

Illnesses and Injuries at Nature Preschools

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Abstract

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This study investigated the incidence of illness and injury at nature preschools compared to conventional preschools. For 14 weeks, teachers at five nature and four conventional preschools logged the number of child absences due to illness and the number of injuries that occurred at preschool. This study found no difference in illness incidence by preschool type and no serious injuries during the course of the study. Girls at nature preschools had a higher incidence of minor injury compared to girls at conventional preschools. For boys, no significant differences in minor injuries by type of preschool were noted. Overall, the study found that nature preschools are a healthy and safe child care model.

Introduction

Time spent outdoors in natural environments has been shown to yield physical, cognitive, and emotional benefits for young children. Outdoor environments promote physical activity and active play that are associated with healthy gross motor development [1]. Motor development is supported both through the physical exertion and physical challenges of playing on the varied features and uneven surfaces typical of the natural environment [2, 3]. Outdoor physical activity is also associated with other physical health benefits for children, such as lower obesity, decreased near-sightedness and improved Vitamin D levels, necessary for healthy bone development [4-7].

In addition to physical health benefits, exposure to nature and outdoor play have been shown to make positive contributions to children's social and emotional development, including increased cooperation, creativity, self-discipline and lowered levels of stress [8-11]. Children also benefit cognitively from time in nature through improved problem-solving abilities, increased attention, and reduced symptoms of attention-deficit hyperactivity disorder [9, 12-14].

While the evidence regarding the many benefits of children's outdoor exposure is growing, outdoor play opportunities for preschoolers residing in urban areas are limited. The American Academy of Pediatrics recommends that preschool age children get 60-90 minutes of outdoor time each day [15]. A study of Washington State's child care programs found that most centers provided less than the recommended amount of daily outdoor time for young children [16]. Another study found that conventional child-care centers provided an average of only 33 minutes of outdoor active play per day [17]. Furthermore, in a nationally representative U.S. sample, less than half of preschool age children were reported to play outdoors with their parents on a daily basis [18].

As parents and educators become increasingly aware of the benefits of time spent outdoors, nature preschools have been gaining in popularity. In nature preschools, exposure to nature is the organizing principle of the program, and both early childhood education and environmental education are emphasized [19]. The nature preschool model is popular in Europe, particularly in Scandinavia and Germany. The German government recognized nature preschools (also called Waldkindergartens or forest kindergartens) as a legitimate form of child care in the 1990's and started to offer subsidies for children to attend, which dramatically increased the number of nature preschools to over 1,000 by 2014 [19]. The movement in the U.S. has been lagging behind Europe, but has accelerated in recent years. Since its inception in 2014, the Natural Start Alliance, a coalition dedicated to connecting young children to nature, has brought together over 230 nature preschools across the U.S. [20]. In May of 2017 the first bill to license nature preschools in the U.S. was passed in Washington State [21]. This historic piece of legislation demonstrates the strong interest of educators, parents, and policy makers in expanding the nature preschool model in the Pacific Northwest, a pioneering step for the licensing of nature preschools across the country.

While interest continues to mount for this alternative model of early childhood education, little research has focused on the health and safety implications for children of spending the preschool day out of doors. To date, there is no research regarding the incidence of illness among children at fully outdoor nature preschools compared to conventional preschools where most of the children's time is spent indoors. Two studies, one conducted in Denmark and one in Sweden, evaluated the effects of outdoor time at preschool on the incidence of illness and reported mixed results. The Danish study found no association between outdoor time and risk of illness, and the Swedish study found that exposure to outdoor time was associated with

decreased illness incidence [22, 23]. A study conducted in Norway compared illnesses between children at outdoor and conventional preschools; however, preschools were classified as outdoor if they spent a minimum of 3.5 hours outside per day. This method of categorization of outdoor preschools included schools where children spent some of their day indoors [24]. No difference was found in the incidence of illness between the outdoor and conventional preschools. However, since contagious illnesses are often spread via contact with shared surfaces, even limited time indoors could increase the incidence of illness. These studies do not directly address the question of whether health outcomes of children who attend outdoor preschools differ from health outcomes of children who attend indoor preschools.

Nature preschools could plausibly demonstrate either a lower or a higher incidence of illness than conventional preschools. Several considerations suggest a decreased risk of infectious disease. First, nature preschools may present fewer shared surfaces to touch and spread infectious agents. Additionally, children at nature preschools may be less likely to inhale airborne viruses since they spend all day outdoors in fresh air [25]. Third, there is evidence that natural exposures may enhance immune activity [26-28]. On the other hand, outdoor exposure may confer an increased risk. Some research has shown that exposure to cold temperatures and low humidity, as well as changes in temperature and humidity, are associated with an increased risk of respiratory illnesses [29].

Children attending nature and conventional preschools may also differ in their risk of injury. More than half of injuries at preschools occur outdoors, with most medically attended injuries occurring on playground equipment [30-32]. Children at nature preschools have greater opportunity to be physically active than children at conventional preschools who spend most of their preschool day indoors. Increased physical activity plus a potentially less predictable play environment may increase the risk of injuries for children at nature preschools. On the other hand, children at nature preschools spend less time on playground equipment compared to children at conventional preschools, which could decrease their risk of serious injury. Furthermore, engaging in outdoor play and risk-taking behaviors provides children with physical and cognitive challenges that improve their problem-solving abilities and can help them push their limits [2, 33-37]. Outdoor play has also been shown to help improve children's motor skill development, which may decrease their injuries as they become more physically confident and competent [2, 37].

