providers. (The National Institute for Occupational Safety and Health (NIOSH), 2021; University of Washington & Safety and Health Investment Projects, 2021). The National Institute for Occupational Safety and Health (NIOSH) (2021) documented bending at the waist more than 20 times/day or lifting objects more than once every 5 minutes may increase risks for some adverse birth outcomes. Our observation results indicated that providers lean or twist their torso quickly for 16 times/30 minutes on average across all age groups, which exceeded the threshold suggested by NIOSH. However, a previous study in Finland found that daycare employees were not at an increased risk of an adverse pregnancy outcome (Riipinen et al., 2010). Nevertheless, pregnant ECE providers and their employees should be more aware of protective measures to manage workplace ergonomic exposures. For example, Waters et al. (2014) recommended lifting thresholds for pregnant workers to prevent maternal lifting-related health problems. The lifting threshold of 23 pounds is the most relevant to ECE providers' work, employers could reasonable accommodations for pregnant ECE workers who care for toddlers as they're generally over 23 pounds.

Ergonomic exposures and chronic health condition

Holding in high knee flexion postures (e.g., kneeling) for an extended amount of time is a workplace risk factor for chronic knee conditions for ECE providers. A Canadian study led by Laudanski et al. (2019) suggested that ECE workers at any age are at higher risk for knee osteoarthritis, a chronic knee degenerative condition, because of holding long kneeling postures they do during childcare. It was suggested that the daily exposures to high knee flexion postures for longer than 1-2 hours are associated with increased knee osteoarthritis risk. We observed providers spent 36% of their time in high knee flexion postures, i.e., sitting in child size furniture, sitting on the floor, squatting, and kneeling cumulatively. Providers in our study were estimated to in be high knee flexion postures for almost 3 hours in a workday, exceeding the previously established thresholds. Their risk for knee osteoarthritis is elevated.

Masking behavior

Our observation study was conducted during the COVID-19 pandemic, so and masking behavior was observed as it was a COVID-19 precaution. Based on the director survey (appendix D), most of the centers required providers to mask up at the time of our observations. Our team observed mask-off (provider did not wear mask) behaviors in indoor classrooms. The mean percent time in mask-off was 6.3% (SD 21.5), which is about 30 minutes in an eight-hour workday. Infant room

providers had the highest mean percent in mask-off – 28.5%, about 2.5 hours in an eight-hour workday.

Results generalizability, limitations, challenges, and strengths

Findings from our observation study seem to be generalizable within the state and the U.S. Children's developmental stages do not vary temporally or geographically. Therefore, we can expect childcare activities/tasks to be rather universal across the board and that our study results could be applied across U.S. urban and rural ECE centers. However, COVID-19 might have introduced differences in ECE work environments compared to 'non-pandemic' times. For instances, there were changes in children enrollment rates, human resources, classroom structure and programming that could impact our study's generalizability.

The study has several notable limitations or weaknesses. First, the sample size is small (N=64). Data was only collected from 8 ECE centers in Washington state, selected centers might not be representative. Small sample size contributed to the instability of the models as there is a disproportionately large number of independent variables to observations – three independent variables to 64 observations. Second, the study only observed licensed, center-based workers, that could mean potentially missing out on important nuances from other (e.g., personal, unlicensed, home-based, Au pairs) ECE providers. Finally, the short duration and timing of the observations limited the extrapolation of study results to a full 8-hour workday. Observations were conducted during convenient times during the workday rather than observing throughout the entire day, which could differ.

The study implementation was challenged by the COVID-19 pandemic. Due to the uncertainty with vaccination status and testing availability, the team relied on open-source videos to practice individually using the observation coding tool (BORIS) rather than practicing in-person at different ECE centers. COVID-19 also posed challenges in center recruitment as some centers were stricter than others about visitors as compared to non-pandemic times.

This study has a few notable strengths. First, the team developed an observation tool to systematically code ECE workers' behaviors that is replicable for future studies. Second, the study provided an objective assessment of the current ergonomic exposures of ECE providers without relying on self-report data. Finally, results contribute to integrating work environment and other psychosocial factors to fully assess the ECE workforce's health.

Recommendations

Workplace hazards within ECE have largely been ignored by health and safety professionals in the past, partially due to a lack of awareness of hazards and inconsistencies in state health and safety requirements (Bright & Calabro, 1999). The ECE field has primarily focused on the children's health and safety. Consequently, ECE workers have high awareness of what constitutes a child-safe environment but are often less aware of work-related hazards that impact their own health and safety. Childcare center licensing requirements in the Washington Administrative Codes mentioned 'providing for personal, professional, and health needs of staff',

however there is no language on ergonomics or protecting workers' safety (Washington State Legislature, 2022). Interventions to ameliorate working conditions of this workforce need to be holistic and include ergonomics to combat of physical job demands (Viotti et al., 2017). One of the ways is to adapt existing ergonomic guidelines to better fit this workforce. Another opportunity is to incorporate trainings on ergonomically favorable childcare techniques (e.g., proper lifting techniques) into online training modules for licensing purposes. Our study results revealed that ergonomic exposure change significantly among age groups, so trainings on childcaring techniques might be more effective if they are tailored to children's age groups. On the bright side, the homogeneity of the ECE workforce gives rise to opportunities to ergonomically enhance work environments. For example, as suggested by the center directors of ECE centers we observed at (appendix D), centers could install adult-size furniture and consider ergonomic trainings.

Conclusion

Despite an increasing attention to ECE workers' job demands, low pay, and few job-related benefits, very little is known about the ergonomic risk factors to the ECE workforce. The goal of this study was to conduct detailed worksite observations to characterize physical health risks, comprehensively describe ergonomic exposures in the ECE workforce, and examine contributing factors to ergonomic exposures. Children's age groups appear to be a key contributor to varying ergonomic exposures ECE workers. Providers' situations, behaviors, and incidents that can cause risk diversified as children grew older. Overall, providers spend half a workday (4 hours) walking and standing and one-third of the time sitting on a chair or floor. Rapid torso bending or twisting, lifting of children, and lifting of objects were the top three observed instantaneous movements that can cause risks. Providers caring for toddlers were estimated to lift about 2000 lbs in an 8-hour workday. At the observed lifting frequency and weight, lifting is considered a 'hazardous' risk to ECE providers that increase their chances of developing back-related MSD. Publicly accessible guidelines are inadequate for the ECE workforce as they (a) referenced inanimate objects rather a dynamic load (moving children), (b) did not account for gender differences in a majority female workforce. Our observed rate of ECE providers bending, lifting, and kneeling emphasized the need to increase providers' awareness of potential reproductive health and knee osteoarthritis risks. Results from this study, alongside emerging research on poor working conditions, physical health, and mental wellbeing could identify and implement healthful interventions to improve working conditions of the underserved, vulnerable yet essential ECE workforce.

Acknowledgement

This research was funded by the United States Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, grant number 6 R21 OH 011623-02-02, awarded to Noah Seixas.

References

Bernard, B. P., editor. (1997). Musculoskeletal disorders and workplace factors. A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. https://doi.org/10.26616/NIOSHPUB97141

Bright, K. A., & Calabro, K. (1999). Child care workers and workplace hazards in the United States: Overview of research and implications for occupational health professionals. Occupational Medicine (Oxford, England), 49(7), 427–437. https://doi.org/10.1093/occmed/49.7.427

Calder, J. (1994). Occupational Health and Safety Issues for Child-Care Providers. Pediatrics, 94(6), 1072–1074. https://doi.org/10.1542/peds.94.6.1072

Centers for Disease Control and Prevention, N. C. for H. S. (2019, January 11). Growth Charts — Clinical Growth Charts. https://www.cdc.gov/growthcharts/clinical_charts.htm

Cheng, K. H.-Y., Cheng, C.-Y., & Ju, Y.-Y. (2013). Work-related musculoskeletal disorders and ergonomic risk factors in early intervention educators. Applied Ergonomics, 44(1), 134–141. https://doi.org/10.1016/j.apergo.2012.06.004

Committee on Early Childhood Care and Education Workforce: A Workshop, Institute of Medicine, & National Research Council. (2011). The Early Childhood Care and Education Workforce: Challenges and Opportunities: A Workshop Report. National Academies Press (US). http://www.ncbi.nlm.nih.gov/books/NBK189909/

Friard, O., & Gamba, M. (2016). Behavioral Observation Research Interactive Software. Methods in Ecology and Evolution, 7(11), 1325–1330. https://doi.org/10.1111/2041-210X.12584

Grant, K. A., Habes, D. J., & Tepper, A. L. (1995). Work activities and musculoskeletal complaints among preschool workers. Applied Ergonomics, 26(6), 405–410. https://doi.org/10.1016/0003-6870(95)00057-7

Gratz, R. R., & Claffey, A. (1996). Adult health in child care: Health status, behaviors, and concerns of teachers, directors, and family child care providers. Early Childhood Research Quarterly, 11(2), 243–267. https://doi.org/10.1016/S0885-2006(96)90008-3

Gratz, R. R., Claffey, A., King, P., & Scheuer, G. (2002). The Physical Demands and Ergonomics of Working with Young Children. Early Child Development and Care, 172(6), 531–537. https://doi.org/10.1080/03004430215109

Holtermann, A., Fjeldstad Hendriksen, P., Greby Schmidt, K., Jagd Svendsen, M., & Nørregaard Rasmussen, C. D. (2020). Physical Work Demands of Childcare Workers in Denmark: Device-Based Measurements and Workplace Observations Among 199 Childcare Workers from 16 Day Nurseries. Annals of Work Exposures and Health, 64(6), 586–595. https://doi.org/10.1093/annweh/wxaa041

Horng Y.-S., Hsieh S.-F., Wu H.-C., Fung C.-T., & Lin M.-C. (2008). Work-related Musculoskeletal Disorders of the Workers in a Child Care Institution. Taiwan Journal of Physical Medicine and Rehabilitation, 36(1), 15–21. https://doi.org/10.6315/2008.36(1)02

King, P. M., Gratz, R., & Kleiner, K. (2006). Ergonomic recommendations and their impact on child care workers' health. Work (Reading, Mass.), 26(1), 13–17.

King, P. M., Gratz, R., Scheuer, G., & Claffey, A. (1996). The Ergonomics of Child Care: Conducting worksite analyses. Journal of Prevention, Assessment & Rehabilitaiton, 6, 25–32.

