

Antibiotic Stewardship for Childhood Respiratory Infections: A Simulated Primary-Care Study

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Abstract

Background: Unnecessary antibiotic treatment of childhood respiratory infections contributes to antimicrobial resistance and avoidable adverse effects. Primary-care interventions should reduce prescribing while maintaining clear pathways for reassessment. **Objective:** To illustrate the evaluation of a brief pediatric stewardship intervention using a transparent, entirely synthetic dataset. **Methods:** This educational analysis modeled 240 encounters involving children aged 2–12 years with uncomplicated acute respiratory infections. Equal pre-intervention and post-intervention groups were constructed. The modeled intervention combined a diagnostic checklist, clinician feedback, caregiver counseling, and written safety-net instructions. Antibiotic prescribing was the primary outcome; seven-day reconsultation, emergency attendance, and hospitalization were secondary outcomes. Descriptive comparisons were calculated without significance testing because the observations were simulated rather than collected from patients. **Results:** Antibiotics were prescribed in 84 of 120 pre-intervention encounters and 48 of 120 post-intervention encounters, corresponding to 70.0% and 40.0%, respectively. This represented a 30.0-percentage-point absolute reduction and a 42.9% relative reduction. Reconsultations occurred in 12 versus 10 encounters, while emergency attendance occurred twice in each group. Neither group contained a hospitalization. **Conclusions:** The constructed example demonstrates how a feasible stewardship evaluation might quantify prescribing changes alongside short-term clinical outcomes. It does not establish intervention effectiveness or safety. Prospective research using actual patient records, appropriate ethical oversight, and longer follow-up is necessary before clinical conclusions can be drawn.

Keywords: pediatrics, antibiotic stewardship, respiratory infections, primary care, antimicrobial resistance, caregiver counseling, simulation

1. Introduction

Acute respiratory tract infections are among the most frequent reasons for children to attend primary care and remain a major source of uncertainty in pediatric prescribing. Although many episodes are viral and resolve with supportive care, antibiotics are often considered when symptoms overlap with those of bacterial disease. The challenge is to identify children who may benefit from antimicrobial treatment while avoiding unnecessary exposure in those unlikely to benefit. This balance is particularly important in young children, in whom respiratory symptoms are common, clinical findings may be nonspecific, and concerns about deterioration can influence decisions made during brief

consultations.

Unnecessary antibiotic use can cause adverse drug reactions, increase treatment costs, and contribute to antimicrobial resistance. Repeated exposure may also alter the developing intestinal microbiome, although the long-term clinical significance of these changes remains incompletely understood. At the same time, withholding antibiotics from a child with a clinically important bacterial infection can delay effective treatment. Pediatric antimicrobial stewardship therefore requires more than reducing overall prescription rates. It requires improving the appropriateness of treatment according to the clinical syndrome, illness severity, patient characteristics, and recommendations applicable to the local setting.

Prescribing decisions are shaped by interacting clinical and contextual factors. Age, fever duration, respiratory findings, comorbidities, and previous treatment may influence clinicians' assessment of bacterial infection risk. Diagnostic uncertainty can be amplified by limited access to testing, inconsistent continuity of care, or concerns that families may be unable to return if symptoms worsen. Caregiver expectations, prior experiences with antibiotics, and beliefs about the significance of fever may also affect consultations. However, clinicians' perceptions of caregiver demand do not necessarily reflect caregivers' actual preferences, making direct assessment of these influences important.

Children younger than five years represent a particularly relevant population for studying these decisions. They experience frequent respiratory illnesses, often cannot describe symptoms clearly, and depend on caregivers to communicate changes in their condition. Distinguishing uncomplicated upper respiratory infections from illnesses requiring antibiotic treatment may be difficult when consultation time and diagnostic resources are constrained. Describing which children receive antibiotics, and whether prescriptions are consistent with documented clinical indications, could identify opportunities for safer, more targeted prescribing without assuming that every respiratory infection should be managed identically.

Local evidence is needed because prescribing patterns and their determinants may differ across health systems and even between clinics serving similar populations. Aggregate antibiotic consumption data cannot reliably distinguish appropriate treatment from avoidable prescribing, while diagnosis codes alone may not capture the findings that informed a decision. Linking consultation-level clinical information with prescription details and caregiver-reported expectations can provide a more informative assessment. Such an approach may help separate factors associated with clinical need from potentially modifiable influences, while recognizing that observational associations cannot establish why an individual prescription was issued.

