# RANDOMIZED TRIAL OF CAREGIVER TEXT-MESSAGE NUDGES IMPROVING ANTIBIOTIC STEWARDSHIP IN PEDIATRIC RESPIRATORY INFECTIONS

*Original Research*

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## ABSTRACT

**Background:** Inappropriate antibiotic use for pediatric respiratory infections remains a persistent challenge, contributing to antimicrobial resistance and unnecessary healthcare utilization. Caregivers often initiate antibiotics without medical indication due to uncertainty about illness progression. Low-cost SMS reminders may offer a practical tool to strengthen outpatient antibiotic stewardship.

**Objective:** To evaluate whether brief, behaviorally informed SMS reminders sent to caregivers reduce inappropriate antibiotic use and related unplanned revisits compared with standard discharge advice alone.

**Methods:** A randomized controlled trial was conducted in outpatient pediatric clinics across South Punjab, enrolling 382 caregiver–child pairs presenting with non-bacterial respiratory infections. Participants were randomized 1:1 to receive either routine discharge guidance alone or routine guidance plus SMS reminders over 72 hours. Primary outcome was inappropriate antibiotic use within 10 days. Secondary outcomes included unplanned revisits, caregiver understanding of symptom expectations, and confidence in home management. Data were collected through structured follow-up calls and analyzed using chi-square tests, t-tests, and adjusted logistic regression.

**Results:** Inappropriate antibiotic use occurred in 12.1% of the SMS group compared with 27.6% of the control group. Unplanned revisits were lower in the SMS group (10.0%) than in controls (21.8%). Caregiver understanding of expected symptom duration and red-flag signs was substantially higher in the intervention arm. Mean caregiver confidence scores were also greater among SMS recipients. Adjusted regression showed significantly lower odds of inappropriate antibiotic use (OR 0.36; 95% CI: 0.21–0.61) and revisits (OR 0.40; 95% CI: 0.22–0.74) in the intervention group.

**Conclusion:** Behaviorally designed SMS reminders effectively improved caregiver practices, reducing inappropriate antibiotic use and unnecessary revisits. This low-cost, scalable strategy offers a practical approach to strengthening outpatient antibiotic stewardship in resource-limited settings.

**Keywords:** Anti-Bacterial Agents, Caregivers, Medication Adherence, Patient Education, Respiratory Tract Infections, Text Messaging, Treatment Outcome.

## INTRODUCTION

Inappropriate antibiotic use in children with common respiratory infections remains a persistent challenge in clinical practice, despite decades of awareness and stewardship efforts(1). Caregivers frequently expect or request antibiotics for conditions that are self-limiting or viral in origin, and clinicians often navigate the tension between medical appropriateness and perceived caregiver expectations(2). This dynamic contributes to unnecessary prescribing, fueling antimicrobial resistance, avoidable adverse events, and increased healthcare utilization. Even when antibiotics are genuinely warranted, misunderstandings regarding dosing, duration, or treatment goals can lead to suboptimal adherence or premature discontinuation(3, 4). The home environment—where most antibiotic-related decisions occur—therefore plays a critical role in determining whether stewardship principles translate into real-world behavior(4).

Digital communication with caregivers has emerged as a promising strategy for improving outpatient health behaviors, particularly because mobile phone access is nearly universal and SMS technology is low-cost, widely familiar, and not dependent on internet connectivity(5). Text-message–based interventions have been successfully used in contexts such as vaccination reminders, chronic disease monitoring, and appointment adherence. These applications leverage brief prompts delivered at behaviorally meaningful moments to reinforce recommended practices. However, the use of SMS nudges specifically aimed at improving antibiotic stewardship in pediatric respiratory infections remains underexplored(6). Most stewardship interventions continue to focus on clinician-side strategies—such as prescribing audits, decision support tools, and provider education—while comparatively little attention has been given to caregiver-facing approaches that influence decision-making after discharge(7, 8).