The primary aim of this study was to compare the incidence of illness and injury among children attending nature and conventional preschools. We hypothesized that the incidence of illness and injury would differ for children enrolled in nature preschools compared to children attending conventional preschools. The hypothesized difference could be in the direction of either higher or lower incidence of illness and injury in outdoor preschool settings. A secondary aim of the study was to determine the feasibility of utilizing a standardized tool to collect illness and injury data at preschools. Study findings will serve as a platform for larger scale research efforts to evaluate the health effects of outdoor preschools. Additionally, the study will assist educators, researchers, and policy makers in considering methods for standardizing the collection of health outcome data in preschool settings.

Methods

Prospective Cohort Study

Study Design and Setting

We designed a prospective cohort study to compare the incidence of illness and injury between children attending nature preschools and conventional preschools. The study was conducted over the course of 14 weeks at five nature preschool sites and four conventional preschools in Seattle, Washington. All nature preschool sites were a part of the local non-profit organization Tiny Trees Preschool. Nature preschools did not have any indoor structures and were located at city park sites approved by the Seattle Parks and Recreation Department. Conventional preschools were held in buildings with indoor classrooms and adjoining outdoor play areas.

Ethical Considerations

The University of Washington Human Subjects Division advised the lead investigator that the study was not considered to be human subjects research since the investigator did not directly collect data from participants, and teachers did not share identifiable participant information with the investigator. Therefore informed consent was not required.

Recruitment and Subjects

Eligibility criteria for all preschools included meeting five days a week for four to six hours a day. Conventional preschools were invited if less than 1.5 hours was spent outdoors each day. A total of 141 children were included in the study, 71 from nature preschools and 70 from conventional preschools. The children's ages ranged from two to five years.

Due to an interest in quantifying health outcomes for children attending nature preschools, Tiny Trees volunteered five of its preschools to participate in the study. Conventional preschools in Seattle were invited to participate through an introductory email describing the study and at least one follow-up phone call. Preschools were contacted if they were believed to have a five day a week, four to six hour school day program. Four conventional preschools were successfully recruited from an initial pool of 36 Seattle preschools that were invited between July and September 2016. A list of Seattle preschools, accumulated through prior research was provided by an author of this study, and was used to establish which preschools to contact. Initially, we intended to recruit conventional preschools in the same zip codes as the nature preschools, but to meet recruitment goals, we broadened our search to include preschools throughout Seattle. Of the 36 preschools, three did not fit study criteria either due to the length of the school day exceeding six hours or spending more than 1.5 hours of outdoor time a day. Of the 33 eligible preschools, eight declined to participate, and 21 did not respond to emails or phone calls.

Illness and Injury Data Collection Instrument

A weekly illness and injury tracking log was developed to standardize illness and injury recording across all preschools. The log was created based on input from nine key informant interviews with preschool teachers and other school health professionals. The weekly logs were printed front and back on 8.5 by 11 inch paper. The log contained one row per child to allow for daily tracking of each child's illnesses and injuries. Binders were assembled for each preschool that contained enough logs to last the duration of the study. The lead author held a meeting in

each of the nine participating preschool to train teachers on use of the tracking log. The illness and injury tracking log is included in Appendix A.

Data Collection

Preschool teachers collected illness and injury data for each child at participating preschools. Data on daily illnesses and injuries were recorded for 14 weeks from mid-September to mid-December, 2016. One conventional preschool started recording one week earlier than the other preschools, and one conventional preschool started the third week of the study.

If a child was absent or sent home due to illness, the teacher indicated the child's illness symptoms (fever, respiratory, stomach, other) and if he or she received professional medical attention (yes, no, unknown). Similarly, if a child had an injury requiring first-aid attention, teachers were asked to indicate the type of injury (open wound/cut, sprain/strain/twist, bite, other) and whether the child received professional medical attention (yes, no, unknown).

Preschool teachers were asked to scan and return the de-identified logs by email on a weekly basis. Teachers used a variety of methods to submit logs including emailing scanned copies, emailing photos of the logs or uploading photos of the logs to a cloud-based server.

The lead author telephoned or emailed preschool teachers if logs were not submitted within one or two weeks from the week of data collection. To encourage timely data collection and reporting, preschool teachers were sent two thank you cards with \$5 Starbucks gift cards at the sixth and tenth weeks of the study. At the end of the study all preschools received a \$50 Amazon gift card in appreciation of their participation.

Operationalizing Illness Episodes and Injury Events

The number of illness episodes was the primary illness outcome of interest. An episode of illness was defined to occur when a child was absent for at least one day due to illness. If a child returned to school for a full day, the illness episode was considered over. A secondary illness outcome was the total number of days that a child was absent due to illness over the duration of the study.

The second outcome of interest was the number of injuries. An injury was counted if it required first-aid attention from teachers, which included the use of Band-Aids or icepacks, or if it required medical attention.

Measurement of Preschool Characteristics

The lead author made at least one site visit to each preschool during the course of the study for the purpose of characterizing the outdoor settings. A checklist was used during site visits to document aspects of the preschool environments that might have contributed to illness or injury. The checklist documented the type of outdoor environment (e.g. forest, field, concrete, etc.), cover from rain (present/not present and type), and playground equipment (description of size and ground covering). Descriptions of eating and handwashing areas and procedures and the teacher to child ratio for each classroom were also documented.

Measurement of Child Characteristics

Preschool teachers assigned each child an identification number, and the lead author was provided with de-identified data. Each preschool recorded data on a set of child characteristics that might have differed between outdoor and indoor preschools and been associated with illness or injury. These potential confounders included child age, sex, pre-existing medical condition (yes/no and a description), vaccination status (up to date/not up to date), afterschool care attendance (yes/no), preschool subsidy received (yes/no), and home zip code.