This study therefore aims to assess antibiotic prescribing for acute respiratory tract infections among children younger than five years attending primary care clinics. Its objectives are to estimate the proportion of encounters resulting in an antibiotic prescription, evaluate concordance with predefined guideline-based criteria, and examine associated clinical, caregiver, and service-related factors. By identifying patterns of potentially avoidable use and areas of diagnostic uncertainty, the study seeks to inform locally feasible pediatric antimicrobial stewardship strategies.

2. Materials and Methods

A prospective observational cohort study will examine whether evening screen exposure is associated with subsequent sleep duration and behavioral difficulties among preschool-aged children. Recruitment will take place over six months at six urban primary care clinics in Tashkent, Uzbekistan, with follow-up six months after enrollment. The protocol will require approval from an institutional research ethics committee before recruitment begins. Written informed consent will be obtained from a parent or legal guardian. Children will receive age-appropriate explanations and may decline individual assessments without affecting their clinical care.

Children aged 3–5 years who attend participating clinics for preventive or nonurgent care will be eligible. Families must anticipate remaining in the clinic catchment area during follow-up and have a caregiver able to complete questionnaires in Uzbek or Russian. Exclusion criteria will include diagnosed sleep disorders requiring treatment, neurological conditions substantially affecting sleep–wake regulation, and regular use of medications known to alter sleep. Children with stable

chronic conditions will otherwise remain eligible. Assessments will be postponed during acute febrile illness until at least seven symptom-free days have elapsed. Clinic staff will screen consecutive eligible attendees during predefined recruitment sessions and document reasons for nonparticipation.

The recruitment target will be 600 children, allowing for approximately 20% attrition and providing an anticipated analytic sample of 480. This target is based on recruitment feasibility and estimation precision rather than an assumed intervention effect. With an anticipated standard deviation of 70 minutes, 480 independent observations would estimate mean sleep duration with a nominal 95% confidence interval half-width of approximately six minutes; clustering and missingness may reduce precision. Recruitment and retention will be summarized by clinic, and baseline characteristics of participants retained and lost to follow-up will be compared descriptively.

Caregivers will complete seven-day media diaries at baseline and follow-up, recording television, smartphone, tablet, and computer use in 15-minute intervals. Entries will distinguish recreational use from video communication and preschool-directed activities. The primary exposure will be average recreational screen time during the two hours preceding intended bedtime, expressed in minutes per evening. Simultaneous use of multiple devices will count as elapsed time rather than summed device time. Secondary exposures will include total daily recreational screen time and bedroom device availability. Staff will review diaries for omissions using standardized, nonjudgmental prompts.

Sleep will be assessed concurrently using wrist-worn actigraphy for seven consecutive days, supported by caregiver-recorded bedtimes, wake times, naps, and device removal. The primary outcome will be mean nocturnal sleep duration at six months, calculated using a prespecified pediatric scoring algorithm and diary-defined sleep windows. A valid assessment will require at least four usable nights, including one weekend night, without prolonged device removal during the reported sleep interval. Secondary outcomes will include sleep onset latency, sleep efficiency, and night-to-night variability in sleep duration. A trained assessor blinded to questionnaire exposure summaries will review ambiguous recordings under a standardized adjudication procedure.

Caregivers will also complete an age-appropriate Strengths and Difficulties Questionnaire in a locally validated language version, where available. If a validated version is unavailable, translated questionnaire findings will be treated as exploratory rather than confirmatory. Height and weight will be measured using calibrated equipment. Baseline covariates will include child age, sex, preschool attendance, household socioeconomic indicators, caregiver education, caregiver psychological distress, physical activity, habitual napping, bedtime routines, and household crowding. Assessment date will capture seasonal variation. Data will be entered into a password-protected database with coded identifiers, range checks, and verification of a random 10% sample against source records.

The primary analysis will use linear regression to estimate the difference in follow-up nocturnal sleep duration per additional 30 minutes of baseline evening screen exposure, adjusting for baseline sleep duration and prespecified covariates selected using a causal diagram. Clinic will enter the model as a fixed effect. Nonlinearity will be explored with restricted cubic splines. Results will be reported as adjusted estimates with 95% confidence intervals, emphasizing magnitude and precision rather than statistical significance alone. Missing covariate and outcome data will be addressed using multiple imputation when its assumptions are defensible, alongside complete-case analyses. Sensitivity analyses will exclude children initiating sleep-altering medication and adjust for total daily screen exposure. Secondary analyses will be explicitly exploratory. Because exposure is not randomized, findings will be interpreted as associations potentially affected by residual confounding and reporting error.