Kumagai, S., Tabuchi, T., Tainaka, H., Miyajima, K., Matsunaga, I., Kosaka, H., Andoh, K., & Seo, A. (1996). Load on the low back of teachers in nursery schools. International Archives of Occupational and Environmental Health, 68(1), 52–57. https://doi.org/10.1007/BF01831633

Labaj, A., Diesbourg, T., Dumas, G., Plamondon, A., Mercheri, H., & Larue, C. (2016). Posture and lifting exposures for daycare workers. International Journal of Industrial Ergonomics, 54, 83–92. https://doi.org/10.1016/j.ergon.2016.05.003

Laudanski, A. F., Buchman-Pearle, J., & Acker, S. M. (2019). Quantifying high knee flexion exposures in occupational childcare to assess the potential for increased risk of knee osteoarthritis. Osteoarthritis and Cartilage, 27, S134–S135. https://doi.org/10.1016/j.joca.2019.02.198

Lessard, L. M., Wilkins, K., Rose-Malm, J., & Mazzocchi, M. C. (2020). The health status of the early care and education workforce in the USA: a scoping review of the evidence and current practice. Public Health Reviews, 41(1). https://doi.org/10.1186/s40985-019-0117-z

Linnan, L., Arandia, G., Bateman, L. A., Vaughn, A., Smith, N., & Ward, D. (2017). The Health and Working Conditions of Women Employed in Child Care. International Journal of Environmental Research and Public Health, 14(3). https://doi.org/10.3390/ijerph14030283

Marcum, J., & Adams, D. (2017). Work-related musculoskeletal disorder surveillance using the Washington state workers' compensation system: Recent declines and patterns by industry, 1999-2013. American Journal of Industrial Medicine, 60(5), 457–471. https://doi.org/10.1002/ajim.22708

Occupational Safety and Health Administration, U. S. D. of L. (n.d.). Ergonomics—Overview | Occupational Safety and Health Administration. Retrieved 11 May 2022, from https://www.osha.gov/ergonomics

Otten, J. J., Bradford, V. A., Stover, B., Hill, H. D., Osborne, C., Getts, K., & Seixas, N. (2019). The Culture Of Health In Early Care And Education: Workers' Wages, Health, And Job Characteristics. Health Affairs (Project Hope), 38(5), 709–720. https://doi.org/10.1377/hlthaff.2018.05493

R Core Team. (2022). R: The R Project for Statistical Computing (4.0.2) [Computer software]. R Foundation for Statistical Computing. https://www.r-project.org/

Riipinen, A., Sallmén, M., Taskinen, H., Koskinen, A., & Lindbohm, M.-L. (2010). Pregnancy outcomes among daycare employees in Finland. Scandinavian Journal of Work, Environment & Health, 36(3), 222–230.

Shimaoka, M., Hiruta, S., Ono, Y., Nonaka, H., Hjelm, E. W., & Hagberg, M. (1997). A comparative study of physical work load in Japanese and Swedish nursery school teachers. European Journal of Applied Physiology and Occupational Physiology, 77(1), 10–18. https://doi.org/10.1007/s004210050293

StataCorp. (n.d.). Stata Statistical Software (Release 17) [Computer software]. StatCorp LLC. Retrieved 13 May 2022, from https://www.stata.com/

Svendsen, M. J., Hendriksen, P. F., Schmidt, K. G., Stochkendahl, M. J., Rasmussen, C. N., & Holtermann, A. (2020). Inter-Rater Reliability of Ergonomic Work Demands for Childcare Workers Using the Observation Instrument TRACK. International Journal of Environmental Research and Public Health, 17(5), E1607. https://doi.org/10.3390/ijerph17051607

The National Institute for Occupational Safety and Health (NIOSH), C. for D. C. and P. (2021, November 12). Physical Demands (lifting, standing, bending)—Reproductive Health | NIOSH | CDC. https://www.cdc.gov/niosh/topics/repro/physicaldemands.html

University of Washington, N. C. for O. H. and S., & Safety and Health Investment Projects, W. S. D. of L. & I. (2021). Protecting Workers from Occupational Reproductive Hazards: A Guide for Employers and Staffing Agencies. https://deohs.washington.edu/pehsu/sites/deohs.washington.edu.pehsu/files/Occ%20Repro%20Employer%20Toolkit/reproductive%20health%20booklet%2012-21-21%20for%20web%20copy.pdf

U.S. Bureau of Labor Statistics. (2021a). Case and Demographic Characteristics for Work-related Injuries and Illnesses Involving Days Away From Work. Number, incidence rate, and median days away from work for nonfatal occupational injuries and illnesses involving days away from work for musculoskeletal disorders by part of body and ownership, National, 2020. https://www.bls.gov/iif/oshcdnew.htm

U.S. Bureau of Labor Statistics. (2021b). Number and rate of nonfatal work injuries in detailed private industries, 2020. https://www.bls.gov/charts/injuries-and-illnesses/number-and-rate-of-nonfatal-work-injuries-by-industry-subsector.htm

U.S. Bureau of Labor Statistics. (2021c). Number of nonfatal occupational injuries and illnesses involving days away from work by occupation and selected parts of body affected by injury or illness, private industry, 2020. https://www.bls.gov/iif/oshwc/osh/case/cd_r10_2020.htm#iif_cd_r10p.f.3

U.S. Bureau of Labor Statistics. (2022, April). Childcare Workers: Occupational Outlook Handbook. https://www.bls.gov/ooh/personal-care-and-service/childcare-workers.htm#tab-1

Viotti, S., Martini, M., & Converso, D. (2017). Are there any job resources capable of moderating the effect of physical demands on work ability? A study among kindergarten teachers. International Journal of Occupational Safety and Ergonomics, 23(4), 544–552. https://doi.org/10.1080/10803548.2016.1267976

Washington State Department of Labor & Industries. (n.d.-a). Caution Zone Checklist. 2.

Washington State Department of Labor & Industries. (n.d.-b). Hazard Zone Checklist. 5.

Washington State Department of Labor & Industries. (n.d.-c). Lift height and risk of injury. Retrieved 12 May 2022, from https://wisha-training.lni.wa.gov/training/articulate/liftheighttool/story_html5.html

Washington State Department of Labor & Industries, S. & H. A. & R. for P. (2019). WMSD Claims Snapshot: Shoulder. SHARP Publication: 99-01-2019, 1.

Washington State Legislature. (2022, July 1). Washingotn Administrative Code Chapter 110-300: Foundational Quality Standards for Early Learning Programs. https://app.leg.wa.gov/wac/default.aspx?cite=110-300&full=true

Waters, T. R., MacDonald, L. A., Hudock, S. D., & Goddard, D. E. (2014). Provisional Recommended Weight Limits for Manual Lifting During Pregnancy. Human Factors, 56(1), 203–214.

Whitaker, R. C., Becker, B. D., Herman, A. N., & Gooze, R. A. (2013). The physical and mental health of Head Start staff: The Pennsylvania Head Start staff wellness survey, 2012. Preventing Chronic Disease, 10, E181. https://doi.org/10.5888/pcd10.130171

Whitebook, M. (2014). Building a Skilled Teacher Workforce Shared and Divergent Challenges in Early Care and Education and in Grades K-12 Building a Skilled Teacher Workforce. 41.

Whitebook, M., Phillips, D., & Howes, C. (2014). Worthy Work, STILL Unlivable Wages: The Early Childhood Workforce 25 Years after the National Child Care Staffing Study. Center for the Study of Child Care Employment, 124.

Appendix A – Observation Tool Definitions

Table 1- Definitions of the 29 items in the observation tool.

Item number	Situation	Definition	Example
01	Clean/Prep	Cleaning, tidying	Tidying – e.g., picking up toys cleaning, disinfecting
02	Meal time	Prepping, serving meals, feeding children	Solid foods, bottles, etc.
03	Child activity	Interacting with children, playtime, group activity	Story time, craft time
04	Nap help	Helping child nap/sleep	Getting children ready for nap, downtime while children are napping. If caregivers are doing other activities while children are napping, code for those activities (i.e., clean)
05	Other situation	Other situation not specified elsewhere	Having an aside conversation with coworker/manager (not casual conversation during childcare work), a phone call, recordkeeping/documentation for extended period
06	Unable to observe	Unable to see caregiver	E.g. in another room Can use to close out/pair items at end of observation period
Item number	**Behavior**	**Definition**	**Example**

07	Sit Floor 1. Carry/hold neutral 2. Carry/hold awkward	Bodyweight on at least one buttock, with feet and buttocks at approximately same height. Includes sitting cross-legged or in a mermaid position	 
08	Sit chair 1. Carry/hold neutral 2. Carry/hold awkward 3. Adult-sized chair	On at least one buttock on chair or other raised object. Assume child-sized chair or low object	  
09	Squat 1. Carry/hold neutral 2. Carry/hold awkward	Neither knees nor buttocks touch the floor and knees less than or equal to 90°	
10	Kneel 1. Carry/hold neutral 2. Carry/hold awkward	Knee(s) and lower leg(s) (but not buttocks) are in contact with floor. Includes when on all fours/hands also on ground,	 

		sitting on heels, standing on knees, one knee on ground	
11	Walk 1. Carry/hold neutral 2. Carry/hold awkward	Taking at least five steps Ignore arm movements	
12	Stand 1. Carry/hold neutral 2. Carry/hold awkward	Standing, okay if a few steps are taken Ignore arm movements	
13	Bent over	Standing bent over for 10 seconds or longer	Select as soon as possible, okay if less than 10 seconds (will clean up with data analysis)
14	Run 1. Carry/hold neutral 2. Carry/hold awkward	Running or walking quickly – at least five steps	Chasing after a child
15	In motion 1. Carry/hold neutral 2. Carry/hold awkward	Moving between postures rapidly, repeatedly	Dancing, hokey pokey, swinging child by arms Use when too fast to code separate postures

16	Lie down	Lying down with torso on floor or other surface. Can be propped up on elbows or similar position	On stomach playing with baby
	Modifier	**Definition**	**Example**
	Carry/hold - neutral	-Holding a child (any weight) with support - Carrying or holding an object five pounds or heavier at neutral height/distance	- Holding child on lap, carrying child in carrier - Carrying box at waist height – always code furniture
	Carry/hold - awkward	-Carrying or holding a child (any weight) without support, or only partially supported -Carrying or holding an object five pounds or heavier at awkward height/distance	- Holding a child in any position using arm(s) to hold up child, child on hip or shoulders - Feeding child in lap, using one arm (unsupported) to hold up head/torso - Holding a chair out from body – always code furniture
Item number	**Point hazards**	**Definition**	**Example**
17	Lift child	Picking up a child not in contact with a surface carried for less than 2 seconds/2 steps. Assumes bend/lean is a part of this action	Picking up a child from a crib, lifting a child from floor
18	Lift object	Picking up an object 5 pounds or heavier not in contact with a surface carried for less than 2 seconds/2 step	Picking up a chair, lifting a box of art supplies Always code furniture