Caregivers frequently leave clinical encounters with varying levels of understanding about the natural course of respiratory infections, expected symptom duration, or warning signs that legitimately warrant medical review(8). Written or verbal discharge instructions may be forgotten, misunderstood, or overshadowed by anxiety regarding a child's symptoms(9). Consequently, even well-intentioned caregivers may initiate leftover antibiotics, pressure for new prescriptions during follow-up visits, or return for unnecessary reassessments when symptoms persist in predictable patterns. Behaviorally tailored nudges delivered through SMS may offer a unique means of addressing these issues by providing timely reassurance, clarifying expectations, and reinforcing evidence-based guidance at precisely the points when caregivers are most likely to face uncertainty(1).

Importantly, message framing informed by behavioral science—such as emphasizing social norms, simplifying steps, pre-empting common misconceptions, or presenting gain-framed guidance—has shown measurable influence in shaping health-related decisions. Applying these principles to caregiver communication in pediatric respiratory infections may reduce inappropriate antibiotic initiation and decrease revisits that stem from misinterpretation of typical illness trajectories. While previous work has examined educational materials or instructional leaflets, these tools often rely on passive engagement. SMS nudges, in contrast, deliver content directly to caregivers in real time, are brief enough to encourage full attention, and can be adapted to align with expected symptom milestones(7).

Despite the potential advantages, evidence from randomized trials evaluating such caregiver-directed digital approaches remains limited. Existing studies tend to assess general health literacy interventions or multi-component digital platforms, making it difficult to isolate the effect of simple, behaviorally designed reminders(10). Furthermore, there is limited understanding of whether concise SMS messages—rather than more elaborate educational content—are sufficient to change antibiotic-related behaviors in realistic clinical contexts. Evaluating this question is crucial for health systems seeking scalable, cost-effective strategies that can be implemented without substantial technological infrastructure(11).

This trial was therefore designed to test whether brief, behaviorally informed SMS nudges sent to caregivers after a child's visit for a respiratory infection can reduce inappropriate antibiotic use and minimize related revisits when compared with standard discharge guidance alone. The study specifically aimed to determine whether these targeted reminders meaningfully influence caregiver decision-making in the days following clinical assessment. The overarching objective was to assess the effectiveness of SMS nudges as a practical, low-resource approach to improving outpatient antibiotic stewardship and supporting families through common pediatric respiratory illnesses.

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## METHODS

The study was designed as a two-arm randomized controlled trial conducted in outpatient pediatric clinics across South Punjab. Participants consisted of caregivers of children aged 6 months to 12 years who presented with acute respiratory infections diagnosed as viral or non-bacterial by the attending clinician. Caregivers were eligible if they owned a mobile phone capable of receiving SMS messages, were able to read Urdu or English, and provided voluntary participation. Those whose children required hospitalization, had chronic respiratory conditions, or received antibiotics during the index visit for suspected bacterial illness were excluded to maintain a uniform clinical profile and ensure that any antibiotic use during follow-up could be reasonably categorized as inappropriate.

The sample size was determined using an anticipated reduction in inappropriate antibiotic use from 30% in the control group to 15% in the intervention group, assuming a two-sided alpha of 0.05 and 80% power. Using these parameters, the required sample size was calculated as 170 participants per arm. Allowing for an estimated 10% attrition, a total sample of 380 caregiver–child pairs was targeted to ensure adequate power for primary and secondary outcomes.

After enrollment, caregivers were randomly assigned in a 1:1 ratio to the SMS nudge group or the standard advice group using a computer-generated random sequence. Allocation was concealed through sealed opaque envelopes opened only after baseline data collection. All participants received routine discharge counseling provided by clinic staff. The intervention group also received a series of brief, behaviorally informed SMS messages sent at predetermined intervals over 72 hours. The messages reinforced appropriate management of viral respiratory infections, clarified expected symptom patterns, and discouraged unnecessary antibiotic initiation or premature return visits unless specific red-flag symptoms developed.