Children's month and year of birth were used to calculate their age at the start of the study. Home zip code was used to ascertain median income for family households within the zip code area, using data from the 2015 American Community Survey [38]. This measure was used as a proxy for household socio-economic status.

Data Analysis

The incidence of illness episodes was calculated over the duration of the study for nature and conventional preschools using child-days expected at preschool as the denominator. Any day when the preschool was open and the child was enrolled to attend was counted as a child-day expected at preschool. Incidence rates of specific types of illness (fever, respiratory, stomach, other) were calculated in the same manner.

The incidence of injury was calculated using child-days in attendance at preschool as the denominator. Child-days in attendance were days during which a child was present at school. Each child-day was standardized to be equivalent to four child-hours present at school so that the denominators of child-days were comparable between preschools with four hour and six hour school days. Each school day a child was present for the six hour/day preschool counted as 1.5 child-days present. The incidence rates of specific types of injury (open wound/cut, sprain/strain/twist, bite, other) were calculated using the same approach.

Poisson regression models were used to calculate the incidence rate ratio (IRR) and 95% confidence interval of illnesses and injuries, comparing nature and conventional preschools. Each child was included in the model as a unit of observation. A two-sided hypothesis test was used, as the direction of differences between outdoor and conventional preschools in the incidence of illness and injury were not specified in the hypotheses. The z-statistic with an alpha level of .05 was used to determine statistical significance of the results. The likelihood ratio test was used to evaluate factors that appeared to modify the effect of preschool type on study outcomes. Potential confounders were adjusted for if doing so resulted in at least a 10% change from the crude incidence risk ratio.

Age was the only child characteristic to meet criteria for a confounding variable and was included as an indicator variable in the Poisson models. The models were offset by child-days expected in preschool for the illness analysis and child-days in attendance at preschool for the injury analysis. The injury model was stratified by sex, when it was determined that the effect of preschool type on the incidence of minor injury differed for girls and boys. Data from three nature preschools and one conventional preschool that did not adhere to the study protocol for documenting injuries were dropped from the injury analysis.

All data analyses were conducted using Stata version 14.2.

Results

Prospective Cohort Study Results

Characterization of the Preschool Environments

Nature Preschools

The environments of the five nature preschools in their respective park locations were similar. Each had areas with tree cover, as well as open space. Several distinct areas were marked off with rocks and other natural features for daily activities.

At the time of the study, there were no procedures in place to license nature preschools by the Washington State Department of Early Learning, therefore the nature preschools were not licensed. The minimum teacher to child ratio was 1:8, and sometimes a parent volunteer was present to provide additional assistance. The number of children enrolled in each nature preschool ranged between 13 and 16.

Each child was provided with a full body waterproof suit to stay warm and dry. Tarps were used on rainy, cold, or windy days to provide dry spaces and shelter for preschool activities. Portable battery-powered heaters were also used to provide additional warmth on particularly cold days. In the case of extreme weather conditions, each nature preschool had access to a shelter structure or building. However, these structures were never used during the course of the study. During the study period the average temperature was 52 degrees Fahrenheit, with at least 0.1 inches of rain falling on 40 of the 70 study days (57%) [39, 40].

Each preschool had a woodchip pile for children to play in. Children were encouraged to play in the natural environment and had plastic tools and toys such as buckets, hand shovels, and toy dump trucks that facilitated their exploration. Although the nature preschools were located in parks with playground equipment, children did not play on the equipment during the school day.

Children ate lunch and snacks in eating areas with various seating arrangements including the use of stumps or logs or small plastic tables. Children ate lunches brought from home; snacks were served by teachers on plastic plates provided by the preschool. Teachers at all but one preschool location took dishes home to wash due to lack of access of a place to wash dishes on site. One preschool was able to use a park learning center to wash dishes.

At three of the five nature preschools children used a portable latrine that was designated just for preschool use. The other two nature preschools used the park bathrooms. All children at nature preschools were expected to wash their hands after bathroom use, before eating, and after art activities. For hand-washing each nature preschool had a water bucket with a pump and a non-anti-bacterial soap. Preschool teachers assisted children in washing their hands. During extremely cold weeks, various methods were used to help ensure children had clean hands without using cold water. Two preschools used hand sanitizer, either a generic store brand or natural brand, depending on teacher and child preference. At one preschool, teachers brought warm water from home that they kept in an insulated container for handwashing. Two preschools used the sinks in the park bathrooms.

Conventional Preschools

Three of the four conventional preschools were located on elementary school premises, and one had a building exclusively for the preschool. Two preschools were licensed by the Department of Early Learning in Washington State, and two were private preschools that were not licensed by the state. In three of four preschools, all participating children were in one classroom. One preschool had three classrooms, organized by age (2 years old, 3 years old and 4 years old at the start of the school year).

The ratio of teachers to children for conventional preschools was 1:8 for two preschools, and 1:4 and 1:11 for the other two preschools. Preschool class enrollment ranged from 6 to 20 children per classroom.

At conventional preschools, most of the children's time was spent indoors. All preschools had indoor play areas with toys and games and seating areas with small tables and chairs. The amount of time scheduled for outdoor play differed by preschool. The three preschools with four hour school days scheduled 20 minutes, 30 minutes, and 50 minutes outdoors, respectively, each day. The one preschool with a six hour school day scheduled 75 minutes of outdoor time a day. All preschool teachers stated that additional time was spent outdoors on days with nice weather.

All conventional preschools had outdoor areas built on concrete. Outdoor spaces differed in size as well as available equipment. The three preschools located at elementary schools had outdoor playgrounds available. Two playgrounds had a ground covering of woodchips and one had recycled rubber. Natural elements to play with were limited in three of the four preschools. At one preschool, children could play on a field featuring a few trees at the edges. None of the preschools had covered areas to protect children from rain. One conventional preschool provided rain suits for all children. All but one conventional preschool reported that children played outdoors even in the rain.

