Title

Comparing light and noise levels before and after a NICU change of design

Running title

Light & noise – NICU change of design

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Abstract

Objective. To compare light and sound levels before and after a change of design and evaluate these levels considering recommended NICU standards.

Study design. A pre-test/post-test design. Light and sound levels were compared between the former open ward (OW) NICU of 34 beds and the current 40 bed unit composed of both pods and single-family rooms (SFR).

Result. Light levels were significantly higher in the pod/SFR unit for all levels of care, days of the week and time of the day. These findings could be attributed to the number and configuration of windows in the new pod/SFR unit allowing for more daylight entry compared to the OW. Sound levels were significantly lower in the current NICU (pod/SFR) compared to the former OW.

Conclusion. Following the change of design, the pod/SFR unit are less noisy than the OW, although light levels are higher indicating the necessity to measure light levels.

Key words: NICU design, lighting, sound, pre-test/post-test design, pods, single-family room, open ward

Introduction

Appropriate light and sound levels in the Neonatal Intensive Care Unit [NICU] are essential to promote preterm infants' growth and development [1-4] and a fundamental consideration in any plan to change the design of a unit [5]. A small change in the NICU light environment creates physiological instability in preterm infants [6] and disrupts their sleep if light protection is insufficient [7]. Similar adverse effects, such as physiological and motor instability [8, 9] and sleep disruption [10] have been reported in preterm infants exposed to NICU sound. These environmental factors could also prevent parents from staying close to their infants [11], while sound restrict their presence [12], and interferes with their sleep in the NICU [13]. An optimal NICU environment includes developmentally appropriate lighting for preterm infants, is exempt of excessive sound [14] and encourages family involvement [15]. In an evidence-based NICU design, light levels should respect diurnal variations and should be adjusted to perform care and procedures, while a combination of environmental control for sound is essential [16]. NICU standards recommend that ambient lighting in the infant care area should be adjustable from ten to 600 lux [17]. White et al. [17] also advise that sound levels should not exceed an hourly average of 45 decibels (dBA) and should never exceed 65 dBA.

In the past few years, many NICUs world-wide have modified their unit configuration from an open ward [OW] design to single-family rooms [SFR] as the latter has been the recommended NICU design [18-20]. SFRs enable family-centered care [21] and allow for better control of light and sound levels and promote families' involvement [22] Still, a pod design which may consist of a cluster of four to six infants cared for in one space has been recently proposed to optimize infants' development and interaction with caregivers and avoid the isolation of infants' that may occur in SFRs if families are not sufficiently present [23]. In the context of a change in design from an OW to 6-bed pods and SFRs at one hospital, the aim of our study was to compare the light and sound levels before and after this NICU change of

design and evaluate if these levels respect the recommended NICU standards. We hypothesized that: a) light levels (in lux) would be more appropriate in the pod/SFR unit compared to the former OW; b) sound levels (in decibels) would be lower in the pod/SFR unit compared to OW; and c) the percentage of time light and sound levels would meet the recommended levels would be higher in the pod/SFR unit.

Methods

The study was a pre-test/post-test design and was conducted in a NICU in Montreal, Canada. Ethics approval was obtained from the institutional review board at the study site (Federal Assurance number 0796). In January 2016, the 34-bed OW design NICU moved to a newly constructed unit with a 40-bed combination design consisting of three pods of six beds for intensive level III care, two pods of six beds for intermediate level II care, and 10 SFRs for level I care prior to discharge of the infant (including two isolation rooms) (see Figure 1 for the pod/SFR unit design). The former OW had all three care levels in one large open space of 400-m^2: critical (14 beds), semi-critical (12 beds) and step-down (8 beds). In the pod/SFR unit of 1145-m^2, infants are admitted to an intensive or intermediate pod and then moved to a SFR when their health status is stable. The nurse-patient ratio remained unchanged between the former OW and the pod/SFR; 1:2 in acute care, 1:3 in intermediate care, and 1:4 in step-down/SFR. In the former unit, nurses sat at a central station at the entry of the NICU and in the new unit nurses sit at stations designed for this use in the pods and at a central station for the SFR area (see Figure 1). Creating optimal environmental conditions for newborn infants was an important goal in the design of the new NICU, so the Recommended Standards for Newborn ICU Design [17] in addition to the guidelines for design and construction of health care facilities [24] were consulted and recommendations followed. In the pod/SFR unit, indirect ceiling neon and procedural lights were installed beside each infant for care or emergency purposes. In addition, outside windows were triple glazed and equipped with light

filtering blinds with double roller shades (one being a blackout shade). For sound, floors of the pods and SFRs were covered in sound absorbent tiles.

