Sleep quality and noise: comparisons between hospital and home settings

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Received 14 March 2018
Accepted 9 June 2018

ABSTRACT

Background Children and their parents report poor sleep in hospital and complain about noise.
Objective To measure sleep quality and noise levels in hospital and compare these with the home environment.
Design Observational within case-controlled study.
Setting Paediatric medical wards at Southampton Children's Hospital and bedrooms at home.
Participants and methods Participants were children aged 3–16 years and their co-sleeping parents. Sleep quality was measured using actigraphy for a maximum of 5 nights in each setting. Median sound levels at the bedside were monitored overnight in a subgroup in both settings.
Main outcome measures Total sleep time, sleep efficiency, median sound levels overnight.
Results 40 children and 16 mothers completed actigraphy in both settings. Children had on average 62.9 min, and parents 72.8 min, per night less sleep in hospital than at home. Both children and parents had poorer sleep quality in hospital than at home: mean sleep efficiency 77.0% vs 83.2% for children and 77.1% vs 88.9% for parents, respectively. Median sound levels in hospital measured in 8 children averaged 48.6 dBA compared with 34.7 dBA at home and exceeded World Health Organization recommendations of 30 dB.
Conclusions Children and their mothers have poor quality sleep in paediatric wards. This may affect the child's behaviour, recovery and pain tolerance. Sleep deprivation adds to parental burden and stress. Sound levels are significantly raised in hospital and may contribute to poor sleep. Reduction in the level of noise might lead to an improvement in sleep, affecting the quality of stay of both parent and child.

What is already known on this topic?

- Children and parents self-report poor sleep on paediatric wards, but the only objective measurements have been made in oncology and intensive care settings.
- Noise at night may contribute to an environment which is not conducive to sleep.

What this study adds?

- Children and mothers experience over an hour less sleep and poorer sleep quality in hospital than when sleeping at home.
- Hospital noise levels exceed World Health Organization recommendations and are significantly louder than in children's bedrooms at home.

INTRODUCTION

In 2016 England's children spent over one million nights in hospital.[1] What is known about their sleep in hospital? Research using self-report sleep diaries, questionnaires and parental interview consistently indicates reduced sleep time, increased night waking and poor sleep quality in both children and co-sleeping parents.[2–4] Self-reported measures can be inaccurate,[5–7] but two small studies in oncology inpatients using objective measures of children's sleep—wrist watch accelerometry or 'actigraphy'—support these assumptions. Linder *et al* studied 15 children aged 5–12 years over three nights in the USA and reported reduced sleep quality on all nights compared with age normative data.[8 9] Setoyama *et al* compared the sleep of 11 Japanese children (aged 2–12 years) over two consecutive nights of admission for chemotherapy with one night at home, allowing children to act as their own controls. Children took longer to fall asleep in hospital (42.1 v 26.5 min) but no differences in sleep quality or total sleep time were reported.[10] Thus, convergent evidence suggests that hospital admission adversely effects sleep quality, but this has not been measured objectively in a general paediatric ward setting.

We have previously identified noise levels as a significant cause of sleep disruption in paediatric medical wards.[3] WHO recommends that average noise levels at night in hospital wards should not exceed 30 decibels (dB), with peak levels not exceeding 45 dB.[11] Oliveira *et al* measured sound levels >45 dB for 85% of the night in general paediatric wards in Portugal, but no comparisons were available with the child's usual sleep environment.[12]

In this study, we aimed to measure sleep quality objectively in both children and their co-sleeping parents admitted to paediatric medical wards and to compare this with their sleep at home. A secondary aim was to measure sound levels at the bedside in both environments.

METHODS

Participants

Inpatients ages 3–16 years, and their resident parents, were recruited across six wards at

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To cite: Bevan R, Grantham-Hill S, Bowen R, *et al*. *Arch Dis Child* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/archdischild-2018-315168

Southampton Children's Hospital, a regional centre in the south of England, between February 2012 and July 2014.

Exclusion criteria included: underlying neurological disorder or epilepsy likely to disrupt sleep; significant sleep disorders as reported by parents; surgical procedure during admission; patients likely to be admitted to the high-dependency unit; and families that did not speak English.

The study was reviewed and approved by a UK national research ethics committee (*reference 10/HO502/82*). Parents completed a consent form on behalf of their child. Where appropriate, children also completed an assent form.