Children ate meals and snacks sitting at tables indoors. One preschool prepared breakfast and lunch on the premises, and children served themselves "family style". Children at the other preschools brought their own lunch. All conventional preschools provided snacks and had a kitchen area with a sink and refrigerator where food was stored and prepared.

All conventional preschools had indoor toilets with multiple stalls. All children at conventional preschools were expected to wash their hands after bathroom use, before eating and after art activities. Two preschools also had children wash their hands after playing outside. Sinks for handwashing were located in the classroom areas at two preschools, and children used sinks in the bathrooms at the other two preschools. Children were supervised in handwashing at all preschools. One preschool used an anti-bacterial soap, while the other three used soaps that were not anti-bacterial.

Comparison of Handwashing Practices

Based on interviews with teachers and preschool site visits, some differences were noted regarding handwashing and snack preparation between nature and conventional preschools. Nature preschool teachers had to assist children in handwashing as they had to dispense water from the containers used to wash hands. The exception was the nature preschools that used bathroom sinks at their park location, however teachers went into the bathrooms with children

and were able to provide assistance there. The conventional preschools provided general supervision for handwashing but teachers were not directly involved in the process. While handwashing was more directly supervised at nature preschools, the water pressure and volume dispensed from the containers was also much lower than from the sinks used at conventional preschools, so handwashing may not have been as thorough as when using a sink.

Child-days Observed

Teachers logged illnesses and injuries for a total of 8,508 child-preschool days over the course of the 14 week study. The five participating nature preschools contributed data on a total of 4,441 child-days for 71 students, and the four conventional preschools contributed data for 4,067 child-days for 70 students.

For the injury analysis, data from four preschools that did not adhere to the logging protocol were dropped. Preschools were told to log all injuries requiring any first-aid care from the teacher. Three nature preschools logged injuries if they required at least two Band-Aids and one conventional preschool only logged injuries occurring during outdoor play. After excluding preschools not adhering to the protocol, the injury analysis included data on a total of 75 children and 4,806 child-days in attendance at preschool. Nature preschools provided data for 29 children and 1,819 child-days in attendance, and conventional preschools provided data on 46 children and 2,987 child-days in attendance at preschool.

Child Characteristics

The sample of children, described in Table 1a, included more boys than girls (58.2% male) and the modal age was 4 years (50.4%). Almost a third of children attended afterschool care (29.8%). Nearly all children were up to date on vaccinations, and only a few had a pre-existing health condition, as noted by teachers. The mean of the median zip code income for all study participants was \$103,036, essentially equivalent to the overall median family income for the City of Seattle (\$102,832) [41].

Compared to children at conventional preschools, children at nature preschools were more likely to be younger than four years, male, to have a pre-existing health condition, and receive a subsidy (Table 1a). Pre-existing health conditions at nature preschools included sensory issues, asthma, eczema and leaking bicuspid aortic valve. Pre-existing health conditions at conventional preschools included a nut/egg allergy, leaking bicuspid aortic valve and an unknown condition where the child had immune system problems and seizures. The nature preschools provided subsidies to more than half of their students, and one conventional preschool provided subsidies to most of their students. Three conventional preschools did not provide student subsidies.

The subset of children included in the injury analysis differed in some of their characteristics compared to the full sample of children, as shown in Table 1b. The proportion of children age four years old was higher in the injury analysis compared to the total sample, with no two year old children included. Included and excluded children were otherwise similar in gender, pre-existing health condition status, afterschool care enrollment, and vaccination status.

Table 1a: Characteristics of Preschool Children by Type of Preschool.*

Characteristics	Nature Preschool (n=71)	Conventional Preschool (n=70)	Total (n=141)
Age			
2	0 (0%)	6 (8.6%)	6 (4.3%)
3	31 (43.7%)	10 (14.3%)	41 (29.1%)
4	32 (45.1%)	39 (55.7%)	71 (50.4%)
5	8 (11.3%)	15 (21.4%)	23 (16.3%)
Male	48 (67.6%)	34 (48.6%)	82 (58.2%)
Pre-existing Health Condition	8 (11.3%)	3 (4.3%)	11 (7.8%)
Afterschool Care Enrollment	22 (31.0%)	20 (28.6%)	42 (29.8%)
Vaccinations Up to Date	69 (97.2%)	70 (100%)	139 (98.6%)
Subsidy Received**	37 (52.1%)	16 (22.9%)	53 (37.6%)
Median Zip Code Income (mean) \$***	97,436	109,132	103,036

*Column percentages may not sum to 100% due to rounding.

**All nature preschools and one conventional preschool offered subsidies for children to attend.

***2015 Census data were used to determine the median income for families in each child's home zip code. The mean of the median home zip code incomes was calculated for each group.

Table 1b: Characteristics of Subset of Preschool Children Included in Injury Analysis by Type of Preschool.*

Characteristics	Children Included in Injury Analysis			Children Excluded
	Nature Preschool (n=29)	Conventional Preschool (n=46)	Total Included (n=75)	Total Excluded (n=66)
Age				
2	0	0	0	6 (9.1%)
3	16 (55.2%)	1 (2.2%)	17 (22.7%)	24 (36.4%)
4	11 (37.9%)	31 (67.4%)	42 (56.0%)	29 (43.9%)
5	2 (6.9%)	14 (30.4%)	16 (21.3%)	7 (10.6%)
Male	20 (69.0%)	22 (47.8%)	42 (56.0%)	40 (60.6%)
Pre-existing Health Condition	5 (17.8%)	1 (2.2%)	6 (8.0%)	5 (7.6%)
Afterschool Care Enrollment	12 (41.4%)	12 (26.1%)	24 (32.0%)	18 (27.3%)
Vaccinations Up to Date	29 (100%)	46 (100%)	75 (100%)	64 (97.0%)
Subsidy Received**	20 (69.0%)	16 (34.8%)	36 (48.0%)	17 (25.8%)
Median Zip Code Income (mean) \$***	92,467	96,724	95,090	114,207

*Column percentages may not sum to 100% due to rounding.