Light and Sound Measurements

Light levels were measured in lux with the Omega® HB3336-03 light meter in a horizontal plane and sound levels were captured with a dBA-weighted scale sound meter (Sound Examiner SE-402), which measures environmental sound as heard by the human ear [25]. The sound measurements were obtained with one decimal in equivalent level (Leq), which is the appropriate measure to obtain an average sound level. Light and sound levels were recorded over 24 hours and for an entire week (7 days). Light levels were recorded every minute and sound levels every second, but for sound a mean was computed every minute for analysis. After measurements were obtained, recordings were downloaded into an Excel spreadsheet for analysis. Measurements in the former and current NICUs were collected over the same months of the year and same time of the day to control for daylight associated with seasonal variations as well as sound associated with nursing workload.

Former NICU. Light and sound levels in the OW were assessed during the summer in 2014, six months prior to the NICU's planned move to the pod/SFR unit configuration. In the OW, light and sound meters were placed in four locations representing the three levels of care: critical, semi-critical and step-down. These locations were selected as they replicated locations used for a previous evaluation of sound levels conducted by the biomedical department of the hospital.

Current NICU. In the pod/SFR unit, light and sound levels were measured during the summer of 2016, six months after the move, which had been delayed from January 2015 to January 2016. Measurements were taken at five different locations representing the same levels of care as in the former unit: critical, semi-critical, and step-down. For critical care,

measurements were taken in two different pods composed of six beds, one pod with windows adjacent to an atrium and the other pod with windows exposed to the exterior of the building. For semi-critical care, measurements were obtained in one 6-bed pod, while for the step-down area; measurements were taken in two SFRs - one with a window and the other without.

Analysis

Analysis were conducted with Stata (version 16). Independent Student t-test were conducted to compare light and sound levels between the former and current NICUs. A test of variance was conducted to compare variability of measures between the former and current NICUs. The percentage of time light and sound levels exceeded the recommended levels was calculated using the two-tailed proportion z-test. These analyses were also performed using nonparametric statistics, and since all findings remained significant, results of parametric statistics are reported. Significance was set at $p < 0.05$ two-sided for all tests.

Findings

A total of 93,620 light readings were collected over both phases of this study. Of these, two light readings from the step-down unit were above 20,000 lux and thus considered outliers and removed from the analysis dataset. In the OW, 43,412 (46.37%) readings of light were captured, and in the pod/SFR unit 50,208 (53.63%). Overall, light readings ranged from 0 to 4,030 lux, with a mean of 189.90 and standard deviation of 359.79 lux. For sound, a total of 5,549,651 measurements were captured over both phases of this study. Of these, 114,896 readings were removed from the dataset as there was missing data (no data recorded), leaving 5,434,755 measurements. For the purpose of analysis 4,792,810 measurements were used: 1,953,612 measurements (40.76%) taken in the OW unit, and 2,839,198 in the pod/SFR unit (59.24%). Overall, sound levels ranged from 37.4 dBA to 97.3 dBA with a mean of 53.10 dBA, and standard deviation of 6.80 dBA. Means and standard deviations of light and sound levels over 24 hours for every day of the week in the OW and current pod/SFR unit are shown

in Table 1. Means and standard deviations of light and sound per 24 hour periods for the three time periods corresponding to the timing of shifts for nursing staff: day (7h30 to 15h30), evening (15h30 to 23h30) and night shifts (23h30 to 7h30) in the OW and current pod/SFR are shown in Table 2.

Light levels

OW versus Pod/SFR. Independent samples t-tests demonstrated that overall mean light levels were significantly higher in the pod/SFR unit (253.29 ± 449.62 lux) compared to the previous OW unit (93.74 ± 61.51 lux), t (83,289) = 64.15, p = <0.001. This finding was the same irrespective of the care level designation. Thus, light levels were also higher in the critical care pods of the new unit (245.79 ± 412.89 lux) compared to the OW unit's critical care area (54.82 ± 35.13 lux), t(32,979) = 52.26, p = <0.001; in the semi-critical care pods of the new unit (407.22 ± 510.45 lux) compared to the previous OW unit's semi-critical care area (120.19 ± 49.50 lux), t(19,743) = 55.24, p = <0.001; and finally in the SFRs of the new unit (step down care) (183.94 ±433.82 lux) compared to the OW's step down area (116.68 ±71.45 lux), t(30,563) = 15.80, p = <0.001.