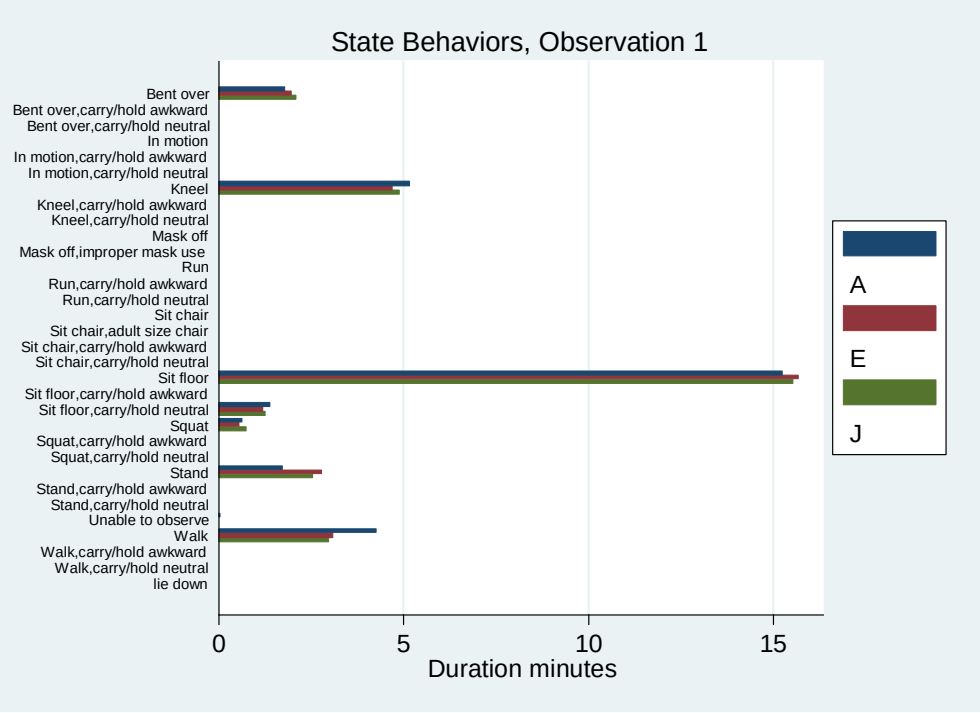
		Assumes bend/lean is a part of this action	
19	Push/pull	Object moved or supported without losing contact with surface	e.g. pulling a wagon, pushing a piece of furtniture to move it – not pushing on swing, trike etc - pushing/pulling chair with child in it
20	Unexpected 1. trip 2. fall 3. hit/kick 4. bite 5. scratch 6. catch	Unforeseen incident with sudden strain	1. trip - stumbling over toy without knees/buttocks hitting the ground 2. fall - missing a step or stumbling over something that results in knees/buttocks hitting the ground 3. hit – child intentionally or unintentionally hits or kicks caregiver 4. bite – child bites caregiver 5. scratch – child intentionally or unintentionally scratches caregiver 6. catch – caregiver rushes to catch child or falling object
21	Biohazard 1. wearing gloves	Touching an item or surface contaminated with bodily substance (except for diapering/toileting – biohazard assumed when that situation is selected), or within 3 feet of sneeze or cough	Cleaning up surface with vomit, blood, runny nose, feces – ignore breastmilk and drool Cleaning child that has vomit, blood, runny nose, feces on them Cleaning toilet
22	Diaper/toileting 1. wearing gloves	Changing a diaper or hands-on help with child using toilet	Glove use – wearing gloves to remove diaper/wiping. Okay if only one glove/no gloves used for putting on clean diaper Biohazard assumed – no need to use biohazard point hazard here Do not code if provider is only supervising/verbally guiding toilet use and not helping to wipe etc.
23	Cleaning product use	Cleaning, disinfecting. Include any spraying or wiping product	1. Wiping product – applying cleaning/disinfecting product with a rag/sponge/Clorox wipe, wiping up

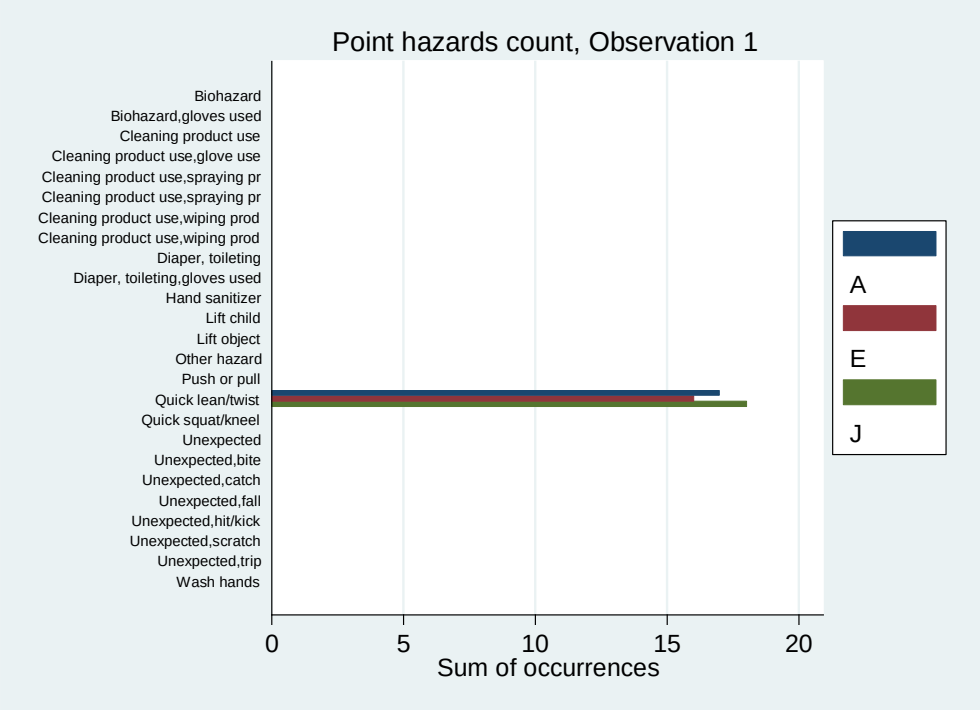
	1. Wiping product 2. Spraying product 3. Glove use	(cleaners, disinfectants, dish soaps, homemade solutions/unknowns). Count each interaction with cleaning product as one cleaning instance (i.e., spraying then wiping sprayed surface as two instances), count different surfaces as one instance each (i.e., two different tables = two instances). If obvious that wiping is completely dry or only water is being used, do not count.	product applied earlier (i.e. wiping up a table after spraying), using product at/in sink or in bucket (non-spray) 2. Spraying product – using cleaning/disinfecting product from a spray bottle/producing aerosol- 3. Wearing liquid-resistant gloves – nitrile/latex exam style gloves, rubber cleaning gloves
24	Quick lean/twist	Back bent more than 30° and/or torso twisted – unsupported for less than 10 seconds.	Bending down to pick up a toy and standing back up straight again. Significant leaning over and/or twisting to grab an item while sitting. Can recode if there's a significant change in posture such as a deeper bend. i.e. code if leaning over, then code again if further bending down to pick something up Do not code in association with lift (child or object) Do not code if bend is supported – i.e. sitting and using elbows on table to support while leaning across table
25	Quick squat/kneel	Buttocks not touching the floor	
26	Wash hands	Washes hands with soap and water	Inentionally washing own hands using soap. Rinsing alone doesn't count, helping child wash hands doesn't count unless also washing own hands
27	Hand sanitizer	Uses a hand sanitizer product	e.g., Purell hand sanitizer
28	Other hazard	Hazard not elsewhere defined	Write a note/comment with description of hazard
Item	Miscellaneous	Definition	Example

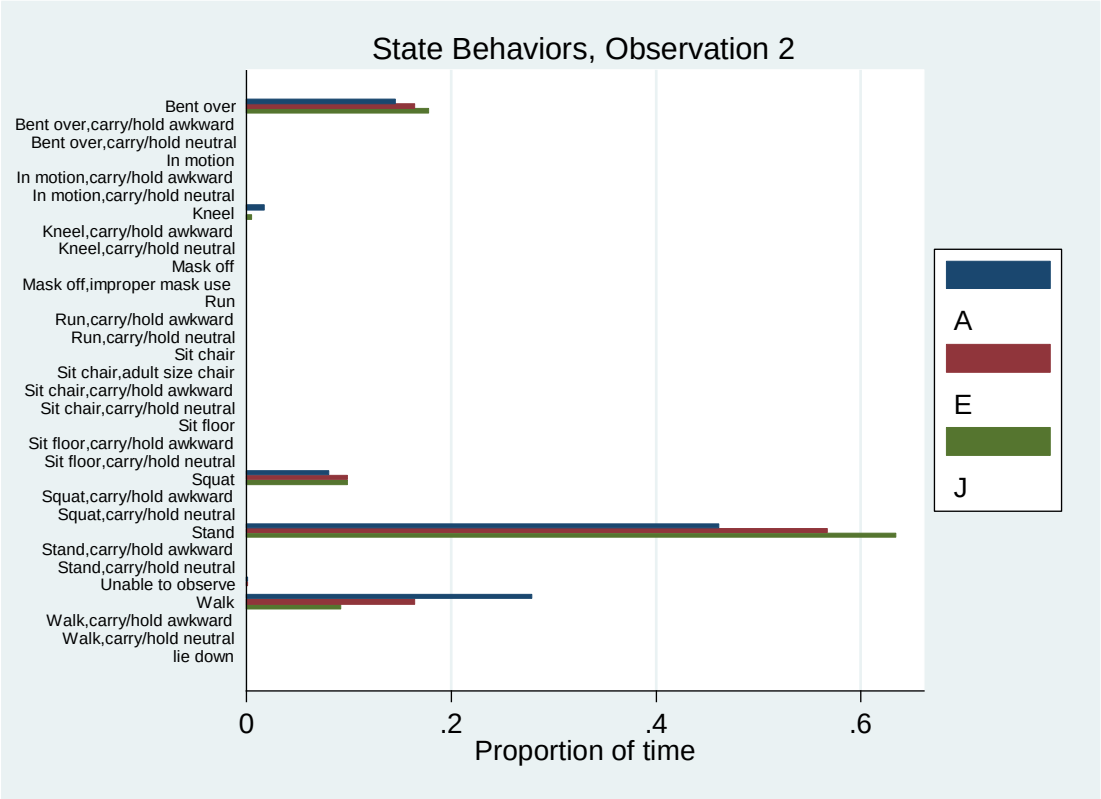
number			
29	Mask off 1. Improper mask wear	Caregiver not wearing mask Caregiver wearing mask improperly	No mask or mouth/nose completely exposed (i.e., mask off/hanging by loop from ear, around neck etc.) Wearing mask with only partial coverage of nose and mouth (or one or the other)