**All nature preschools and one conventional preschool offered subsidies for children to attend.

***2015 Census data were used to determine the median income for families in each child's home zip code. The mean of the median home zip code incomes was calculated for each group.

Incidence of Illness

The overall incidence of illness was 1.55 illness episodes per 100 child-days expected in preschool. There was no statistically significant difference when comparing the incidence of illness for nature preschools relative to conventional preschools (age-adjusted IRR: 0.93, 95% CI: 0.64-1.34) (Table 2). Children in the study were absent from school due to illness for 2.16% of all expected school days with a similar percentage of absence by preschool type (2.25% and 2.05% for nature and conventional preschools).

A total of 8% of children in the study were known to have received professional medical care for their illness with no statistically significant difference by type of preschool (6.80% and 9.10% for nature and conventional preschools).

The most common type of illness at both types of preschools was respiratory illness. Illnesses that were marked as “Other” included chicken pox, urinary tract infection, ear and eye infections, rash and general malaise.

The incidence of illness at preschools did not vary by the teacher-to-child ratio.

Children at nature preschools who attended afterschool care had a higher, although not statistically significant, incidence of illness compared to children at nature preschools who did not attend afterschool care (1.70 vs 1.39 illness episodes per 100 child-days). There was no significant difference in illness incidence between conventional preschoolers who did and did not attend afterschool care.

Table 2: Number of Illness Episodes, Crude Incidence of Illness and Incidence Rate Ratio Comparing Illness Incidence between Nature and Conventional Preschools.

Illness Type*	Number of Illness Episodes		Crude Incidence**		Incidence Rate Ratio (95% CI)***
	Nature	Conv.	Nature	Conv.	
Total Illness	66	66	1.49	1.62	0.93 (0.64-1.34)
<i>Fever</i>	11	19	0.25	0.47	-
<i>Respiratory</i>	41	41	0.92	1.01	-
<i>Stomach</i>	13	15	0.29	0.37	-
<i>Other</i>	8	3	0.18	0.07	-

*Sub-categories of illness are not mutually exclusive.

**Illness incidence calculated as number of illnesses per 100 child-days expected in attendance at preschool.

***Incidence rate ratio (IRR) adjusted for age and offset by child-days expected in preschool. IRR compares nature preschools relative to conventional preschools.

Incidence of Injury

There were no serious injuries requiring professional medical attention over the course of the study at any of the eight preschools. Injuries incurred were described as scratches, scrapes, minor cuts, bumps, bruises, and splinters. Over the course of the study one child with a scraped face was sent home due to injury. The incidence rate ratio of minor injury comparing outdoor to conventional preschools differed for girls and boys (Table 3). No statistically significant difference in minor injury was found between boys at nature and conventional preschools (age-

adjusted IRR: 1.46, 95% CI: 0.59 - 3.6), while girls had a statistically significantly higher incidence of minor injury reported at nature preschools compared to conventional preschools (age-adjusted IRR: 5.91, 95% CI: 1.98 - 17.7).

The teacher-to-child ratio at preschools was not associated with incidence of injury.

Table 3: Number of Injuries, Crude Incidence of Injury and Incidence Rate Ratio Comparing Injury Incidence between Nature and Conventional Preschools, Stratified by Child Sex.

Injury Type	Number of Injuries		Crude Incidence*		Incidence Rate Ratio (95%CI)**
	Nature	Conv.	Nature	Conv.	
Boys					
Total Injury	11	16	0.94	0.96	1.46 (0.59 - 3.60)
Open wound/cut	7	8	0.60	0.48	-
Sprain/strain/twist	0	0	0	0	-
Child bite	2	0	0.17	0	-
Other	2	8	0.17	0.48	-
Girls					
Total Injury	10	6	1.87	0.34	5.91 (1.98 - 17.7) [†]
Open wound/cut	7	4	1.31	0.23	-
Sprain/strain/twist	0	0	0	0	-
Child bite	0	0	0	0	-
Other	3	2	0.56	0.11	-

*Injury incidence calculated as number of injuries per 100 child-days in attendance preschool.

** Incidence rate ratio (IRR) adjusted for age and offset by child-days in attendance at preschool. IRR compares nature preschools relative to conventional preschools.

† p-value <0.01

Feasibility Study Results

Recruitment

The four conventional preschools were successfully recruited from a pool of 33 eligible Seattle preschools that were invited to participate in the study. While only eight conventional preschools declined to participate, a high proportion (21/33) did not respond to emails or phone calls.

Preschools that were contacted in the early summer before the hectic school preparation period in August and September were more likely to agree to participate in the study.

Time Commitment

Teachers varied in how often they completed illness and injury logs. One preschool logged information daily, two preschools logged twice a week, and the remaining six preschools logged at least once a week. Frequency of logging was not associated with type of preschool.

Teachers reported that the log was easy to use and that it took from 30 seconds to 10 minutes to complete the log each day. Teachers at four preschools mentioned using their official school attendance or sign in sheet to make note of absences caused by illness, which they later referred to when filling out the log. Injuries were more likely to be entered in the log immediately after they occurred or at the end of that day.