Light variability. To better understand the variability that appeared to be notable in our study, an F-test for equality of variances was performed to test the hypothesis that the variance of the two units differed. In all three care levels of the new pod/SFR unit, that is in critical care, F(20,157, 12,822) = 138.12, p = <0.001, semi critical care F(10,006 , 9,737) = 106.35, p = <0.001 and step-down care, F(20,037 , 10,526) = 36.86, p = <0.001, there was significantly more variability in light levels compared to the former OW (see Figure 2).

Light levels versus recommendations. In the respective critical care areas, the current pod/SFR unit had significantly more (11.3%) light readings that surpassed the ambient light recommendation of 600 lux compared to the OW where it never exceeded 600 lux (z = 39.36, p = <0.001). The pod/SFR unit's semi-critical care pod also had significantly more readings

over 600 lux (27.7%) than the OW's semi-critical area that had none (z = 56.01, p = <0.001), a trend that continued in the SFRs (step down area), where the proportion of light readings over 600 lux was significantly higher (9.5%) than those of the OW which were 0% (z = 32.57 p = <0.001) (See supplemental file, Table 1).

Pods versus SFRs. Comparing light data recorded in the pod/SFR in the current NICU, we noticed differences in the estimated means. However, as the two mean distributions overlapped, we could conclude that there was no significant difference between the mean levels observed in the pods and those from the SFR.

Sound levels

OW versus Pod/SFRs. Irrespective of the day of the week, sound levels were always lower in the pod/SFR unit compared to the OW (see Figure 3). Independent samples t-tests confirmed that this difference was significant overall, with lower levels in the current unit (49.32 ± 5.28 dBA) compared to the former NICU (58.62 ± 4.64 dBA), t(4.8e+06) = -2.0e+03, p = <0.001. At every level of care this trend held. Thus, sound levels were lower in the pod/SFR critical care area (49.70 ± 5.43 dBA) compared to the OW unit's critical care area (58.97 ± 3.83 dBA), *t*(1.9e+06) = -1.3e+03, p = <0.001; in the semi-critical pod (49.33 ± 4.99 dBA) compared to the OW unit's semi-critical care area (60.84 ± 3.41 dBA), *t*(1.2e+06) = -1.5e+03 p = <0.001; and finally in the SFRs (48.89 ± 5.24 dBA) versus the OW's step down area (56.13 ± 5.30 dBA), *t*(1.7e+06) = -8.7e+02, p = <0.001.

Pods versus SFRs. For the comparisons of the mean levels obtained in the pods and SFRs in the current unit, even if there are differences in the estimated means, we could conclude that there was no significant difference between the means as the two distributions overlapped.

Sound levels versus recommendations. Maximum recommended sound levels of 45 dBA were met 100% of the time in the OW for all levels of care (critical, semi-critical, and step-down areas); however, in the pod/SFR unit, minimum levels were only met 76.7%, 79.5% and 75.8 % of the time for critical and semi-critical pods as well as the SFRs respectively (Supplemental files, Table 2). With respect to sound surpassing the recommended upper level of 65 dBA, the former OW had significantly more readings above 65 dBA than the critical care pods (7.1% OW versus 0.7% pods), the semi-critical care pods (11.1 % OW versus 0.5% pods) and the SFRs (6.6% OW versus 1.5% SFRs). All differences were statistically significant ($p =<0.001$).

DISCUSSION

Light levels

Our study findings do not support the hypothesis that light levels would be more appropriate in the pod/SFR unit compared to the former OW nor that the percentage of time light levels would meet the recommended levels would be higher in the current NICU. Light levels were significantly higher in the pod/SFR unit for all levels of care, days of the week and time of the day. However, these findings should be interpreted with caution as they more likely reflect architectural design decisions and not that light levels are necessarily higher in pods/SFR. These findings could be attributed to the number and configuration of windows in the new pod/SFR unit allowing for more daylight entry compared to the OW. In fact, had the SFR unit rooms with north-facing windows or a suitable window overhang, excessive light entering the rooms could have been avoided. In the former OW, all the windows were located on only one side of the large open space on the only exterior wall therefore limiting daylight entry into many areas of the OW, especially the intermediate and step-down areas that were further from the windows. In contrast, all pods and five of 10 SFRs in the new unit have windows either exposed onto an outdoor atrium or a fully exposed exterior wall allowing for