3. Results

The following results describe a simulated cross-sectional study of recreational screen exposure, sleep duration, and obesity among school-aged children; the numerical findings are hypothetical and do not represent observations from an actual patient cohort. The analysis included children aged 6–12 years attending pediatric primary care clinics. Outcomes were examined using measured anthropometry and caregiver-reported behavioral characteristics, with obesity defined as a body mass index at or above the age- and sex-specific 95th percentile.

Of 712 children approached, 668 underwent initial assessment and 624 had complete information for the primary analysis. Forty-four families declined participation, while 44 assessed children were excluded because anthropometric measurements, screen exposure, or sleep duration were unavailable. The final sample therefore represented 87.6% of children approached. Included and excluded children had similar recorded age and sex distributions, although incomplete behavioral information prevented a comprehensive assessment of potential selection bias.

The mean age was 9.3 ± 1.9 years, and 312 participants (50.0%) were girls. Mean body mass index z score was 0.62 ± 1.12 . Overall, 114 children (18.3%) had obesity and another 100 (16.0%) had overweight without obesity. Obesity was present in 64 boys (20.5%) and 50 girls (16.0%). This descriptive difference was not interpreted as establishing a sex-specific association. No children were excluded because of their weight category.

Recreational screen exposure averaged 3.0 ± 1.7 hours daily. Exposure was below 2 hours in 208 children (33.3%), between 2 and 4 hours in 258 (41.3%), and above 4 hours in 158 (25.3%). Children in the highest exposure category were older on average and had shorter reported sleep duration. The prevalence of obesity increased across the three exposure categories, from 12.0% to 17.4% and 27.8%, respectively. Table 1 summarizes the principal unadjusted characteristics.

Table 1. Participant characteristics by daily recreational screen exposure in the simulated cohort

Characteristic	Below 2 hours (n = 208)	2–4 hours (n = 258)	Above 4 hours (n = 158)
Age, years, mean $\pm$ SD	8.8 ± 1.8	9.3 ± 1.9	10.0 ± 1.7
Girls, n (%)	110 (52.9)	129 (50.0)	73 (46.2)
Sleep, hours nightly, mean $\pm$ SD	9.5 ± 0.8	9.0 ± 0.9	8.4 ± 1.0
Sleep below 9 hours, n (%)	48 (23.1)	95 (36.8)	85 (53.8)
Obesity, n (%)	25 (12.0)	45 (17.4)	44 (27.8)

Mean reported sleep duration was 9.0 ± 1.0 hours nightly, and 228 children (36.5%) slept fewer than 9 hours. The prevalence of short sleep was 30.7 percentage points higher in the highest screen exposure category than in the lowest. Among children with short sleep, 60 (26.3%) had obesity, compared with 54 of 396 children (13.6%) sleeping at least 9 hours. These comparisons describe co-occurring behaviors and weight status rather than the temporal sequence of their development.

In unadjusted logistic regression, screen exposure above 4 hours daily was associated with higher odds of obesity compared with exposure below 2 hours (odds ratio, 2.83; 95% confidence interval, 1.64–4.90). The corresponding estimate for exposure between 2 and 4 hours was 1.55 (95% confidence interval, 0.91–2.62). Adjustment for demographic, household, and behavioral covariates attenuated both estimates. The highest exposure category retained an association with obesity, whereas the confidence interval for the intermediate category included the null value.

The primary multivariable model included screen exposure, short sleep, age, sex, parental obesity, physical activity, sugar-sweetened beverage consumption, and household income. As shown in Table 2, parental obesity had the largest adjusted association among the included binary predictors. Short sleep was also associated with higher odds of obesity after adjustment for screen exposure and the remaining covariates. Daily physical activity of at least 60 minutes was associated with lower odds, although its confidence interval approached the null.

Table 2. Mutually adjusted associations with obesity in the simulated cohort of 624 children

Predictor and comparison	Adjusted odds ratio	95% confidence interval
Screen exposure 2–4 versus below 2 hours daily	1.32	0.75–2.32
Screen exposure above 4 versus below 2 hours daily	1.96	1.08–3.55

Sleep below 9 versus at least 9 hours nightly	1.68	1.03–2.75
Age, per additional year	1.07	0.95–1.21
Male versus female sex	1.24	0.79–1.96
Parental obesity, present versus absent	2.41	1.49–3.90
Physical activity at least 60 minutes daily, yes versus no	0.62	0.39–0.99
Sugar-sweetened beverages daily, yes versus no	1.43	0.89–2.29
Lower versus higher household income	1.21	0.75–1.95

When screen exposure was modeled continuously, each additional daily hour was associated with an adjusted odds ratio for obesity of 1.16 (95% confidence interval, 1.03–1.31). This estimate was directionally consistent with the categorical analysis, but it depended on the assumption of a linear relationship on the log-odds scale. A screen exposure-by-sex interaction was not clearly supported (interaction $P = 0.48$); the available sample nevertheless provided limited precision for subgroup comparisons.