Measures

Demographic data

Data were collected on parent and child age and ethnicity. The child's reason for admission was classified as either an acute or chronic condition. Chronic conditions were defined as significant health problems, with a history of regular hospital admission and/or experience of ward attendance (eg, cystic fibrosis, chronic renal disease). Location of the hospital bed (4–6 bed open bays or single occupancy cubicle) was recorded for children recruited in the latter part of the study.

Actigraphy

Children and caregivers were monitored using a Basic Mini Motionlogger actigraph watch worn on their non-dominant wrist (Ambulatory Monitoring Inc, New York, USA) for up to five consecutive nights in hospital, and up to five consecutive nights at home. This device has been validated against 'gold standard' polysomnography for identifying sleep–wake patterns in children.[13] Watches were initialised to record in zero-crossing mode (number of times per 1 min period that the activity signal level crosses zero—that is, a measure of frequency of movement). A sleep diary was used to record 'lights out' and wake times.

Sound levels

For a subset of the children, sound levels were monitored overnight using an industry standard calibrated Bruel & Kjaer 2236 sound level meter at the patient's bedside for up to two nights in hospital and two nights at home. This detected ambient sound levels, measured in A weighted decibels (dBA), these represent sound levels as perceived by the human ear.[11] The device was set to record during the child's sleep. Median sound levels (LAeq) during the child's sleep period are reported.

Data analysis

The lack of prior studies meant that estimation of sample size was pragmatic with initial estimates of 20 child–parent dyads. This was re-assessed at the study mid-point and the sample size was extended.

Actigraphy data

Actigraphy data were analysed using ActionW2 software using the Sadeh algorithm validated for use with children.[14] Raw data were visually inspected to reject periods during which the watch had been removed. Primary outcome measures included:

1. Total sleep time (TST): total minutes between sleep onset and final morning wakening.
2. Sleep efficiency (SE): percentage of minutes scored as sleep from sleep onset to morning wakening.

Data were analysed in SPSS version 21 (IBM) and examined for normality using the Shapiro-Wilk test. Normally distributed data were analysed using paired or independent samples t-tests. Non-normally distributed data were analysed using Wilcoxon signed rank test for paired samples and Mann-Whitney U test for independent samples. Change in sleep measures within a location over time were assessed using analysis of variance with repeated measures or Friedman test for non-parametric data.

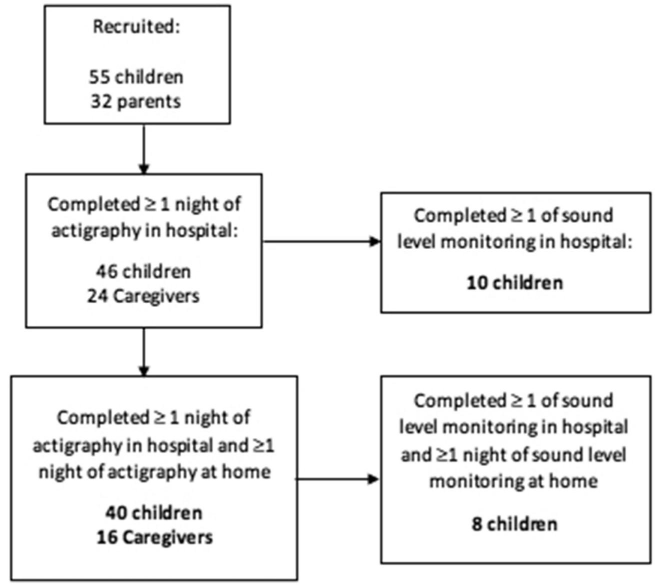

Figure 1 Recruitment.

RESULTS

Participants

Fifty-five children and 32 parents met the inclusion criteria and were recruited to the study (figure 1). Forty children and 16 parents completed a minimum of one night of actigraphy both in hospital and at home. Attrition was due to children not tolerating the actiwatch, limitations of equipment availability and reluctance to continue the study after discharge. The 40 children (19 male) had a mean age of 9.3 years (SD 3.5), 87.5% were white and 65% were admitted with an acute condition. All 16 parents were mothers with an average age of 37.9 years (SD 6.1). Ages were missing for one child and two mothers. There were no significant differences in demographics, or reason for admission between the children recruited and the final sample.