193 more daylight entry (see Figure 1). The effect of windows on light levels in the current unit is
194 particularly noticeable when comparing the readings taken in a SFR with and without
195 windows. In the SFR without windows (SFR B), light levels never go beyond 10 lux (Tables
196 3 and 4, supplemental files). Our findings are consistent with one study where the mean light
197 levels were found to be higher in a SFR unit compared to an OW due to the higher number of
198 windows in the new SFR unit [25]. Windows guarantee the entry of daylight, which is the
199 optimal lighting for care procedures and to observe infants' skin color [16, 17]. Windows may
200 increase light levels in the NICU but are also recommended so that both professionals and
201 parents have access to daylight for psychological benefits [17]. Nonetheless, control of light
202 levels in important for the well-being of the infants.
203 Seasonal and diurnal variability is also a factor influencing light intensity in the NICU
204 and infants' exposure to light [26]. In our study light readings from the former and current
205 NICU were taken during the summer when sunny days tend to be more frequent and the days
206 are longer. Our readings reflect the influence of natural light entering the pod/SFR unit as
207 levels of light increased and decreased in a typical diurnal cycle in all three care areas,
208 peaking near 3 pm daily (see Figure 2). Independent of the day of the week, and without
209 reaching statistically significant differences, light levels were always higher in the semi-
210 critical pod (overall mean of 407 lux) compared to critical care (overall mean of 246 lux), a
211 trend which was also observed for daytime and across weekdays with the highest mean level
212 reaching 741 lux in the semi-critical pod during the day, a mean above the upper
213 recommended ambient level of 600 lux (see Tables 1 and 2). The orientation of the windows
214 to the sun may explain these findings as the entry of light is more direct in this critical care
215 pod compared to the semi-critical care pod. Direct sunlight entering the critical care pod may
216 be more noticeable and prompt NICU nurses and other professionals to close windows blinds
217 to lower both light and heat; whereas in the semi-critical care pod where the light is more

indirect, windows blinds may not be closed as often or as much and thus contributing to the higher levels observed. Thus, NICU staff should be aware of the light exposure provided by windows in various areas of their unit in addition to abrupt changes in lighting [27], as small light variations in the NICU have been found to disrupt preterm infants' physiological stability and sleep [6, 7]. It might be difficult for NICU staff to estimate when light levels are too high, thus regular light meter readings should be readily available for NICU professionals to facilitate appropriate control of the environment. For instance, sound-level system providing direct and visual color feedback to staff when a 50 decibels threshold is exceeded in the NICU was found to successfully reduce sound levels in patient care areas [28]. Also, a noise-sensor light alarm activating in the NICU when noise levels reached more than 65 dBA was reported to decrease noise levels inside incubators [29]. Similar technology could therefore be designed for a continuous reading of NICU light levels and automatic feedback provided to staff.

Due to weather conditions (cloudy, partly cloudy or sunny), ambient light was occasionally above 600 lux in the current pod/SFR unit. In contrast, light in the OW never surpassed this recommended upper limit (Table 1, supplemental file). Generally, in the current pod/SFR unit for the critical and semi-critical levels of care, readings were more frequently above 600 lux on sunny days. Still, in the SFR with a window, light levels were on average, frequently higher on partly cloudy days compared to sunny or cloudy days suggesting again that NICU staff or parents, may tend to close blinds more often on sunny days compared to partly cloudy days where daylight enters the unit but it may be less apparent that the level is high. For the SFR without a window, the recommended maximum level of 600 lux was always respected (Table 1, supplemental file). As suggested, all NICU windows should be equipped with adequate shading [17] to avoid directly exposing infants to direct sunlight and allow for the control of light levels at any time of day.