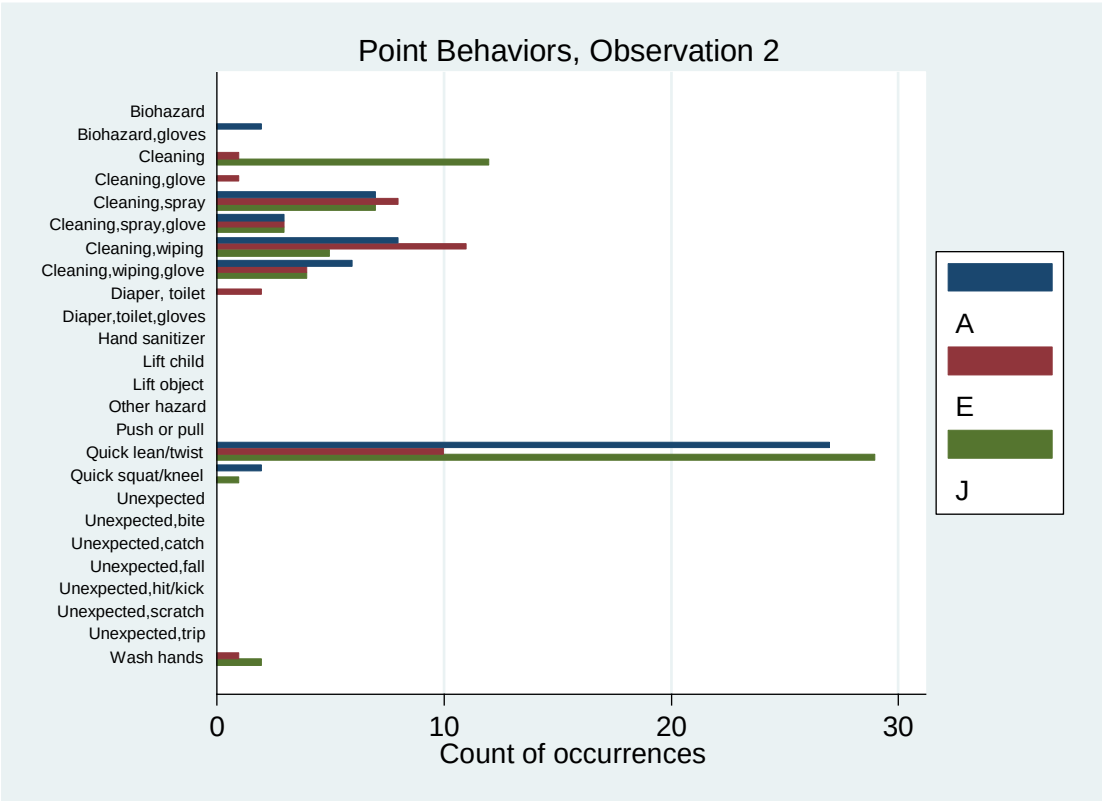
Appendix B – Inter-Observer Agreement Comparison

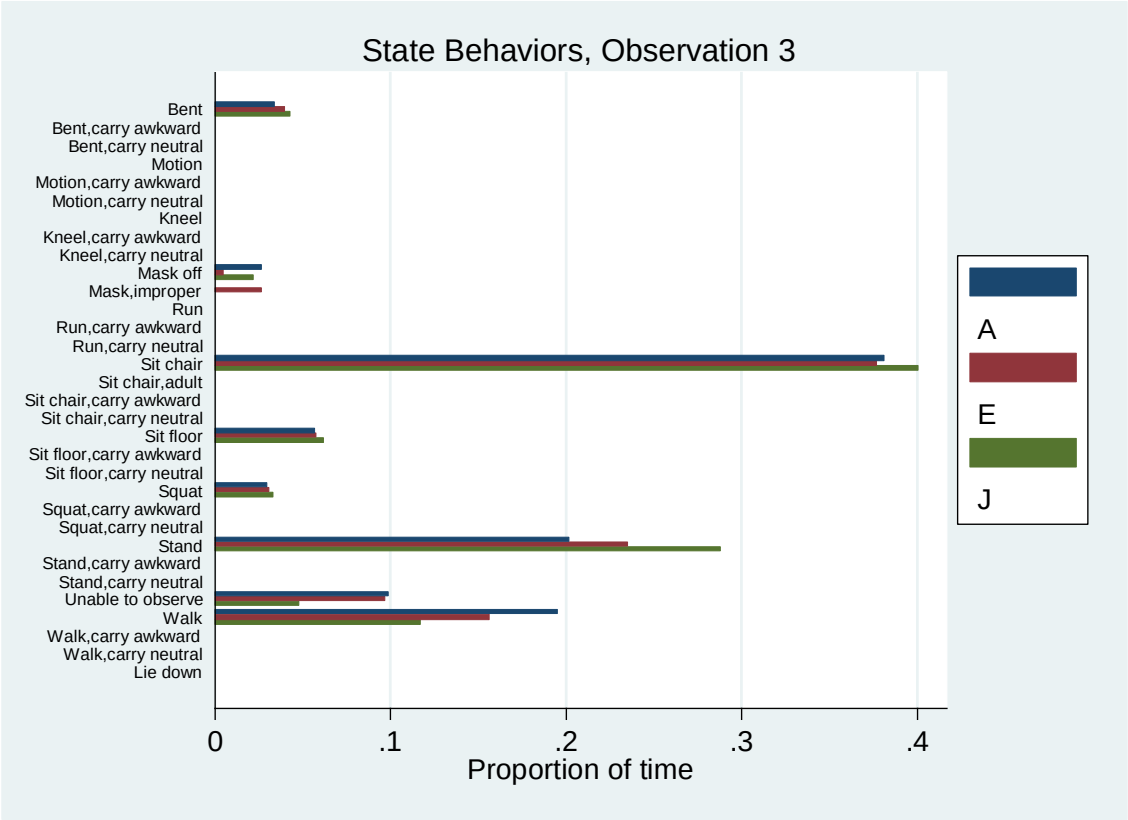
Bar graphs showing three sets of observation comparisons between three observers. Each set of observation consists of state behaviors recorded in duration of time/proportion of time and point hazards frequencies.

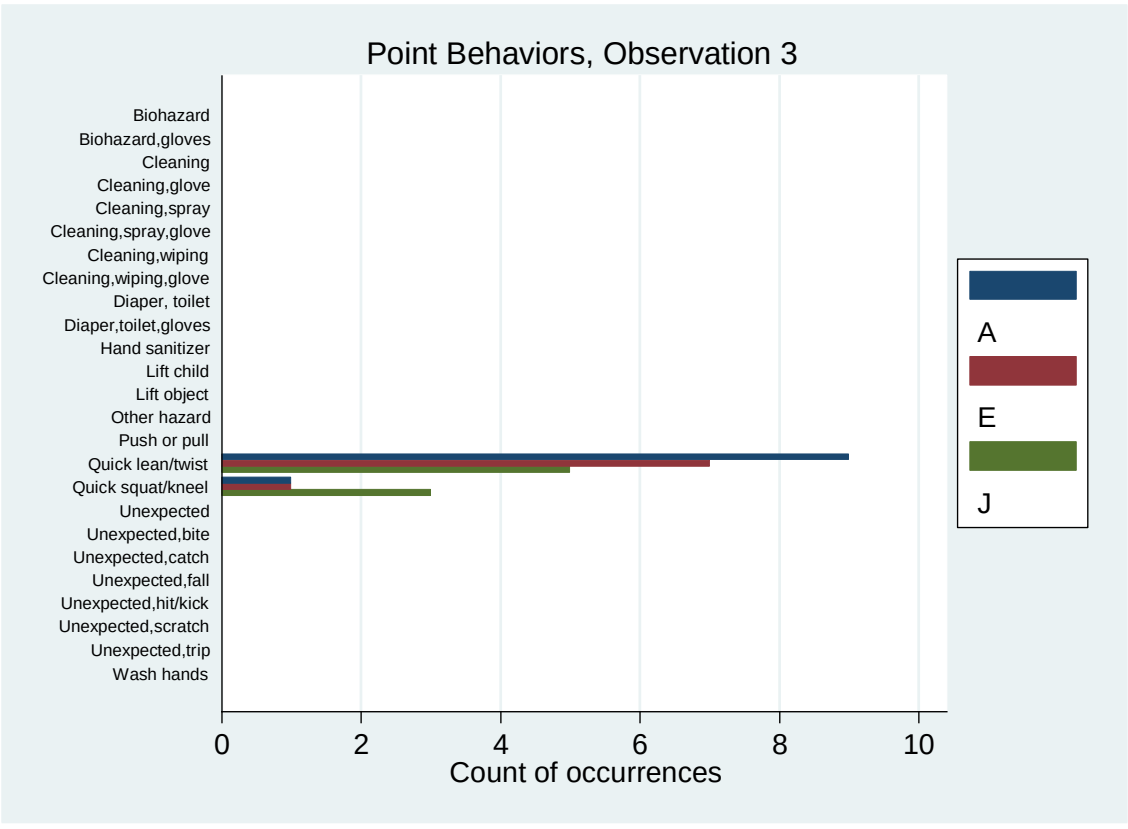





State Behaviors, Observation 2
Bent over
Bent over,carry/hold awkward
Bent over,carry/hold neutral
In motion
In motion,carry/hold awkward
In motion,carry/hold neutral
Kneel
Kneel,carry/hold awkward
Kneel,carry/hold neutral
Mask off
Mask off,improper mask use
Run
Run,carry/hold awkward
Run,carry/hold neutral
Sit chair
Sit chair,adult size chair
Sit chair,carry/hold awkward
Sit chair,carry/hold neutral
Sit floor
Sit floor,carry/hold awkward
Sit floor,carry/hold neutral
Squat
Squat,carry/hold awkward
Squat,carry/hold neutral
Stand
Stand,carry/hold awkward
Stand,carry/hold neutral
Unable to observe
Walk
Walk,carry/hold awkward
Walk,carry/hold neutral
lie down
0
.2
.4
.6
Proportion of time
A
E
J


Point Behaviors, Observation 2
Biohazard
Biohazard,gloves
Cleaning
Cleaning,glove
Cleaning,spray
Cleaning,spray,glove
Cleaning,wiping
Cleaning,wiping,glove
Diaper, toilet
Diaper,toilet,gloves
Hand sanitizer
Lift child
Lift object
Other hazard
Push or pull
Quick lean/twist
Quick squat/kneel
Unexpected
Unexpected,bite
Unexpected,catch
Unexpected,fall
Unexpected,hit/kick
Unexpected,scratch
Unexpected,trip
Wash hands
0
10
20
30
Count of occurrences
A
E
J


State Behaviors, Observation 3
Bent
Bent,carry awkward
Bent,carry neutral
Motion
Motion,carry awkward
Motion,carry neutral
Kneel
Kneel,carry awkward
Kneel,carry neutral
Mask off
Mask,improper
Run
Run,carry awkward
Run,carry neutral
Sit chair
Sit chair,adult
Sit chair,carry awkward
Sit chair,carry neutral
Sit floor
Sit floor,carry awkward
Sit floor,carry neutral
Squat
Squat,carry awkward
Squat,carry neutral
Stand
Stand,carry awkward
Stand,carry neutral
Unable to observe
Walk
Walk,carry awkward
Walk,carry neutral
Lie down
0
.1
.2
.3
.4
Proportion of time
A
E
J