It took approximately 15 to 20 minutes for the lead researcher to enter data from the log into a spreadsheet. This time included downloading the electronic logs, reformatting if necessary, entering data, and verifying information with prior logs. In addition, approximately one hour a week was spent in telephone or email follow-up with all the preschools to make sure that logs were sent in or to clarify data from the logs. Emails were always the initial means of communication, as this was stated to be preferred by all preschools, and phone calls were made if there was no email response. There was considerable variability among preschools in how much follow-up was required to obtain logs. The best time to connect with preschool teachers was in the morning around 10 am or at the end of the school day, which was around 1 or 2 pm for most preschools.

Teacher Challenges and Overall Experience

The biggest challenge for preschool teachers in completing the logs was contacting parents to determine why a child was absent. This prevented the immediate logging of absences, since teachers had to wait for parents to get back to them regarding the reason for the absence. All teachers were asked if they would prefer an electronic spreadsheet to a paper log to track illnesses and injuries. Only one teacher expressed a preference for the paper log. All other teachers either did not have a preference in the type of log they used or preferred an electronic spreadsheet. Teachers did not have any other suggestions for improvement. All teachers said that study was easy to participate in and that they would be willing to continue to log illnesses and injuries for a longer duration project.

Maintaining Standards for Logging Protocol

After data collection was completed, the lead researcher determined that four preschools had operationalized injury in ways that varied from standard. Three of the nature preschools misinterpreted instructions with the understanding that they were only to log more serious injuries. Two of the nature preschools stated that they used a “two Band-Aid rule” for deciding whether to log an injury. One indoor preschool documented only injuries that occurred during outdoor play. In hindsight, a common standard might have been maintained by carrying out a quality assurance check-in with all preschool teachers during the first week of data collection to make any needed corrections to data collection methods.

Discussion

Summary of Results

The results of this study carry implications about the risk of illness and injury in children attending nature preschools as well as about the feasibility of studying health outcomes in preschool settings. There was no statistically significant difference in the incidence of illness between children at nature and conventional preschools. The incidence of minor injuries was found to be the same for boys at nature and conventional preschools, but higher for girls at nature preschools than at conventional preschools. No serious injuries occurred at any preschool over the course of the study. We determined that it was feasible to conduct a study to compare the incidence of illnesses and injuries at nature and conventional preschools and offered lessons learned for future larger scale studies of the health effects of nature preschools.

Illness

The overall illness incidence was 1.55 illness episodes per 100 child-days and was not statistically significantly different for children at nature and conventional preschools. The incidence of illness we found is consistent with prior study findings reporting the incidence of illness episodes in conventional preschools [22, 42]. Respiratory illnesses were the most common type of illness, which is also consistent with current literature on preschool illnesses [22, 42-44]. The overall percentage of days of absence due to illness of 2.2% was found to be similar to a study of illnesses in conventional preschools conducted in Seattle, Washington but lower than prior studies conducted in New York and abroad which showed absence from preschool due to illness ranging from 4.1% to 10.9% [22-24, 45]. States and countries might differ in children's incidence of illness and/or practices of keeping children home sick.

While a number of studies have investigated illnesses at different types of preschools, such as conventional preschool, home-based child care, and preschools with varying amounts of outdoor time, this is the first study to compare the incidence of illness for children at exclusively outdoor nature preschools to conventional preschools [24, 43, 44, 46, 47].

In this study, prospective data were collected by preschool teachers who were trained to track illness and injury using a standardized reporting log. This is a methodology employed by prior studies of preschooler health [22, 23, 42, 45]. Training teachers to collect prospective data reduces potential reporting bias that could occur if data were collected retrospectively without teacher training and a standardized reporting form. It also prevents recall bias that can occur if teachers or parents are asked to recall child illnesses from an earlier time period.

There are several reasons why the incidence of illness at nature preschools was similar to that of conventional preschools. We hypothesized that illness incidence might be lower at nature preschools due to fewer shared surfaces to spread infectious agents. However, our observations of the preschool settings revealed that children attending both nature and conventional preschools played with traditional toys, such as blocks and toy cars, which could act as fomites to transmit infectious agents. Additionally, in general young children play in close contact with each other which can also facilitate the spread of infectious agents. Studies have shown that children who are exposed to many other children in large daycare settings have an increased risk of illness compared to children at home-based child care settings, with 6-8 children being found to be a threshold after which illness incidence stabilizes [44, 48, 49]. All but one preschool met this minimum threshold of students with at least 11. The one preschool with smaller class sizes had at least 6 children per class.

We also hypothesized that children might have a higher incidence of illness at nature preschools due to exposure to cold temperatures. There was no indication that children attending nature preschools had a higher incidence of illness, compared to children attending conventional preschools. The climate in Seattle is mild, and the average temperature of 52 degrees Fahrenheit during the study was likely not low enough to increase the risk of illness. Studies that have found a higher incidence of illnesses in cold temperatures were conducted in sub-arctic regions [29].

Attendance at afterschool care may also influence the incidence of illness for children at nature preschools. In our study, nature preschoolers attending afterschool care had a higher incidence of illness compared to those who did not attend afterschool care. This difference was not statistically significant, but it is plausible that the conditions to which a child is exposed in afterschool care could moderate potential protective effects of the nature preschool

environment. There was no difference in illness incidence for conventional preschools based on attendance at after school care. Future larger scale studies should consider attendance at afterschool care when studying illness in nature preschoolers.