Sound levels

For sound levels, our findings support the hypothesis that levels would be more appropriate in the pod/SFR unit compared to the former OW and that the percentage of time sound levels would meet the recommended levels would be higher in the current NICU. For every day of the week, every time of the day and for all levels of care, sound levels were significantly lower in the new pod/SFR unit compared to the OW. We also compared sound levels between pods and SFRs. A recent systematic review concluded that sound levels in SFRs or enclosed unit design are usually lower than in OW [19]. More precisely, in one study, the sound level was lower in the SFRs compared to an unoccupied OW (i.e. no patients, no staff) [20] and lower in pods of 6 beds compared to OW of 11 beds [30]. In contrast to our study where no significant difference was found between the 6-bed pods compared to our SFRs for sound levels, two studies reported significantly lower levels in SFRs compared to NICU design similar to pods. Sound levels were reported to be lower in SFR units compared to a 8-bed OW [25] and significantly more time at lower sound levels was observed in the SFRs compared to an OW of six to 10 infants [31]. In our study, the critical and intermediate care pods had comparable mean levels of sound to the former NICU (i.e. critical care pods: 50 dBA; semi-critical care pods: 49 dBA; SFRs: 49 dBA). Others reported a significantly higher mean sound level in their critical versus semi-critical care areas of their NICU [32]. In the current NICU the similar levels recorded in the different room configurations (i.e. pods vs. SFRs) and every day of the week may be due to the use of construction materials (i.e. floor, wall materials) meeting the current NICU recommendations, which may contribute to lower sound levels even if there is more than one infant in a pod. The NICU acoustic environment also depends on factors such as sound containment with walls, sound absorption by flooring materials and doors with an acoustic seal that prevent intrusive sounds from entering [17]. It might be that both the unit design as well as the construction materials used in the new unit

268 may be effective in addressing these issues leading to comparable sound levels in the various
269 care areas of our pod/SFR unit.

270 Our findings are important since lower NICU sound levels are essential to promote
271 preterm infants' growth and development. Studies report that preterm infants exposed to
272 lower sound levels by wearing earmuffs have longer quiet sleep [33, 34] in addition to improved
273 physiological stability [34], which in turn could limits their energy expenditure and favor
274 growth [35-37]. In addition to appropriate sound levels, it is equally important that preterm
275 infants are exposed to developmentally appropriate auditory experiences during their NICU
276 hospitalization for optimal brain development [38]. Preterm infants are more susceptible to
277 poorer language development which may be attributed to being exposed to high sound levels,
278 as well as low language exposure during their NICU hospitalization. Positive, appropriate
279 auditory stimulation is essential as infants exposed to a higher number of adult words in the
280 NICU were found to have better language and cognitive development at 7- and 18-months
281 corrected age [39].

282 In the former OW NICU mean sound levels ranged from 54 dBA to 61 dBA and were
283 consistently (100%) above the recommended hourly level of 45 dBA [17], whereas mean levels
284 in our current NICU ranged from 47 dBA to 51 dBA and exceeded 45 dBA no more than 75%
285 of the time. In addition, in the pod/SFR NICU sound levels almost never exceeded 65 dBA
286 (less than 1.1%). Although our mean sound levels in the pod/SFR unit were not always lower
287 than the recommended 45 dBA, we had a significant mean decrease of 7 to 10 decibels
288 compared to the former OW. Nonetheless, in order to sustain appropriate sound levels in
289 NICUs, there is a need to continue to educate NICU staff and provide reminders to maintain a
290 quiet sound level [40]. Every NICU should have a program of sound control and be aware of
291 the effects of sound on preterm infants.

A significant contribution of our study is both the comparison of light and sound levels between an OW and a pods/SFR NICU, in addition to pods versus SFRs. We found that light levels were higher in the current pod/SFR unit compared to the former OW, which may be explained by not only updated lighting but also a higher number of windows and their orientation to the sun. Accordingly, the higher mean light levels measured in the new pod/SFR unit may reflect architectural design decisions and should not be interpreted to indicate that OWs are more conducive to appropriate light levels. Measurement of the light levels in a vertical plane could have provided, from another angle, more precise information about the sun's contribution to the intensity of lighting in the pods. Sound levels were significantly lower in the current NICU compared to the former NICU and those levels were similar between pods and the SFRs. Although we collected data on confounding factors which may influence light and sound levels (i.e. numbers of : infants, staff, windows with blinds, ventilators and phototherapy lamps in function), it was not possible to interpret meaningfully these comparisons between the OW and pods/SFR units. For example, we noted the total of infants hospitalized as well as staff nurses in both the former and current NICU, but those units were not occupied the same way in the pod/SFR unit (i.e. a maximum of six infants and two nurses in the pods; one infant and one nurse in SFR) precluding comparisons with OW.