Point Behaviors, Observation 3
Biohazard
Biohazard,gloves
Cleaning
Cleaning,glove
Cleaning,spray
Cleaning,spray,glove
Cleaning,wiping
Cleaning,wiping,glove
Diaper, toilet
Diaper,toilet,gloves
Hand sanitizer
Lift child
Lift object
Other hazard
Push or pull
Quick lean/twist
Quick squat/kneel
Unexpected
Unexpected,bite
Unexpected,catch
Unexpected,fall
Unexpected,hit/kick
Unexpected,scratch
Unexpected,trip
Wash hands
0
2
4
6
8
10
Count of occurrences
A
E
J

Appendix C – Observation Protocol

Pre-observation/site enrollment protocols – via phone/email

- Oral consent process
    - Going over purpose of study, what site visit will entail, confidentiality, getting study results
- Planning a site visit (may happen over multiple emails/phone calls)
    - Choosing day/time
        - When do kids arrive? When would site like us to arrive?
        - Travel considerations
    - Agree on a tentative plan for observations
        - Confirm site details - Numbers of classrooms/providers, usual schedules for classrooms
        - Decide how many observers will go, which classrooms to observe
- Director survey – ask whether they prefer to do it over the phone or in person on day of observations, plan accordingly
- Ask directors to pre-identify providers that are eligible for study/willing to participate
    - 18 or older, English proficiency for consent
    - May consider choosing classrooms where all providers have consented
    - Give information/handout to give to providers
- Go over COVID-19 prevention –child care site requirements

Day of site visit

- Meet with director – ensure understanding of study, answer questions
- Go over plan for observations – which areas, providers etc
- Aim for 8 observations total at site, ideally 8 providers over a variety of rooms/age groups. Can repeat providers if needed (i.e. small center)
- See if pre-identified care providers have been given information/handout – provide info if not

Observation protocols

- Ensure providers being observed have given oral consent, answer any questions
- Choose a location to observe where you have the best vantage point of the provider to be observed without being an obstacle
- Choose an eligible/consented provider to observe
    - Try to observe one subject for longer periods? Or aim for observing more providers?
- Start observation when settled, no need to wait until certain activity is happening in classroom
- Find position from which as much of the classroom can be seen at once. Avoid following providers around the room. Okay to shift as needed to get better viewpoint.
- If unable to see provider for just a few seconds, continue with posture/other coding factors from previous action. If unable to observe for a longer time, use “unable to observe” situation.

- If the entire class moves to another area, okay to follow provider. Do not follow provider out of the room if they are on their own/without the class.
- For brief interruptions to observer (i.e. child says hello), carry on observing/coding as able. Use "unable to observe" if needed for longer interruptions
- If a provider goes on break or leaves for an extended period, end observation at that point. If provider takes a brief leave (i.e. quick bathroom break), use "Unable to Observe"

- Information to keep track of on "Observation Notes Page"
    - Number of workers in the room
    - Number of children in room, Age of children in room
    - Age of provider, years of experience
    - Notes/Corrections to make in BORIS
    - Notes regarding anything not appropriately captured with BORIS coding options (include in comments section)

BORIS software protocols

- Open latest BORIS project version through BORIS application
- Create new Observation
    - Naming - **Observation name:** InitialMonthDay_obs# **Example:** a0302_1
    - Enter up front observation info as able
        - Center – site ID previously assigned
        - Children – age group of children being care for by observed provider
        - Count – number of children in classroom of observed provider
        - Workers – number of workers in classroom of observed provider (including observed provider)

- Start/End Observation – match unpaired events as needed (or finish later if you have notes)
- Save project after each observation is done
- Enter situation/activity details for Observation
    - Go to Observations>Edit Observation, then click on the row of the Observation to add detail to – will take you to initial input screen
- Make edits as needed
- Save Project after each Observation is completed
    - Naming - **Project name:** ece#_InitialMonthDay **Example**: ece18_a0302

Appendix D – Director Survey Results Summary

<table>
<tr><th>Question</th><th>Summary of Responses</th></tr>
<tr><td>1a) Number of children in each class currently (max and typical)

DCYF definitions Based on WA state DCYF, age group classification goes like this:
• Infant: 0-11 months; 1:4 caregiver to child
• Toddler: 12-29 months (1-2.4 years old); 1:7 caregiver to child
• Pre-schooler: 30 months - 6 years old (2.5-6 years old); 1:10 caregiver to child</td><td>
<table>
<tr><th>Children age</th><th>Pre-covid</th><th>Mean of # of children in each class currently</th></tr>
<tr><td>Infants</td><td>9</td><td>5.57 (n=7)</td></tr>
<tr><td>Toddlers</td><td>14</td><td>9.88 (n=8)</td></tr>
<tr><td>Preschooler</td><td>20</td><td>13.64 (n=11)</td></tr>
<tr><td>Pre-K</td><td></td><td>16.40 (n=5)</td></tr>
<tr><td>Early learning classroom</td><td></td><td>14 (n=1)</td></tr>
</table>

*Recategorized based on DCYF definition. Some centers have more than one classroom for toddlers and preschoolers.</td></tr>
<tr><td>1b) Number of staff in each class currently (max and typical)</td><td>
<table>
<tr><th>Children age</th><th>Mean of # of staff in each class currently</th></tr>
<tr><td>Infants</td><td>2.33 (n=6)</td></tr>
<tr><td>Toddlers</td><td>2.25 (n=8)</td></tr>
<tr><td>Preschooler</td><td>2.56 (n=9)</td></tr>
<tr><td>Pre-K</td><td>2 (n=5)</td></tr>
<tr><td>Early learning classroom</td><td>2 (n=1)</td></tr>
</table>
</td></tr>
<tr><td>1c) Is each class in a separate room or do some share space?</td><td>Mostly separate. Share some common area e.g., hallway and bathrooms</td></tr>
<tr><td>2) How many staff work with multiple classes or move between multiple groups?</td><td>Range from 0-10. On average 3-4 floaters among classes, sometimes these floaters are leadership team or admin staff</td></tr>
<tr><td>3) Are any of your administrative staff currently working from home?</td><td>Majority no. One center reported only on an ad-hoc basis. Another center reported only marketing, licensing, enrollment staff, director can work remotely.</td></tr>
<tr><td>Section Header: Screening practices
4) What is your current protocol for employee health screening?</td><td>Screening involves temperature checks, self-report symptoms, get tested for COVID asap and 24-72 hours of quarantine, before shift.
One center stopped doing screenings.</td></tr>
</table>

a. How is screening conducted? b. How frequently is screening conducted? c. If someone reports symptoms, what happens next?	
5) What is your current protocol for child health screening? a. How is screening conducted? b. How frequently is screening conducted? c. If someone reports symptoms, what happens next?	Daily screening usually at drop off, parents will do attestation form (self-report symptoms), temperature check. Go home or isolation room if symptoms appear. Rely on communication between parents and school, esp. travel plans.
6) If an employee or child becomes ill or shows signs of illness symptom, is there an isolation area for them to go to?	Mainly yes - use admin room or outdoors. Child gets picked up asap

7. For each of the following: *one center wasn't open prior to the pandemic, sample size = 8 for this question

	What if anything is your center doing differently regarding ___?	How consistently are these changes implemented?
Child drop off/pick-up *(probe: to reduce contact)*	Parents drop off children at the door, parents cannot enter the building anymore. One center reported "none", I.e., no changes.	Consistent
Play time *(probe: to reduce contact, fewer/different supplies)*	Less sharing in general - no more joining class or share toys especially soft toys. Sensory play is more individualized	Consistent
Amount of time spent outdoors	5/8 centers reported spending more time outside. 3/8 reported no change in time spent outdoors.	Consistent
Group gatherings *(probe: still having any?)*	No more in-person group gatherings. Parent meetings gone virtual. Graduation was held outdoors. If gatherings were necessary, they were held outdoors with masks on.	Consistent

Employee and child hand washing *(probe: change in frequency/points in day, supplies used)*	Increased handwashing frequency and vigilance, especially when children arrive the center. Increased use of hand sanitizer. Staff have already been doing a lot of handwashing, COVID further increased awareness and intention.	Consistent
Employee and child use of personal protective equipment	Employees are required to wear masks. Mainly kids 5 years old and up wear masks. Some centers encourage children 2+ and 3+ yo to mask up.	Consistent
Use of supplies shared between classrooms and children *(bedding, bins, toys, etc.)*	Less sharing in terms of supplies. Never shared personal items & adhered to the three-step cleaning regardless of COVID.	Consistent regardless of COVID
Cleaning and/or disinfecting spaces and supplies *(type, areas/objects, frequency, who is responsible)*	Follow CDC guidelines. A lot of centers reported that they have been doing a lot of cleaning regardless of COVID. Though they have increased cleaning solution concentration and frequency.	Consistent regardless of COVID
Opening doors and windows	Opened more windows than before if weather permits. 3/8 centers reported no change.	Consistent
Meal times	6/8 centers reported that they no longer do family style, children eat and get served individually now with sufficient distance.	Consistent

8) What personal protective equipment (PPE) does the center provide employees and what PPE do employees provide themselves (e.g., gloves, masks, face shield)?	Both. Majority said staff used their own PPE but center also provides PPE
8a) How easy or difficult has it been to ensure that employees have sufficient supply of PPE?	PPE were difficult to get in the beginning, it's better now. Gloves stood out to be twice as pricy.

<table>
<tr><td>9) Has your center made, planned, or considered any changes with regard to ventilation systems in the child care center?</td><td>Air filtration system implemented to multiple centers. HVAC updates for a couple centers due to price. 3/9 centers reported no changes or plans to update ventilation systems.</td></tr>
<tr><td>10) What cleaning supplies does the center use to clean, disinfect, and sanitize?</td><td>Bleach, soap, Ecolab commercial cleaning and disinfecting products. Follow the three-step process by DCYF</td></tr>
<tr><td>10a) How easy or difficult has it been to ensure that the center has sufficient supply of cleaning supplies?</td><td>It was difficult at the beginning of the pandemic, not difficult to purchase now. Bleach and hand sanitizers prices went up in the beginning.</td></tr>
<tr><td>10b) Who does the cleaning, disinfecting, and sanitizing at the center?</td><td>Primarily staff during operational hours and professional crew/contractor during off-hours e.g., at night or weekends.</td></tr>
<tr><td>10c) How often does [cleaning, disinfecting, sanitizing) happen?</td><td>Regularly, some centers reported every three hours, some reported after meal time, some reported at the end of the day. Toys and surfaces get cleaned more often. Centers can “deep cleaned” every week or every two weeks by professional cleaners.</td></tr>
<tr><td>11) Overall, what is the biggest change that the center has made or experienced in implementing COVID preventive measures?</td><td>5/9 centers reported Parents cannot enter the building, leads to less interaction and communication between parents and providers.