Of the eight children (five male) who completed sound level monitoring, the average age was 9.0 years (SD 3.1) and a higher proportion (27.5%) were from black and ethnic minority backgrounds. No other significant differences were noted.

Actigraphy: children

Children were monitored for a mean of 2.9 (SD 1.5) nights in hospital and 3.5 (SD 1.5) nights at home. TST was normally distributed and SE was not normally distributed; means and CI are reported for ease of reading. Both TST (mean 446.6 min hospital, 95% CI 416.0 to 477.2 vs 509.5 min home, 95% CI 482.1 to 536.9, $P<0.001$) and SE (mean 77.0% hospital, 95% CI 73.2% to 80.9% vs 83.2% home, 95% CI 80.1% to 86.4% $P=0.002$) were significantly lower in hospital than at home. There was an average reduction in TST of 62.9 min (SD 86.6, 95% CI 36.43 to 65.6) in hospital compared with home (figures 2 and 3).

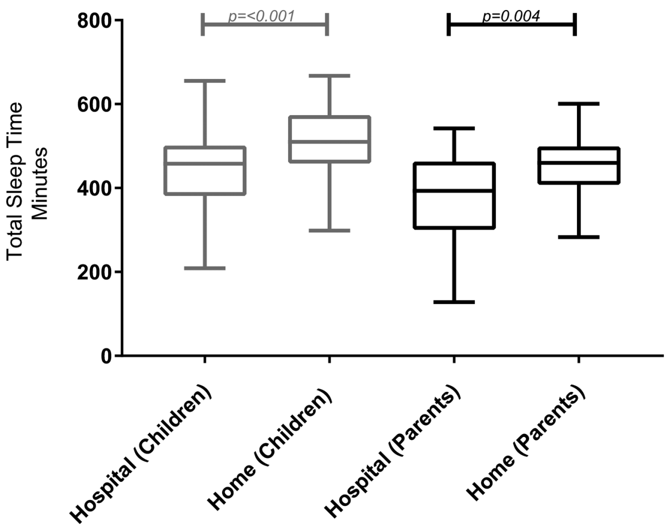

Figure 2 Mean total sleep time of children and their co-sleeping parents during hospital admission compared with at home.

Actigraphy: parents

Parents were monitored for a mean of 2.6 nights (SD 1.5) in hospital and 3.6 nights (SD 1.2) at home. Both TST and SE were normally distributed. Both TST (mean 381.1 min hospital, 95% CI 320.5 to 441.7 vs 453.9 min home, 95% CI 414.0 to 493.7, P=0.004) and SE (77.1% hospital, 95% CI 71.1% to 83.1% vs 88.9% home, 95% CI 85.5% to 92.3%, P<0.001) were significantly lower in hospital than at home. There was an average reduction in TST of 72.8 min (SD 85.01, 95% CI 35.58 to 115.23) in hospital compared with home (figures 2 and 3).

Differences in hospital sleep measures by type of admission and sleep location

A larger group of 46 children and 24 parents completed one night of actigraphy in hospital. There was no significant difference in demographic characteristics or reason for admission in this subgroup as compared with the recruited sample. Data entry for location of sleep was incomplete.

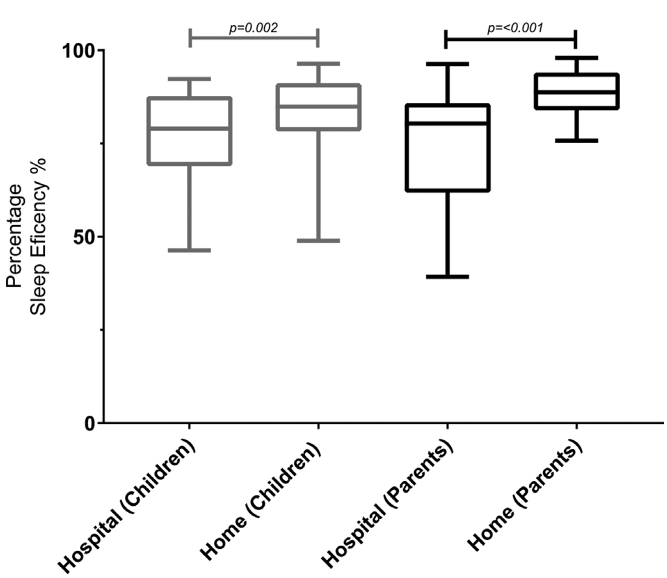

Figure 3 Mean sleep efficiency of children and their co-sleeping parents during hospital admission compared with at home.