Recommended light and sound levels should be respected in NICUs to promote infant growth and development as well as to encourage family involvement and optimize work conditions for staff. Future studies should evaluate pod compared to SFRs on preterm infants' health outcomes as well as parents' perceptions.

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Conflict of interest

No conflict of interest to declare.

Authors' contributions

MA: Supervised data collection and analysis and drafted the manuscript with judicious input from all authors (NF, SR, LC, PDD). NF: Obtained funding, supervised data collection and analysis. SR: Supervised data collection. NF, MA, SR, LC: Conceived the study and interpreted the data. PDD: Conducted the statistical analysis. All authors read and approved the final manuscript.

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437 **Table 1.** Means of light and sound levels over 24 hours for every day of the week in former
438 NICU (OW) and current NICU (pod/SFR) units

Level of care	**Light (lux)**		**Sound (dBA)**	
	OW	Pod/SFR	OW	Pod/SFR
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Critical	55 (35)	246 (413)[a]	59 (3.8)	50 (5.4)
Sunday	63 (55)	219 (383)	58 (3.7)	50 (5.6)
Monday	66 (30)	296 (457)	59 (3.6)	51 (5.0)
Tuesday	52 (22)	359 (560)	60 (3.9)	50 (5.4)
Wednesday	41 (21)	189 (243)	59 (3.8)	50 (5.2)
Thursday	47 (20)	260 (456)	59 (4.2)	48 (5.2)
Friday	54 (27)	183 (304)	59 (3.7)	50 (5.3)
Saturday	79 (53)	213 (375)	58 (3.4)	49 (5.9)
Semi-Critical	120 (49)	407 (510)[b]	60 (3.4)	49 (5.0)
Sunday	114 (50)	507 (611)	60 (3.0)	48 (5.0)
Monday	95 (5)	532 (472)	60 (3.4)	48 (5.1)
Tuesday	170 (53)	336 (403)	60 (2.8)	50 (5.1)
Wednesday	153 (25)	273 (308)	61 (3.0)	49 (4.7)
Thursday	157 (21)	242(241)	61 (3.7)	50 (4.6)
Friday	60 (25)	246 (281)	62 (3.5)	49 (4.7)
Saturday	100 (20)	710 (798)	62 (3.8)	50 (5.0)
Step down	117 (71)	184 (433)[c]	56 (5.3)	49 (5.2)
Sunday	52 (8)	238 (500)	55 (4.8)	48 (5.0)
Monday	84 (82)	110 (200)	56 (5.3)	48 (5.1)
Tuesday	125 (64)	88 (171)	56 (5.6)	48 (4.6)
Wednesday	151 (66)	212 (572)	56 (5.0)	49 (5.2)
Thursday	142 (67)	249 (525)	58 (5.2)	50 (5.8)
Friday	141 (74)	259 (539)	56 (5.1)	49 (5.3)
Saturday	114 (54)	129 (260)	55 (5.2)	48 (4.9)

439 [a] Includes readings from two different critical care pods, [b] Includes readings from one semi-critical
440 care pod; [c] Includes readings from two different SFRs
441

442 **Table 2**. Means of light and sound per 24 hour period: day (7h30 to 15h30), evening (15h30
443 to 23h30) and night shifts (23h30 to 7h30) in the former NICU (OW) and current NICU
444 (pods/SFR) units

Level of care	**Light (lux)**		**Sound (dBA)**	
	OW	Pod/SFR	OW	Pod/SFR
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Critical				
Day	69 (32)	368 (403)	59 (3.8)	50 (5.3)
Evening	48 (18)	342 (525)	60 (3.6)	50 (5.4)
Night	48 (45)	28 (48)	58 (3.9)	49 (5.4)
Semi-Critical				
Day	131 (54)	741 (540)	61 (3.3)	50 (5.0)
Evening	122 (55)	410 (503)	61 (3.4)	50 (4.8)
Night	108 (35)	78 (144)	60 (3.4)	48 (5.1)
Step down				
Day	141 (62)	309 (495)	57 (5.2)	49 (5.0)
Evening	158 (63)	232 (522)	57 (5.3)	51 (5.6)
Night	48 (24)	13 (36)	54 (5.0)	47 (4.6)