Other challenges include masking, new sick policy, social distancing, adding outdoor program.</td></tr>
<tr><td>12) Overall, what are the biggest challenges that you have experienced in taking steps to implement COVID preventative measures?</td><td>4/9 centers reported shortage funds for supplies and staffing.
3/9 centers reported trouble accessing the right information - policy changing all the time.
2/9 centers reported parents’ frustration and the stress of the responsibility keeping children safe</td></tr>
<tr><td>13) Is your child care center part of an organization with multiple sites/locations?</td><td>
<table>
<tr><td>No, our center is independent</td><td>Yes, our center is part of a small organization with 10 or fewer childcare sites</td><td>Yes, our center is part of a large organization with more than 10 childcare sites</td></tr>
<tr><td>4 out of 9 centers</td><td>3 out of 9 centers</td><td>2 out of 9 centers</td></tr>
</table>
</td></tr>
</table>

14) How many staff are/were employed at your center now and before the COVID-19 pandemic?

Reporting mean number of teachers

Position type	Currently	Before COVID-19 (around Jan 2020)
Administrative staff	3.78 (n=9)	3 (n=6)
Lead teachers	9.13 (n=8)	9.5 (n=6)
Assistant teachers	11.17 (n=6)	14.4 (n=5)
Other staff	2.14 (n=7)	4.43 (n=7)

15) How many children are/were enrolled at your center now and before the COVID-19 pandemic?

Reporting mean number of children

Age group	Currently	Before COVID-19 (around Jan 2020)
Infants	8.29 (n=7)	9.83 (n=6)
Toddlers	28.71 (n=7)	32.17 (n=6)
Preschool	33.33 (n=6)	41.4 (n=5)
Total (infants, toddlers, preschoolers) Two centers reported totals. One of the two centers was not open prior to COVID	96.5 (n=2)	17.5 (n=2)

16) What percent of children enrolled at your center are on state or local subsidies?

Range: 0-90%

% of children on state or local subsidies	Number of centers
0	4
1-2	2
5	1
80	1
90	1

17) What is the starting hourly pay rate for teaching staff at your center?

Reporting mean staring hourly pay rate

Position	Mean starting hourly rate ($)	Range ($)
Assistant/support staff	$16.65 (n=5)	$15-18
Lead teacher	$19.30 (n=5)	$17-21
General	$15.50 (n=4)	$15-17

18) How many injuries occurred on the job among staff in the past year? Include any requiring medical attention beyond first aid or use of leave, or that were reported

8/9 centers reported zero. One center reported two injuries.

18a) What was the nature of these injuries?

Back and shoulder injuries

19) Which of the following does your center have, if any?

Workplace health and safety document or program	# of centers that have that (N=9)
A written and posted Accident Prevention Plan	3
A written policy or procedure for documenting and responding to employee safety concerns	4
An established Safety Committee	2
An established schedule for emergency/fire drills	9
An employee wellness program	2

<table>
<tr><td>20) How easy or challenging is it to cover staff absences?</td><td>
<table>
<tr><td>0 out of 9 centers</td><td>1- Very easy</td></tr>
<tr><td>1 out of 9 centers</td><td>2- Fairly easy</td></tr>
<tr><td>3 out of 9 centers</td><td>3- Neutral</td></tr>
<tr><td>1 out of 9 centers</td><td>4- Fairly challenging</td></tr>
<tr><td>4 out of 9 centers</td><td>5- Very challenging</td></tr>
</table>
About half reported fairly to very challenging, another half reported fairly easy to neutral.
</td></tr>
<tr><td>21) How does your center typically cover staff absences?</td><td>
<table>
<tr><td>9 out of 9 centers</td><td>We use other staff scheduled to work that day</td></tr>
<tr><td>3 out of 9 centers</td><td>We bring in temporary help</td></tr>
<tr><td>2 out of 9 centers</td><td>Other</td></tr>
</table>
Other methods include having admin or leadership team to cover.
</td></tr>
<tr><td>22) Does your center require that staff take any specific training related to employee safety or health above and beyond state licensing requirements?</td><td>2/9 centers reported yes. Safety topics are provided from Kindercare corporate, while another center said they require staff to be trained on emergency plans, and bloodborne pathogens (BBP)
1/9 center said no but encourage staff to take trainings related to physical health promotion and stress reduction e.g., BBP, CPR
Remaining 6 centers responded no.</td></tr>
<tr><td>23) Does your center offer any specific training or support, or provide financial support for training or support, related to employee safety or health above and beyond state licensing requirements?</td><td>7/9 centers reported yes. Training and support include: in-service health and safety trainings, wellness days/time off, wellness class, financial support
2/9 centers do not offer specific training or support.</td></tr>
<tr><td>24) What do you consider to be the most important health and safety concerns for the child care workforce (aside from the current concerns related to COVID)?</td><td>Mental health was mentioned the most, then physical health and social & economic wellbeing.
Mental health: stress, burnout, overworked, deal with children’s behavioral issues
Physical health and safety: physical demand, exposure to infectious disease (not only COVID)
Social and economic wellbeing: low pay, hard to support family</td></tr>
<tr><td>25) What 2-3 things do you think might help to support the health and safety of the childcare workforce?</td><td>Most providers mentioned better compensation and benefits (Health insurance, time off, vacation days, sick days, PTO). More staff to help was also in the top 3. Then, adult furniture and better/more manageable class sizes. Lastly, more health and safety discussions, trainings</td></tr>
</table>

Appendix E – Simple Lifting Operations Analysis

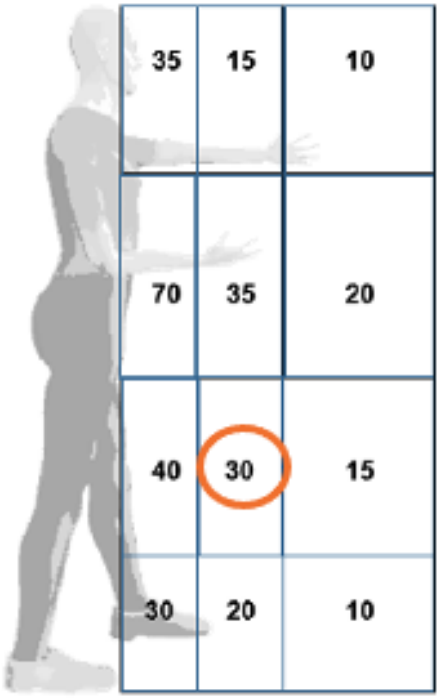
Hazard Zone Checklist - Jobs with intense activities like these, will likely cause sprains and strains.

Calculator for Analyzing Lifting Operations

1 **Enter the weight of the object lifted.**

Weight Lifted
30 Lb.

2 **Circle the number on a rectangle below that corresponds to the position of the person's hands when they begin to lift or lower the objects.**



You can find web and app versions of this calculator here: https://osha.oregon.gov/OSHAPubs/apps/liftcalc/lifting-calculator-app.html

3 **Circle the number that corresponds to the times the person lifts per minute and the total number of hours per day spent lifting.**

Note: For lifting done less than once every five minutes, use 1.0

How many lifts per minute?	How many hours per day?		
	1 hr or less	1 hr to 2 hrs	2 hrs or more
1 lift every 2-5 min	1.0	1.0	0.85
1 lift every min	0.95	0.95	0.7
2-3 lifts every min	0.90	0.85	0.6
4-5 lifts every min	0.85	0.7	0.5
6-7 lifts every min	0.6	0.5	0.35
8-9 lifts every min	0.4	0.30	0.15
10+ lifts every min	0.2	0.1	0.05

4 **Circle 0.85 if the person twists 45 degrees or more while lifting.** 0.85

Otherwise circle 1.0

5 **Copy below the numbers you have circled in steps 2, 3, and 4.**

30 lb.	x	0.85	x	0.85	=	Lifting Limit
Step 2		Step 3		Step 4		21.7 lb.

6 **Is the Weight Lifted (1) less than the lifting Limit (5)?** Yes – OK / No – HAZARD

Appendix F – R code

R code - Thesis on ECE Work and Health

Joycelyn Chui

5/11/2022

Set up

Set working directory, then load necessary packages

```
knitr::opts_chunk$set(echo = TRUE)

setwd("/Users/joycelynchui/Dropbox/JC's Thesis Work/Products")

# load packages as needed with tidyverse and tinytex.
library(tidyverse)
library(tinytex)
library(ggplot2)
library(lattice)
```

Create functions: Mean & SD, Group Stats

```
#Create a function to format the mean and s.d.
mean_sd <- function(x) {
  paste0(round(mean(x, na.rm = TRUE), 2),
         ' (', round(sd(x, na.rm = TRUE), 2), ')')
}
# Create a function to format the range.
min_max <- function(x) {
  paste(round(min(x, na.rm = TRUE), 2), '-',
        round(max(x, na.rm = TRUE), 2))
}
# Create a function to summarize by group variable(s).
# See: https://tidyeval.tidyverse.org/dplyr.html
grouped_stats <- function(.data, .summary_var, ...) {
  summary_var <- enquo(.summary_var)
  .data %>%
    group_by(...) %>%
    summarize(N = sum(childn),
              Mean_SD = mean_sd(!!summary_var),
              Range = min_max(!!summary_var),
              .groups = "drop")
}
# Tables 2-4 only need 1 decimal place display, so create a function to
# format the mean and s.d. with 1 decimal place
mean_sd1 <- function(x) {
```

```
  paste0(round(mean(x, na.rm = TRUE), 1),
         ' (', round(sd(x, na.rm = TRUE), 1), ')')
}
# Create a function to format the range with 1 decimal place#
min_max1 <- function(x) {
  paste(round(min(x, na.rm = TRUE), 1), '-',
        round(max(x, na.rm = TRUE), 1))
}
```

Read Dataset

```
##Read, Rename dataset ###
data <- read_csv("20220228TableData.csv")
```

Data cleaning

- Trim white spaces in the dataset
- Add a column with subsidy enrollment
- Mutate numbers in the “bclass” column to something more meaningful

```
##### Clean dataset ### Trim white spaces
data <- data %>% mutate(childrenage = str_trim(childrenage))

## Add a "subsidy enrollment" column to dataset

data <- data %>%
  mutate(subsidyenrollment = ifelse(center %in% 2, "High",
                           ifelse(center %in% 9,
                                  "High", "Low")))
data %>% group_by(center, subsidyenrollment) %>% summarise()

## bclass: 1=state (tables 3.1-3.3); 2=situation (table 2); 3=point hazards(t
ables 4.1-4.3)
## mutate data from numbers to meaningful categories with if-else
data <- data %>%
  mutate(bclass = ifelse(bclass %in% 2, "situation",
                                 ifelse(bclass %in% 1,
                                        "state event", "point hazard")))
```

- “pcttime” is percentage of time in a certain situation/posture
- “halfrate” is the number of point hazards happened in a standardized timeframe, 30 mins
- “noccurrence” is the number of behavior or point hazard happened in one observation