In a sensitivity analysis using overweight or obesity as the combined outcome, exposure above 4 hours remained associated with higher adjusted odds than exposure below 2 hours (odds ratio, 1.72; 95% confidence interval, 1.08–2.75). Overall, the simulated analyses showed consistent associations between greater screen exposure, shorter sleep, and higher weight status, without establishing causality or demonstrating that sleep mediated the screen exposure–obesity relationship.

4. Discussion

The findings of this study suggest that greater recreational screen exposure is associated with a less favorable weight profile among school-aged children, with shorter sleep duration emerging as a potentially important accompanying factor. This pattern supports considering digital media use within the broader behavioral context of pediatric obesity rather than as an isolated exposure. The association should not be interpreted as evidence that screen use independently causes excess weight gain. Instead, the results indicate that screen habits, sleep, and weight status may cluster in ways that are relevant to preventive pediatric care.

A central interpretation is that the timing and context of screen exposure may matter alongside its duration. Evening device use can displace bedtime, while stimulating content and notifications may make settling to sleep more difficult. Screen use during meals may also reduce attention to hunger and satiety cues or coincide with greater consumption of energy-dense snacks. These mechanisms are biologically and behaviorally plausible, but they were not directly established by the present analysis. In particular, total recreational screen time cannot distinguish passive viewing from interactive entertainment, social communication, or activities shared with caregivers, each of which may have different implications for health.

The concurrent association between shorter sleep and higher adiposity strengthens the rationale for evaluating sleep when discussing weight-related behaviors with families. Insufficient sleep may influence appetite regulation, emotional self-regulation, and opportunities for physical activity, although these pathways are difficult to separate in observational data. Conversely, children with obesity may experience disturbed sleep because of sleep-disordered breathing or other conditions. Sleep should therefore be regarded as both a possible contributor and a potential consequence of unfavorable weight status. Formal mediation claims would require clearer temporal ordering and more detailed assessment than a cross-sectional design can provide.

The clinical relevance of these findings lies less in identifying a single harmful behavior than in recognizing modifiable household routines. Brief consultations could include questions about bedtime

consistency, device use before sleep, eating while viewing screens, and opportunities for active play. Such assessment may reveal practical targets that are more actionable than a general instruction to reduce screen time. Recommendations should be developmentally appropriate and negotiated with caregivers, recognizing that digital devices also support education, social participation, and family functioning. A nonjudgmental approach is especially important because weight-focused counseling can unintentionally reinforce stigma or discourage future engagement with healthcare.

Interpretation must also account for the social conditions surrounding children's daily behaviors. Limited access to safe outdoor spaces, caregiver work schedules, crowded housing, and the affordability of organized activities may simultaneously influence screen exposure, sleep regularity, and obesity risk. Adjustment for measured household characteristics can reduce some confounding but cannot fully capture these interconnected constraints. Accordingly, an observed association should not be translated into assumptions about parental motivation or responsibility.

Several measurement considerations further qualify the findings. Caregiver-reported screen use and sleep duration are vulnerable to recall error and social desirability bias, particularly when routines vary between school days and weekends. Even measured body mass index is an imperfect indicator of adiposity and requires interpretation using age- and sex-appropriate standards. These issues may either obscure or exaggerate associations, depending on whether reporting errors differ by weight status, underscoring the value of more precise behavioral assessment.

The clinical relevance of the observed association between evening recreational screen exposure and poorer sleep in school-aged children lies primarily in its potential modifiability. Although the findings do not establish that reducing screen use improves sleep, they support including media habits in routine pediatric sleep assessments. Asking about device use during the hour before bedtime, access to screens in the bedroom, and consistency of evening routines may identify concerns that are not captured by questions about total daily screen time alone. These discussions should remain supportive rather than punitive, recognizing that digital devices may serve educational, social, and practical functions within families.

Several mechanisms could plausibly contribute to this association. Screen use may delay bedtime by displacing established routines, while emotionally stimulating content and interactive activities may increase cognitive arousal. Evening light exposure may also influence circadian timing, although its contribution depends on exposure duration, brightness, viewing distance, and individual sensitivity. These pathways were not directly measured and should therefore be interpreted as possible explanations rather than demonstrated mediators. Reverse causation is also credible: children who struggle to fall asleep may be offered devices or seek screen-based activities while awake.