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448 **List of Figures**

449

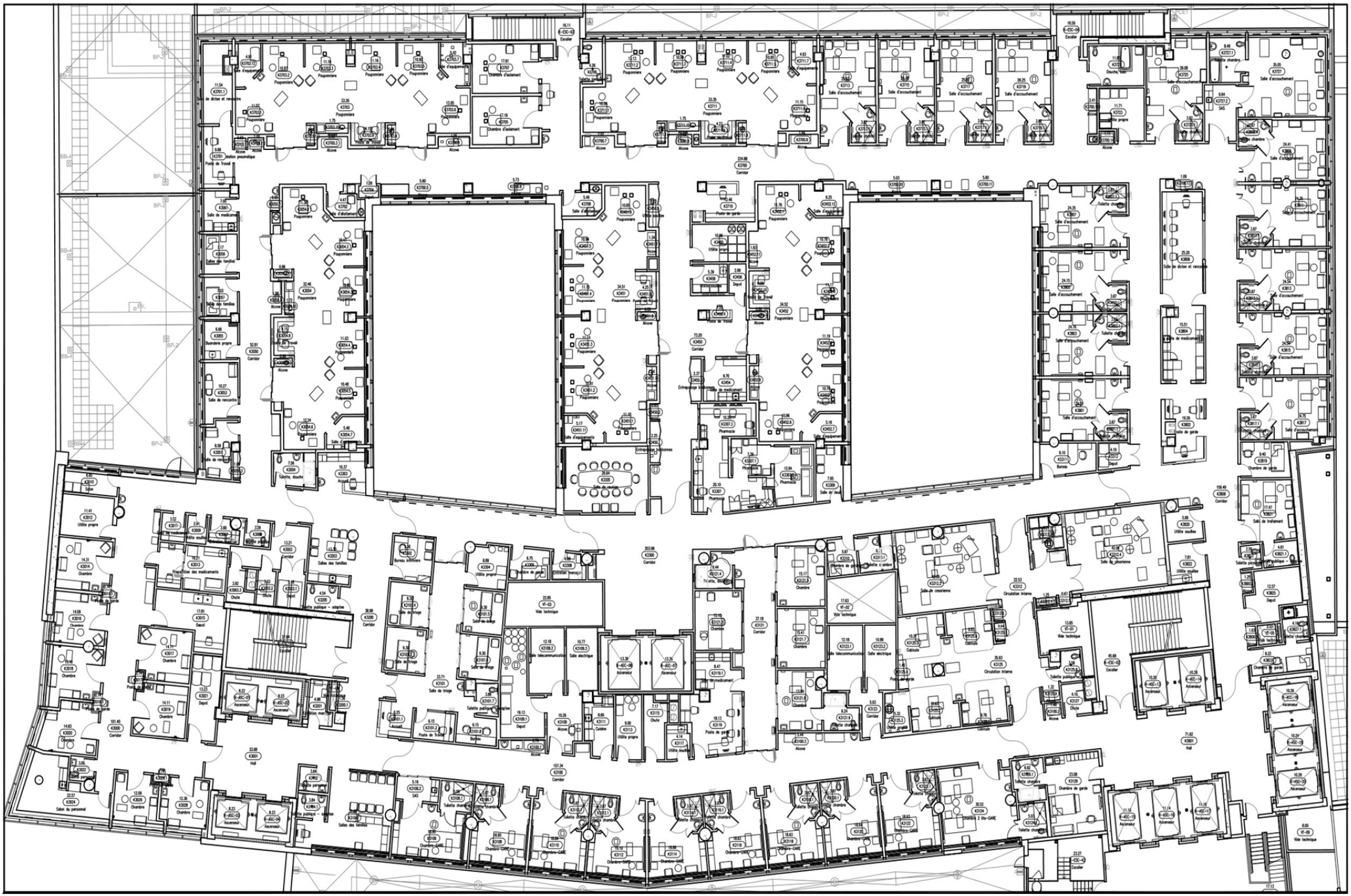

Figure 1. NICU Design of the current NICU. Scale 1:250.