Table 1: Descriptive Table

```
# add column to calculate ratio
data.dedup <- data %>%
  mutate(ratio = childn/workern) %>%
  distinct(childn, workern, ratio, tenure, obsnum, .keep_all=TRUE)

# compute sub-totals first
```

```
t1subtotals <- data.dedup %>%
  group_by(centersize, subsidyenrollment, center, childrenage) %>%
  summarise(
    'Number of children' = mean_sd(childn),
    'Number of staff' = mean_sd(workern),
    'ECE Mean age (SD)' = mean_sd(eceage),
    'Tenure Mean (SD)' = mean_sd(tenure),
    'Length Mean (SD)' = mean_sd(lengthminute),
    'Ratio' = round(`ratio`, 2),
    N = n()) %>%
select(`centersize`, `center`, `subsidyenrollment`, `childrenage`, `Number of
 children`,
       `Number of staff`, `Ratio`, `ECE Mean age (SD)`, `Tenure Mean (SD)`, `
N`,
       `Length Mean (SD)`)

## `summarise()` regrouping output by 'centersize', 'subsidyenrollment', 'cen
ter',
## 'childrenage' (override with `.groups` argument)

# then, compute a total for each center
t1total <- data.dedup %>%
  group_by(center, centersize, subsidyenrollment) %>%
  summarise(
    N=n(),
    'Number of children' = sum(childn),
    'Number of staff' = sum(workern),
    'ECE Mean age (SD)' = mean_sd(eceage),
    'Tenure Mean (SD)' = mean_sd(tenure),
    'Length Mean (SD)' = mean_sd(lengthminute)) %>%
  mutate(Ratio = `Number of children`/`Number of staff`, round(`Ratio`, 2))
 %>%
  mutate(childrenage = "Total") %>%
  select(`centersize`, `center`, `subsidyenrollment`, `childrenage`, `Number
of children`,
         `Number of staff`, `Ratio`, `ECE Mean age (SD)`, `Tenure Mean (SD)`,
 `N`,
         `Length Mean (SD)`)

## `summarise()` regrouping output by 'center', 'centersize' (override with
## `.groups` argument)

# finally, compute a row for grant total
t1.grand.tot <- data.dedup %>%
  summarise(
    centersize = 'Total',
    center = NA,
    subsidyenrollment = NA,
    'Number of children' = sum(childn),
    'Number of staff' = sum(workern),
    'ECE Mean age (SD)' = mean_sd(eceage),
```

```
    'Tenure Mean (SD)' = mean_sd(tenure),
    'Length Mean (SD)' = mean_sd(lengthminute),
    N = n(), na.rm=TRUE) %>%
  mutate(Ratio = `Number of children`/`Number of staff`, round(`Ratio`, 2))
 %>%
  mutate(childrenage = "Total") %>%
  select(`centersize`, `center`, `subsidyenrollment`, `childrenage`, `Number
of children`,
         `Number of staff`, `Ratio`, `ECE Mean age (SD)`, `Tenure Mean (SD)`,

         `N`, `Length Mean (SD)`)
```

Table 2: Classroom situations

```
## Table 2 (Situations) results, aggregate by children age
situations <- data %>%
  filter(bclass == "situation") %>%
  group_by(behavior, childrenage, outdoor) %>%
  summarise(N=n(),
            "Mean number of occurences per observation" = round(mean(noccurre
nce), 1),
            "Mean (SD)" = mean_sd1(pcttime)) %>%
  pivot_wider(id_cols = c(behavior, outdoor),
              names_from = childrenage, values_from = c(N, `Mean number of oc
curences per observation`,
                                                        `Mean (SD)`)) %>%
  select(`outdoor`, `behavior`, `Mean number of occurences per observation_In
fant`,
         `Mean (SD)_Infant`, `Mean number of occurences per observation_Toddl
er`,
         `Mean (SD)_Toddler`, `Mean number of occurences per observation_Pre-
schooler`,
         `Mean (SD)_Pre-schooler`, `Mean number of occurences per observation
_Mixed`,
         `Mean (SD)_Mixed`) %>%
  arrange(outdoor, behavior)

## `summarise()` regrouping output by 'behavior', 'childrenage' (override wit
h
## `.groups` argument)

names(situations)

## Table 2 totals (Situation), not aggregate by children age (total)
totalsituation <- data %>%
  filter(bclass == "situation") %>%
  group_by(behavior, outdoor) %>%
  summarise(N = n(),
            "Mean number of occurences" = mean(noccurrence),
            "Mean (SD)" = mean_sd1(pcttime),
```

```
            "Range (Min-Max)" = min_max1(pcttime)) %>%
   arrange(outdoor, behavior)

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)

t2 <- situations %>% inner_join(totalsituation, by = c('outdoor','behavior'))
```

Table 3.1: Behaviors/state events summary

```
##Summary tables
## The key is to ensure rows collapse correctly. The goal is to collapse modi
fiers, so we need to sum by behavior & pct time
## then take mean and SD across behaviors
t3.dedup <- data %>%
  filter(bclass == "state event") %>%
  group_by(outdoor, behavior, obsnum) %>%
  summarise("Total % time per behavior per obs" = sum(pcttime),
            "Total # of occurences per behavior per obs" = sum(noccurrence))

## `summarise()` regrouping output by 'outdoor', 'behavior' (override with
## `.groups` argument)

t3summary <- t3.dedup %>%
  group_by(outdoor, behavior) %>%
  summarise("Mean # of occurences" = round(mean(`Total # of occurences per be
havior per obs`),1),
            "Mean % time (SD)" = mean_sd1(`Total % time per behavior per obs
`),
            "Range (Min - Max)" = min_max1(`Total % time per behavior per obs
`)) %>%
  arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                                      'Sit floor', 'Stand', 'Walk',
                                      'Bent over', 'Kneel', 'Squat',
                                      'lie down', 'In motion', 'Run',
                                      'Unable to observe'))) %>%
  arrange(outdoor)

## `summarise()` regrouping output by 'outdoor' (override with `.groups` argu
ment)

## Table 3 sub-totals, aggregate by children age
t3subtotal <- data %>%
  filter(bclass == "state event") %>%
  group_by(behavior, childrenage, outdoor) %>%
  summarise(N = n(),
            "Mean # of occurences" = round(mean(noccurrence),1),
            "Mean % time (SD)" = mean_sd1(pcttime)) %>%
  mutate(`Number of obs` = N) %>%
  pivot_wider(id_cols = c(behavior, outdoor),
              names_from = childrenage, values_from = c(`Number of obs`,
                                                        `Mean % time (SD)`,
```

```
                                                          `Mean # of occurences
`)) %>%
  select(`outdoor`, `behavior`, `Number of obs_Infant`,`Mean # of occurences_
Infant`,
         `Mean % time (SD)_Infant`, `Number of obs_Toddler`,
         `Mean # of occurences_Toddler`,`Mean % time (SD)_Toddler`,
         `Number of obs_Pre-schooler`,`Mean # of occurences_Pre-schooler`,
         `Mean % time (SD)_Pre-schooler`,
         `Number of obs_Mixed`,`Mean # of occurences_Mixed`,
         `Mean % time (SD)_Mixed`) %>%
  arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                                      'Sit floor', 'Stand', 'Walk',
                                      'Bent over', 'Kneel', 'Squat',
                                      'lie down', 'In motion', 'Run',
                                      'Unable to observe'))) %>%
  arrange(outdoor)

## `summarise()` regrouping output by 'behavior', 'childrenage' (override wit
h
## `.groups` argument)

## Join summary tables
t3 <- t3subtotal %>% inner_join(t3summary, by = c('behavior', 'outdoor'))
```

Table 3.2: Behaviors/state events, indoor with modifiers

```
## State events, with modifiers, indoor
state_mod_in <- data %>%
  filter(bclass == "state event", outdoor == 0) %>%
  group_by(behavior, modifier, childrenage) %>%
  summarise(N = n(),
            "Mean number of occurrences" = round(mean(noccurrence), 1),
            "Mean % of time (SD)" = mean_sd1(pcttime))%>%
  mutate(`Number of obs` = N) %>%
  pivot_wider(id_cols = c(behavior, modifier),
              names_from = childrenage, values_from = c(`Number of obs`,`Mean
 % of time (SD)`,
                                                        `Mean number of occur
rences`)) %>%
  select(`behavior`, `modifier`,
         `Number of obs_Infant`,`Mean number of occurrences_Infant`,
         `Mean % of time (SD)_Infant`,
         `Number of obs_Toddler`,
         `Mean number of occurrences_Toddler`,
         `Mean % of time (SD)_Toddler`, `Number of obs_Pre-schooler`,
         `Mean number of occurrences_Pre-schooler`, `Mean % of time (SD)_Pre-
schooler`,
         `Number of obs_Mixed`, `Mean number of occurrences_Mixed`,
         `Mean % of time (SD)_Mixed`) %>%
  arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                                      'Sit floor', 'Stand', 'Walk',
```

```
                                    'Bent over', 'Kneel', 'Squat',
                                    'lie down', 'In motion', 'Run',
                                    'Unable to observe')))

## `summarise()` regrouping output by 'behavior', 'modifier' (override with
## `.groups` argument)

## Below is state events with modifiers, indoors, not aggreate by childrenage

totalstate_mod_indoor <- data %>%
  filter(bclass == "state event", outdoor == 0) %>%
  group_by(behavior, modifier) %>%
  summarise(N = n(),
            "Mean number of occurences" = round(mean(noccurrence),1),
            "Mean % of time (SD)" = mean_sd1(pcttime),
            "Range (Min - Max)" = min_max1(pcttime)) %>%
  mutate(`Number of obs` = N) %>%
  select(-N) %>%
  arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                                    'Sit floor', 'Stand', 'Walk',
                                    'Bent over', 'Kneel', 'Squat',
                                    'lie down', 'In motion', 'Run',
                                    'Unable to observe')))

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)

## Join the above two tables. Result = table for indoor state events, with mo
ds
t3.2_indoor_join <- state_mod_in %>%
  inner_join(totalstate_mod_indoor, by = c('behavior', 'modifier'))
```