Injury

The lack of serious injuries in this 14 week study is consistent with several studies conducted in conventional preschool settings that demonstrated very low incidence rates (1.5 to 2.5 injuries per 100,000 child-hours) for injuries requiring professional medical attention [50-53]. The higher incidence of minor injury for girls at nature preschools compared to conventional preschools is a novel finding. In our study girls at nature preschools incurred a higher incidence of minor injury than boys, while at conventional preschools boys incurred a higher incidence of injury than girls. Current literature on preschool injury has found either a higher incidence of injury among boys compared to girls or no sex difference in injury incidence [32]. This is the first study to assess injury incidence for preschoolers at nature preschools compared to conventional preschools, which has allowed for the investigation of sex differences in reported injury based on preschool settings.

While we found a statistically significantly higher incidence of minor injury for girls at nature preschools compared to conventional preschools, it should be noted that this difference was based on a total of 16 injuries, 10 for nature and 6 for conventional preschools, and a small sample of 33 girls, 9 at nature and 24 at conventional preschools.

The injury incidence from two prior studies was compared to the injury incidence found in our study. These two studies reported injury incidence using denominators of standardized 8 hour child-days present at preschool and 2,000 child-hours [54, 55]. The study findings were re-calculated using denominators of 100 4 hour child-days in order to facilitate comparison [54, 55]. Other studies of preschooler injury using similar methods of injury ascertainment did not report incidence rates with denominators that were comparable to our study [31, 56, 57].

One of the prior studies used retrospective record review to ascertain injuries and calculated incidence of injury for boys and girls at each of 4 participating preschools [54]. The investigators found a wide range of injury incidence for both boys (0.25 to 2.6 injuries per 100 child-days) and girls (0.30 to 2.30 injuries per 100 child-days). Our injury incidence for boys at nature and conventional preschools (0.93 and 0.96 injuries per 100 child-days) and girls at nature and conventional preschools (1.87 and 0.34 injuries per 100 child-days) were within the reported ranges of the prior study.

The other study used prospective data collection by teachers and reported on the overall sex specific incidence of injury at 4 preschools [55]. The reported injury incidence for boys was higher than in our study (1.28 injuries per 100 child-days). The reported injury incidence for girls (1.00 injuries per 100 child-days) was lower than the injury incidence we found for girls at nature preschools, but higher than the injury incidence we found for girls at conventional preschools.

The differences we found in incidence of minor injury between girls at nature and conventional preschools may be due to differing expectations of girls' and boys' capabilities in outdoor settings. Research has demonstrated that as children grow up, boys and girls are subject to different expectations regarding risk-taking behavior and physical capabilities [58]. Studies find that boys are given more independence and more encouragement to engage in rough play, while girls are more likely to be provided with parental assistance as well as instruction regarding safety concerns [58]. Children internalize these expectations, with one study finding

that both boys and girls thought that girls were at a higher risk of injury compared to boys, despite boys having the higher incidence of injury [59].

Teachers may have been more likely to acknowledge a minor injury for a girl, or girls may have been more likely to seek care for such an injury, leading to differential reporting of injury by child sex. While all teachers were instructed that they were to document any injury that required first aid care, two preschool teachers noted that the first-aid they provided was sometimes a form of comfort, such as an icepack for a fall that was soothing, but may not have been medically indicated.

The teacher to student ratio was not found to influence the incidence of injury at the preschools studied. All but one preschool met Washington state standards of at least one teacher per 10 children, with one preschool having a ratio of one teacher per 11 children [60]. Given that there were no injuries requiring professional medical attention at nature preschools, there were no indications from this study that the nature preschool model poses a safety risk for children. In addition, differences in minor injuries were only found for girls. This could be due to gender socialization or reporting bias and not an increased risk of injury. In general, minor injuries could be a sign of healthy risk-taking behaviors and expected consequences of children exploring their physical limits. Outdoor play and risk-taking behavior has been shown to have numerous benefits such as supporting the development of motor skills, increasing confidence and independence and facilitating the development of risk-mitigation strategies [2, 33-37]. The preliminary findings in this study indicated that nature preschools are safe environments for young children. Future larger scale studies of longer duration should be conducted to verify these findings.

Limitations

The major limitations of this study were the small sample size for the injury analysis and the short duration of the study. A larger sample size and longer duration study would have increased the number of child-days of observation, providing more precise relative risk estimates for illness and injury incidence. Specifically, this would have allowed for better ascertainment of how gender modifies the association between preschool type and injury, as stratification by preschool type and gender resulted in a small sample size for girls at nature preschools (nine girls). A greater number of child-days of observation would have also increased the likelihood of serious injuries, which might have allowed us to compare serious injuries by preschool type. In addition, a longer duration study would have enabled us to investigate temporal changes in the incidence of injuries at nature and conventional preschools as children adapted to their preschool environments. Lastly, a longer term study would have provided data for the comparison of illnesses by preschool type during different seasons. Despite the small sample size, enough child-days of observation were accrued (8,508 for the illness analysis and 4,806 for the injury analysis) for us to draw initial conclusions about incidence of illness and injury for children at nature preschools compared to conventional preschools.

Selection factors pose a limitation of this study, as children were not randomly assigned to a preschool type. Several differences between children enrolled in nature and conventional preschool were observed. Children in nature preschools were younger and more likely to be male. Since this was the first year the nature preschools were open, they may have enrolled more children who were entering their first preschool experience. Age was controlled for by using age adjusted risk estimates. Sex did not confound the association between preschool type

and the incidence of illness. Sex did modify the effect of preschool type on injury incidence, and therefore risk estimates for injury incidence were stratified by sex.

There may have been other sources of non-comparability that were unmeasured in this study and could have influenced the incidence of illness or injury. It is possible that families are more likely to enroll healthier children at nature preschools than conventional preschools. However, from data that were available, the percentage of children with a pre-existing health condition was higher at nature preschools compared to conventional preschools (11.3% vs 4.3%). Families with children enrolled in nature preschools may also be more likely to engage in healthy behaviors such as spending more time outdoors and being more physically active, which could influence children's overall health.