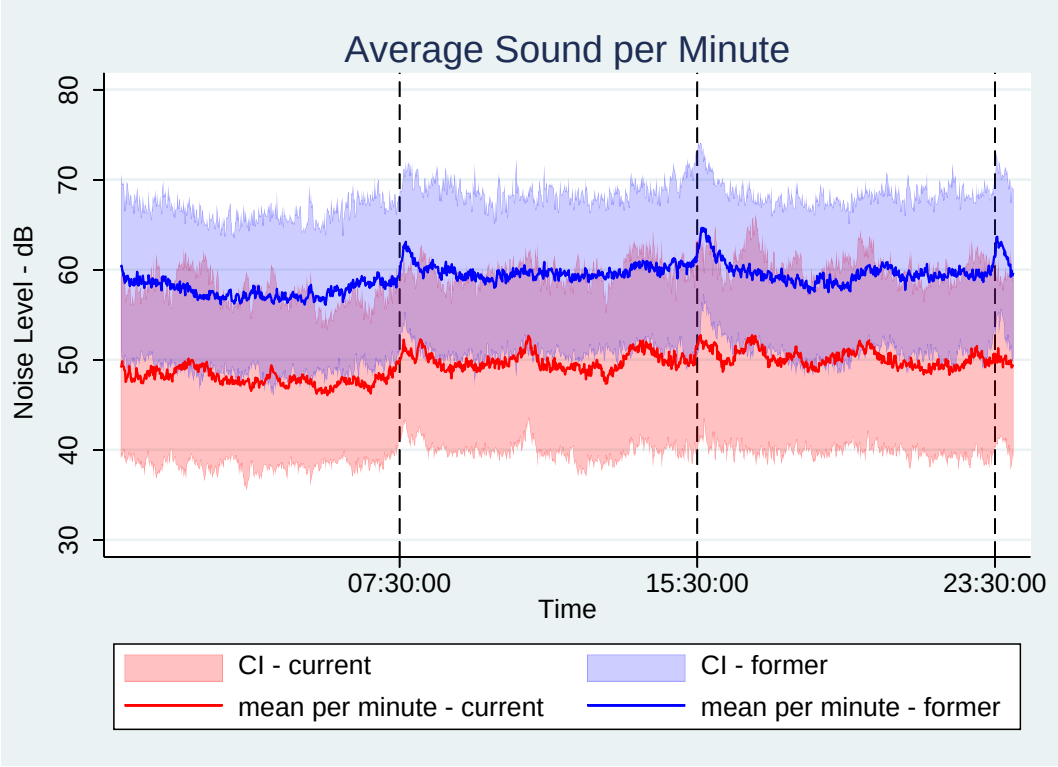

Figure 3. Sound levels peak at shift changes in both former and current NICUs.

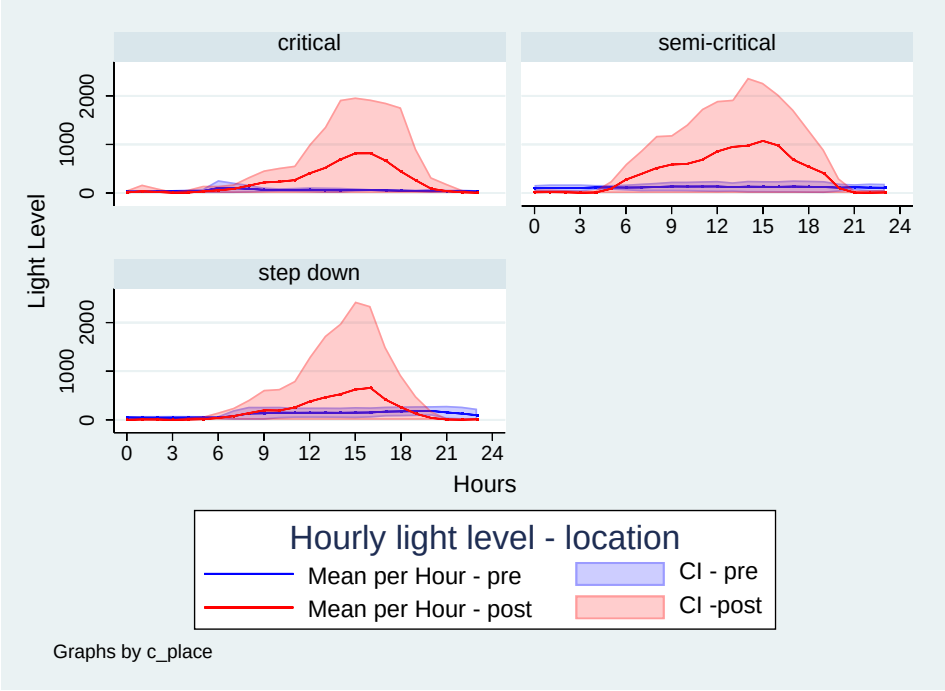

Figure 2. Hourly light levels per level of care designation in the former and current NICUs.