Table 3.3: Behaviors/state events, outdoor with modifiers

```
## Table 3 (State events) results, aggregate by children age, have modifiers!

## separate out indoor vs outdoor. Below is state events with modifiers, outd
oor
state_mod_out <- data %>%
  filter(bclass == "state event", outdoor == 1) %>%
  group_by(behavior, modifier, childrenage) %>%
  summarise(N = n(),
            "Mean number of occurrences" = round(mean(noccurrence), 1),
            "Mean % of time (SD)" = mean_sd1(pcttime))%>%
  mutate(`Number of obs` = N) %>%
  pivot_wider(id_cols = c(behavior, modifier),
              names_from = childrenage, values_from = c(`Number of obs`,`Mean
 % of time (SD)`,
                                                        `Mean number of occur
rences`)) %>%
    select(`behavior`, `modifier`, `Number of obs_Toddler`,
```

```
           `Mean number of occurrences_Toddler`,
          `Mean % of time (SD)_Toddler`, `Number of obs_Pre-schooler`,
          `Mean number of occurrences_Pre-schooler`, `Mean % of time (SD)_Pre
-schooler`,
          `Number of obs_Mixed`, `Mean number of occurrences_Mixed`,
          `Mean % of time (SD)_Mixed`) %>%
   arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                            'Sit floor', 'Stand', 'Walk',
                            'Bent over', 'Kneel', 'Squat',
                            'lie down', 'In motion', 'Run',
                            'Unable to observe')))

## `summarise()` regrouping output by 'behavior', 'modifier' (override with
## `.groups` argument)

## Below is state events with modifiers, outdoors, not aggreate by childage
totalstate_mod_outdoor <- data %>%
  filter(bclass == "state event", outdoor == 1) %>%
  group_by(behavior, modifier) %>%
  summarise(N = n(),
            "Mean number of occurences" = round(mean(noccurrence),1),
            "Mean % of time (SD)" = mean_sd1(pcttime),
            "Range (Min - Max)" = min_max1(pcttime)) %>%
  mutate(`Number of obs` = N) %>%
  select(-N) %>%
  arrange(factor(behavior, levels = c('Mask off', 'Sit chair',
                                      'Sit floor', 'Stand', 'Walk',
                                      'Bent over', 'Kneel', 'Squat',
                                      'lie down', 'In motion', 'Run',
                                      'Unable to observe')))

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)

## Join the above two tables. Result = table for outdoor state events, with m
ods
t3.3_outdoor_join <- state_mod_out %>%
  inner_join(totalstate_mod_outdoor, by = c('behavior', 'modifier'))
```

Table 3.4: Mask-off behaviors, indoor and outdoor with modifiers Table was build by extracting “mask-off” rows from tables 3.2

Table 4.1: Point hazards summary

```
## Table 4 summary, subtotals
t4.dedup <- data %>%
  filter(bclass == "point hazard") %>%
  group_by(outdoor, behavior, obsnum) %>%
  summarise("# of occurences per obs" = sum(halfrate))
```

```
## `summarise()` regrouping output by 'outdoor', 'behavior' (override with
## `.groups` argument)

t4summary <- t4.dedup %>%
  group_by(outdoor, behavior) %>%
  summarise("Mean # of occurences per obs" = mean_sd1(`# of occurences per ob
s`),
            "Range (Min - Max)" = min_max1(`# of occurences per obs`)) %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected'))) %>%
  arrange(outdoor)

## Warning in min(x, na.rm = TRUE): no non-missing arguments to min; returnin
g Inf

## Warning in max(x, na.rm = TRUE): no non-missing arguments to max; returnin
g -Inf

## `summarise()` regrouping output by 'outdoor' (override with `.groups` argu
ment)

## Table 4 sub-totals
t4subtotal <- data %>%
  filter(bclass =="point hazard") %>%
  group_by(behavior, childrenage, outdoor) %>%
  summarise("Mean number of occurrences (SD)" = mean_sd1(halfrate)) %>%
  pivot_wider(id_cols = c(behavior, outdoor),
              names_from = childrenage, values_from = c(
                                      `Mean number of occurrences (SD)`)) %>%

  select(`outdoor`, `behavior`, `Infant`, `Toddler`, `Pre-schooler`, `Mixed`)
 %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected'))) %>%
  arrange(outdoor)

## `summarise()` regrouping output by 'behavior', 'childrenage' (override wit
h
## `.groups` argument)
```

```
## Join table 4 summary tables
t4 <- t4subtotal %>% inner_join(t4summary, by = c('behavior', 'outdoor'))
```

Table 4.2: Point hazards, indoor with modifiers

```
point_mod_in<- data %>%
  filter(bclass =="point hazard", outdoor == 0) %>%
  group_by(behavior, modifier, childrenage) %>%
  summarise(N = n(),
            "Mean number of occurrences (SD)" = mean_sd1(halfrate)) %>%
  pivot_wider(id_cols = c(behavior, modifier),
              names_from = childrenage, values_from = c(N,
                                                        `Mean number of occur
rences (SD)`)) %>%
  select(`behavior`,`modifier`,
         `N_Infant`,`Mean number of occurrences (SD)_Infant`,
         `N_Toddler`,`Mean number of occurrences (SD)_Toddler`,
         `N_Pre-schooler`, `Mean number of occurrences (SD)_Pre-schooler`,
         `N_Mixed`,`Mean number of occurrences (SD)_Mixed`) %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected')))

## `summarise()` regrouping output by 'behavior', 'modifier' (override with
## `.groups` argument)

## Below is point hazards with modifiers, indoors, not aggreate by childage
totalpoint_mod_in<- data %>%
  filter(bclass =="point hazard", outdoor == 0) %>%
  group_by(behavior, modifier) %>%
  summarise(N = n(),
            "Mean number of occurrences (SD)" = mean_sd1(halfrate),
            "Range (Min - Max)" = min_max1(halfrate)) %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected')))

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)
```

```
## Join the above two tables. Result = table for outdoor point hazards, with
mods
t4_indoor_join <- point_mod_in %>%
  inner_join(totalpoint_mod_in, by = c('behavior', 'modifier'))
```

Table 4.3: Point hazards, outdoor with modifiers

```
#Below is point hazards with modifiers, outdoors, agg by children age
point_mod_out<- data %>%
  filter(bclass =="point hazard", outdoor == 1) %>%
  group_by(behavior, modifier, childrenage) %>%
  summarise(N = n(),
            "Mean number of occurrences (SD)" = mean_sd1(halfrate)) %>%
  pivot_wider(id_cols = c(behavior, modifier),
              names_from = childrenage, values_from = c(N,
                                                        `Mean number of occur
rences (SD)`)) %>%
  select(`behavior`,`modifier`, `N_Toddler`,`Mean number of occurrences (SD)_
Toddler`,
       `N_Pre-schooler`, `Mean number of occurrences (SD)_Pre-schooler`,
       `N_Mixed`,`Mean number of occurrences (SD)_Mixed`) %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected')))

## `summarise()` regrouping output by 'behavior', 'modifier' (override with
## `.groups` argument)

## Below is point hazards with modifiers, outdoors, not aggreate by childage
totalpoint_mod_out<- data %>%
  filter(bclass =="point hazard", outdoor == 1) %>%
  group_by(behavior, modifier) %>%
  summarise(N = n(),
            "Mean number of occurrences (SD)" = mean_sd1(halfrate),
            "Range (Min - Max)" = min_max1(halfrate)) %>%
  arrange(factor(behavior, levels = c('Quick lean/twist', 'Quick squat/kneel
',
                                      'Lift child', 'Lift object',
                                      'Cleaning product use', 'Hand sanitizer
',
                                      'Wash hands', 'Biohazard',
                                      "Diaper, toileting", "Push or pull",
                                      'Other hazard', 'Unexpected')))

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)
```

```
## Join the above two tables. Result = table for outdoor point hazards, with
mods
t4_outdoor_join <- point_mod_out %>%
  inner_join(totalpoint_mod_out, by = c('behavior', 'modifier'))
```

Graphs

Table 3.1: State events –> box plot show % of time indoors, one for total, one for each age group (infants, toddlers, preschoolers) Source: Make dataframe to plot box plots

```
plot3.data <- data %>%
  filter(bclass == "state event", outdoor == "0", behavior != "Mask off") %>%

  group_by(behavior, obsnum) %>%
  summarise("% time in behavior" = sum(pcttime))

## `summarise()` regrouping output by 'behavior' (override with `.groups` arg
ument)

plot3.subdata <- data %>%
  filter(bclass == "state event", outdoor == "0",
         behavior != "Mask off", childrenage != "Mixed") %>%
  group_by(behavior, childrenage) %>%
  summarise("% time in behavior" = (pcttime))

## `summarise()` regrouping output by 'behavior', 'childrenage' (override wit
h
## `.groups` argument)

write.csv(plot3.data, file = "/Users/joycelynchui/Dropbox/JC's Thesis Work/Pr
oducts/plot3.data.csv", row.names = F)
write.csv(plot3.subdata, file = "/Users/joycelynchui/Dropbox/JC's Thesis Work
/Products/plot3.subdata.csv", row.names = F)

plot3.data$behavior <- factor(plot3.data$behavior, levels = c("Unable to obse
rve",
                                                              "In motion", "l
ie down",
                                                              "Sit floor", "K
neel",
                                                              "Squat", "Bent
over",
                                                              "Sit chair", "S
tand",
                                                              "Walk" ))

boxplot(`% time in behavior`~behavior, data = plot3.data,
        main = "Percent Time Spent On Indoor Postures",
        ylab = " ", xlab= "% Time In a Posture",
        horizontal = TRUE,
```

```
        ylim=c(0,80),
        las=2)

ggplot(plot3.subdata, aes(x =`% time in behavior`, y=behavior,
                          color=childrenage)) + geom_boxplot()
```

Table 4.1: point hazards –> box plot show mean # of point hazards, esp. quick lean/twist, lift child, lift object. One for total, one for each age group (infants, toddlers, preschoolers)

```
plot4.data <- data %>%
  filter(bclass == "point hazard", behavior %in% c("Quick lean/twist",
                                                   "Lift child", "Lift object
")) %>%
  group_by(behavior, outdoor, obsnum) %>%
  summarise("Mean # of point hazards" = (halfrate)) %>%
  arrange(outdoor)

## `summarise()` regrouping output by 'behavior', 'outdoor' (override with
## `.groups` argument)

plot4.subdata <- data %>%
  filter(bclass == "point hazard", childrenage!= "Mixed", behavior %in% c("Qu
ick lean/twist",
                                                   "Lift child", "Lift object
")) %>%
  group_by(outdoor, behavior, childrenage) %>%
  summarise("# of point hazards/30 mins" = (halfrate))

## `summarise()` regrouping output by 'outdoor', 'behavior',
## 'childrenage' (override with `.groups` argument)

write.csv(plot4.data, file = "/Users/joycelynchui/Dropbox/JC's Thesis Work/Pr
oducts/plot4.data.csv", row.names = F)
write.csv(plot4.subdata, file = "/Users/joycelynchui/Dropbox/JC's Thesis Work
/Products/plot4.subdata.csv", row.names = F)

boxplot(`Mean # of point hazards` ~ behavior, data = plot4.data,
        main = "Number of Point Hazards Observed",
        ylab = " ", xlab= "Number of Point Hazards",
        horizontal = TRUE,
        ylim=c(0,80),
        las=2)

ggplot(plot4.subdata, aes(x =`# of point hazards/30 mins`, y=behavior,
                          color=childrenage)) + geom_boxplot()
```