There was no difference in TST and SE during hospital stays between children admitted with acute or chronic conditions (acute mean TST 439.0 min (95% CI 402.6 to 477.3), chronic mean TST 471.4 min (95% CI 429.4 to 517.4), P=0.22; acute mean SE 75.9%, 95% CI 70.7% to 81.1%), chronic mean SE 79.1%, (95% CI 74.3% to 83.8%) P=0.661, n=46)

There was no difference in average TST between children sleeping in open bays compared with single occupancy cubicles (open bay TST 426.4 min (95% CI 388.1 to 467.8), single occupancy cubicle 399.2 min (95% CI 336.9 to 459.3), P=0.47, n=19) or average SE (open bay SE 82.8 (95% CI 75.7% to 89.9%), cubicle SE 72.4% (95% CI 61.3% to 82.1%), P=0.17, n=19).

Controlling for recovery night at home

As participants might have experienced a night of recovery sleep on returning home, differences between consecutive nights at home were assessed.[15 16] There was no recovery effect noted in TST and SE in either children or parents in a repeated measure analysis comparing the first and third nights at home (children TST P=0.807, children SE P=0.984; parents TST P=0.249, parent SE P=0.607)

Sound level monitoring

Sound level monitoring was completed at the bedside for at least one night in 10 children during their hospital admission of whom five had two nights of measurement. The average median sound level LAeq recorded was 48.24 dB with a trend towards a difference between the seven children sleeping in open bays versus those sleeping in single occupancy cubicles (n=3): open bay mean 50.35 dBA, 95% CI 38.7 to 62.0, single occupancy cubicle mean 42.27 dBA, 95% CI 33.3 to 51.2, P=0.077).

Eight children were monitored both in hospital and at home. Median sound levels were significantly higher in hospital than at home: LAeq 48.6 dBA in hospital (95% CI 42.3 to 54.8) compared with 34.7 dBA at home (95% CI 27.9 to 41.5); P=0.017 (figure 4).

DISCUSSION

This is the first report of poor sleep quality in both children and mothers in a paediatric medical ward using objective measures. Children lost over 1 hour of sleep in hospital compared with sleep at home, averaging just under 7.5 hours of sleep, while mothers had almost an hour and quarter less sleep, averaging only 6 hours and 20 min in hospital. Children and mothers had a shorter sleep in hospital and the quality of their sleep was also relatively poor.

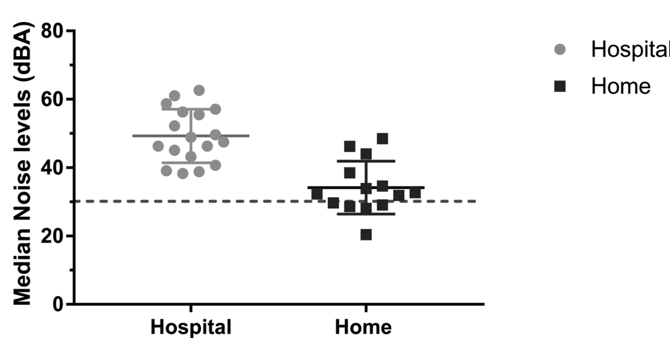

Figure 4 Median sound levels (dBA) during children's sleep period in hospital compared with nights spent at home.

Does this matter? Growing evidence supports the role of sleep in behavioural and emotional regulation across life.[17] School-aged children deprived of 54 min of sleep (less than in this study) over five nights had restless-impulsive behaviour and poorer emotional regulation.[18–20] A study of mothers caring for children with eczema found that only 39 min of sleep deprivation correlated with increased maternal anxiety and depression.[21] Having a child in hospital is stressful.[3 22] Even during a short admission period, 90% of parents report feeling upset, and 52% mentally exhausted.[23] Sleep loss may compound parental stress and anxiety, and emotionally dysregulated children will be less likely to comply with treatment.