Subsidy data and median income by home zip code were collected and ascertained to serve as proxies for socio-economic status, which could have been a source of confounding. However, our subsidy variable was not a robust measure. Not all preschools offered subsidies, and those that did had different requirements for who could receive a subsidy. Therefore, median income was used as a marker of socio-economic status instead of subsidy received. Median income for home zip code allowed for a broad comparison of the two groups, but family income can vary widely from the median income within a geographic area. A more accurate measure of socio-economic status would have been useful, as it may influence children's incidence of illness as well as the parent having an option to stay home with a child or find child care if a child is ill [61]. Additional factors that may influence children's illness incidence for which data were unavailable include prior preschool attendance, number of siblings, and parental smoking [47, 49, 62].

Feasibility

This study demonstrated that it is feasible to conduct research comparing health outcomes for children at nature and conventional preschools by training teachers to track illness and injury events. No preschools dropped out from the study. All teachers found the study to be a small time commitment and reported that they would be willing to track illnesses and injuries for a future longer duration study.

One challenge of conducting this study was recruiting preschools to participate. Only 12% of the eligible conventional preschools that were invited agreed to participate. This was partially due to the timing of school recruitment. Some schools were first approached as late as August or September when teachers were gearing up for fall enrollment. The best time to recruit was determined to be early in the summer prior to the start of the school year. Furthermore, the best time of day to contact preschool teachers via telephone was found to be in the morning around 10 am or at the end of the school day.

Another challenge of this study was getting teachers to upload and email the tracking logs to the lead investigator in a timely manner. Direct tracking of illnesses and injuries using an online spreadsheet would reduce the added step of submitting the logs to researchers. This would also reduce the redundancy of data entry, saving overall time as well as decreasing potential for data entry mistakes. Delays in reporting were often due to implementing the study protocol to verify from parents whether an absence was due to illness and to determine whether medical intervention was sought. Future studies should consider the cost: benefit ratio of gathering medical intervention data.

Teacher's adherence to the protocol for collecting illness data was determined to be good based on intermittent follow up with teachers during the data collection phase of the study and on the

final teacher interview. We had no reason to believe that there were any differences in quality of reporting by type of preschool. However, future studies may incorporate data quality checks with parents to ensure that teachers complete illness logs accurately.

For injuries, we determined that four preschools did not adhere to the protocol for data collection, leading to an unfortunate drop in reliable data available for the injury analysis and reducing the number of schools for this analysis to two nature preschools and three conventional preschools. We did not learn until the post-study interviews with preschool teachers that schools had adopted different definitions of injury. This variability occurred despite all of the preschools receiving the same training at the beginning of the study. These reporting differences and subsequent loss of data could have been addressed with early visits to each preschool and conversations with each of the reporting teachers about their understanding of the study protocol.

This study has shown that engaging preschool teachers to track health outcomes for students at nature preschools is possible. We offer suggestions regarding recruitment, data collection, and data quality assurance that can be used to design future studies to further elucidate the effects of nature preschools on children's health.

Conclusion

The study also had a number of strengths, including excellent cooperation from participating preschools, well-characterized outdoor and conventional preschool settings, and, for the illness analysis, a large sample of child days of observation in both types of preschools. We conclude that the outdoor preschool offers a model in which the occurrence of illness and injury among children enrolled compares favorably with conventional preschools.

While these results suggest that nature preschools do not present an increased risk of illness, further research would clarify and extend these results. First, as this was a small study, larger studies would enable more definitive conclusions. Second, replication in different settings, such as in colder and warmer climates, would clarify whether these results are widely generalizable. Third, important questions remain unanswered that could be addressed in appropriately designed studies. Examples include investigating the potential effects of nature preschools on other health outcomes, such as physical activity, sleep and emotional health; studying how time spent outdoors beyond the preschool setting may influence health outcomes; and evaluating long-term effects of exposure to outdoor preschools on children as they age into elementary schools and beyond. Finally, the suggestion of increased risk of injury among girls should be further assessed, including evaluating the potential of differential teacher responses to minor injuries of girls and boys.

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Appendix A: Illness and Injury Tracking Log

Preschool: Week:	Illness Log: For each day a child is Absent or Sent home due to illness: 1) Write A (absent) or S (sent home) ALL illness symptoms the child was known to have. 2) If the specific illness causing symptoms is known right it in the notes box (eg. Flu, bronchitis, etc) 3) Describe other illnesses/symptoms or injuries in Notes box. Write unknown if symptoms not known. 4) For medical attention, <u>circle</u> Y (yes), N (no), or U (unknown). Symptom descriptions: Stomach: diarrhea, vomiting, stomach pain, etc. Respiratory: cough, cold, flu, etc Other: eye infection, ear infection, rash etc																	Injury Log: 1) Mark with X any injuries sustained during week. 2) Circle Y, N, U for medical attention received.					Additional Notes Use this space for any other notes for illnesses/injuries.			
Child Name <i>(do not send names to researchers)</i> ID#	Mon				Tue				Wed				Thur				Fri				Med. Attention?	Open wound/cut	Sprain/strain/twist	Child Bite	Other	Med. Attention?
	Fever	Stomach	Respiratory	Other	Fever	Stomach	Respiratory	Other	Fever	Stomach	Respiratory	Other	Fever	Stomach	Respiratory	Other	Fever	Stomach	Respiratory	Other						
1																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
2																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
3																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
4																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
5																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
6																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
7																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				
8																					Y N U					Y N U
	Notes:				Notes:				Notes:				Notes:				Notes:					Notes:				