The findings should be interpreted within the broader context of family circumstances. Caregiver work schedules, household crowding, parental stress, and limited access to safe recreational spaces can shape both screen habits and sleep opportunities. Consequently, advice focused exclusively on parental supervision may underestimate structural barriers and inadvertently increase caregiver blame. Pediatric counseling may be more feasible when it prioritizes a small number of jointly agreed changes, such as a predictable wind-down period, overnight charging outside the bedroom, or replacement of stimulating media with quiet activities. Such approaches warrant evaluation rather than being assumed effective on the basis of observational associations.

Important limitations constrain interpretation. The cross-sectional design prevents assessment of temporal ordering and cannot distinguish whether screen exposure precedes sleep disturbance. Caregiver-reported exposure and sleep measures are vulnerable to recall error and social desirability bias; shared reporting methods may additionally influence the strength of observed associations. Adjustment for measured covariates cannot eliminate residual confounding from factors such as child temperament, caregiver mental health, or unrecognized sleep disorders. Recruitment from a limited clinical setting may also reduce generalizability, particularly to children with different socioeconomic circumstances or neurodevelopmental profiles. Moreover, grouping diverse screen activities together may obscure meaningful differences between educational viewing, social communication, and highly interactive gaming.

Future research should use longitudinal designs with repeated assessments to clarify directionality

and identify developmental periods of greater susceptibility. Combining device-based exposure records with actigraphy and validated sleep questionnaires could improve measurement while preserving attention to privacy and family burden. Pragmatic trials should assess whether family-centered evening media interventions produce sustained improvements in sleep and daytime functioning, rather than simply reducing reported screen minutes. Prespecified analyses could explore whether intervention effects vary by baseline sleep difficulties, age, or household resources.

Overall, the present findings identify evening screen habits as a potentially relevant component of pediatric sleep health, not an isolated explanation for sleep problems. Their practical value is to encourage individualized assessment and feasible family discussions while maintaining appropriate uncertainty about causality and intervention benefit. Persistent sleep difficulties require broader clinical evaluation rather than attribution to screen exposure alone.

5. Conclusion

This study supports the importance of improving antibiotic prescribing for acute respiratory tract infections in pediatric outpatient care. The observed prescribing patterns suggest that opportunities remain to reduce potentially unnecessary antibiotic exposure, particularly when clinical findings are more consistent with self-limiting viral illness than bacterial infection. These findings should be interpreted as evidence of a quality-improvement opportunity rather than proof that individual prescribing decisions were inappropriate, because routine clinical documentation may not fully capture diagnostic uncertainty or the circumstances influencing treatment.

A practical response should combine structured clinical assessment, guideline-informed prescribing, and clear communication with caregivers. Explaining the expected duration of symptoms, appropriate supportive care, and warning signs that require reassessment may help clinicians manage uncertainty without automatically initiating antibiotics. Where clinically appropriate and supported by local guidance, delayed prescribing may offer an additional option. However, stewardship must not become a barrier to timely treatment for children with suspected serious bacterial infection, significant comorbidities, or limited access to follow-up. Prescribing decisions should remain individualized and responsive to the child's clinical condition.

The interpretation of these findings is constrained by the observational design, dependence on recorded clinical information, and potential differences in illness severity and healthcare access. Associations between prescribing and patient or consultation characteristics cannot establish causality. In addition, prescription records do not necessarily indicate whether medicines were obtained, administered correctly, or completed. Without sufficiently detailed follow-up, the study cannot determine whether lower prescribing would produce equivalent clinical outcomes or reduce subsequent antimicrobial resistance. These limitations favor cautious conclusions and discourage direct extrapolation to settings with different resources or disease burdens.

Future research should evaluate pediatric stewardship interventions prospectively, incorporating symptom resolution, repeat consultations, hospital admissions, adverse drug events, caregiver understanding, and equitable access to care. Multicenter studies would help establish whether observed patterns are reproducible and which interventions are feasible across diverse outpatient settings. Overall, the findings support a balanced approach to pediatric antibiotic stewardship: reducing avoidable treatment while preserving rapid recognition and management of bacterial disease. Embedding this approach within routine care, with accessible reassessment and ongoing monitoring of safety outcomes, offers a clinically relevant direction for improving prescribing quality and protecting child health.

AUTHOR INFORMATION

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