Sleep loss in hospital may have other physiological consequences. An association between lack of sleep and increased pain sensitivity is well established in adults.[24] Experimental studies are lacking in children, but it is reasonable to assume the same is true.[25 26] Better sleep might, in theory, improve children's ability to cope with pain and reduce the need for analgesia. There is also good evidence that sleep regulates immune function, although it is not known to what extent this is affected by sleep loss.[26–28] As infection is the leading cause of hospital admission, it makes little sense to risk further impairment of immune function through sleep loss.[29] In paediatric intensive care units, there is growing interest in the impact of sedation or mechanical ventilation on sleep, and the impact this has on the child's outcome.[30]

Our study was not designed to explain why children and their parents experienced poor sleep. In a US paediatric oncology setting, sound, light, medication dose, pain and nausea accounted for 57% of the variance in total sleep time between patients.[31] Parents in our previous research had identified noise as a modifiable source of sleep disruption.[3] Median bedside sound levels in this present study (48.2 dBA) exceeded WHO guidelines of 30 dBA, and were similar to levels in a Portuguese general paediatric ward (43.4–54.9 dB) and oncology wards in the USA (49.5 dB).[11 12 32]

We did not measure the inter-relationship between sleep quality and noise levels, but it is reasonable to infer that noise will have affected sleep. The sleeping brain is highly attuned to sound, an important evolutionary defence to potential threat. Nocturnal noise can induce changes in sleep stage and awakening, resulting in fragmentation of sleep architecture.[33] Electronic sounds, such as IV pump alarms, are particularly likely to arouse patients.[34] Furthermore, the autonomic arousal associated with such repeated exposure to noise does not show the acclimatisation that occurs when awake. Our findings that noise levels in children's bedrooms (34.7 dBA) also exceeded the WHO recommendation of 30 dBA LAeq were interesting and underline the importance of home measures.[11] Traffic noise in urban settings can affect children's sleep, and exposure to traffic noise has been linked to increased frequency of emotional symptoms and hyperactivity and may influence blood pressure.[35 36] Are WHO guidelines unrealistic for modern society, or are some children chronically overexposed to night time noise?

Limitations

No record was kept of the families who declined participation, or who were not approached, so there may have been sampling bias in our original sample of 55 children. However, families of sicker children were likely to refuse to take part at the outset, therefore selection bias would be towards children with less disrupted sleep. Of the 55 children recruited to the study, only 73% completed sleep measures in both settings; however, the lack of demographic differences between the original and final samples suggests no systematic bias.

Importantly these data represent the largest series of children with objective sleep measures in hospital. That each child acted as their own control with measures both in hospital and in their home environment is a further strength.

Expert consensus is that five nights of actigraphy is optimal for reliable interpretation.[37] In this study, on average, children were studied for 2.9 nights and mothers for 2.6 nights. This was a necessary compromise as the average length of admission to paediatric units was 2.1 days in 2012/2013.[38] Indeed, previous research using this approach has reported data including only one night of actigraphy.[10]

Limited data were recorded for other variables that might have affected sleep. Future studies could usefully explore how child factors (treatment, observation schedules, pain, fever, primary diagnosis) and environmental factors (light, temperature, noise) relate to children's sleep.

Finally, each hospital ward has a unique and fluctuating environment dictated by physical design, resident children and parents and by staff behaviour. Generalisability of our findings cannot be assumed, although our data do confirm a growing literature in this field.[3 4 12 39]

CONCLUSION

Children and their mothers in this study had significantly less sleep at night in hospital than at home. Furthermore, they were exposed to significantly higher noise levels that exceeded WHO recommendations. Despite 150 years of medical progress we have forgotten the basic lessons of patient care,

'Unnecessary noise is the cruellest absence of care.' Florence Nightingale 1859.

Sleep is one aspect of care that can be freely delivered and future research should evaluate interventions which promote sleep for children and parents alike.

Contributors AS and EC: research governance, protocol development, data collection, reviewed final draft. HG, RBo, HCV: data collection, reviewed final draft. RBe: data collection, data analysis, co-authored manuscript, reviewed final draft. SG-H: data analysis, co-authored manuscript. CMH: conceptualised the study, data analysis, co-authored manuscript.

Funding The work reported in this article was undertaken as part of undergraduate BMedSci studies (RS, AS , EC, HCV). RBo and SG-H were supported by the University of Southampton National Institute of Health Research Academic Foundation Programme.

Competing interests None declared.

Patient consent Not required.

Ethics approval UK National Research ethics committee.

Provenance and peer review Not commissioned; externally peer reviewed.

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