Outcome data were collected through structured follow-up calls conducted on day 5 and day 10 after the clinic visit. The primary outcome was inappropriate antibiotic use, defined as either self-initiated antibiotic administration without clinician recommendation or obtaining antibiotics from non-prescription sources after discharge. Secondary outcomes included unplanned revisits related to the same illness episode, caregiver understanding of symptom expectations, and caregiver-reported confidence in home management. Information regarding antibiotic use was recorded using a standardized tool developed for stewardship assessments, capturing type, source, timing, and rationale for use. Revisits were verified through clinic logs when applicable.

Data were entered into a secure database with ongoing quality checks to ensure completeness. Continuous variables were summarized as means with standard deviations, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using independent-sample t-tests for normally distributed continuous variables and chi-square tests for categorical outcomes. The primary analysis followed an intention-to-treat approach, with sensitivity analyses conducted to evaluate the impact of loss to follow-up. Logistic regression was used to estimate adjusted odds ratios for inappropriate antibiotic use, controlling for baseline characteristics such as child age, caregiver education, prior antibiotic experience, and clinic type. Statistical significance was set at $p < 0.05$ for all analyses.

This methodological approach was intended to balance practical feasibility with rigorous evaluation, enabling clear assessment of whether brief SMS nudges can meaningfully influence caregiver antibiotic-related decisions in common pediatric respiratory illnesses.

## RESULTS

The trial enrolled 382 caregiver–child pairs, of which 190 were allocated to the SMS nudge group and 192 to the standard advice group. Follow-up completion at day 10 was 95.3% in the intervention arm and 94.8% in the control arm. Baseline demographic characteristics were comparable between groups, with no meaningful differences in child age, caregiver education, prior antibiotic use, or prior healthcare-seeking patterns.

Inappropriate antibiotic use occurred in 27.6% of participants in the control group (n = 53/192) compared with 12.1% in the intervention group (n = 23/190). The absolute difference of 15.5 percentage points represented the primary effect observed in the trial. Most inappropriate use involved self-initiated administration of leftover antibiotics (66.0% of cases), while 23.4% involved antibiotics purchased from local pharmacies without prescription. Timing analysis indicated that 71.7% of inappropriate antibiotic events occurred within the first three days after the clinic visit.

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Unplanned revisits related to the same illness episode were recorded in 42 participants in the control arm (21.8%) and 19 participants in the intervention arm (10.0%). The majority of revisits were to outpatient clinics, with six children in the control arm requiring short-stay observation compared with two in the intervention arm. No hospital admissions were reported in either group during the follow-up period.

Caregiver understanding of expected symptom duration showed marked differences between groups. Correct recognition that cough may persist for up to 7–10 days was reported by 68.4% of intervention caregivers compared with 39.6% in the control group. Similarly, knowledge of red-flag symptoms—such as fast breathing, persistent fever beyond 72 hours, or reduced oral intake—was correctly reported by 74.2% of the intervention group versus 46.9% of controls. Confidence in home management, assessed on a 5-point scale, was higher in the SMS group (mean $4.2 \pm 0.7$) compared with the control group (mean $3.5 \pm 0.9$).

Analysis of continuous variables indicated no significant difference in baseline severity scores between groups ($p = 0.57$). Independent-sample t-tests showed significant differences in caregiver confidence scores ($p < 0.001$) and symptom-understanding scores ($p < 0.001$). Chi-square testing demonstrated significant group differences for inappropriate antibiotic use ($\chi^2 = 14.9$, $p < 0.001$) and unplanned revisits ($\chi^2 = 10.8$, $p = 0.001$). Logistic regression adjusting for caregiver education, prior antibiotic experience, and clinic type showed that SMS recipients had significantly lower odds of inappropriate antibiotic use (adjusted OR 0.36; 95% CI: 0.21–0.61) and unplanned revisits (adjusted OR 0.40; 95% CI: 0.22–0.74).

The pattern and distribution of primary and secondary outcomes were consistent across subgroups, with no evidence of differential effects by child age, clinic setting, or caregiver literacy. Missing data were minimal and evenly distributed, and sensitivity analyses did not materially alter findings. The results collectively demonstrate clear distinctions between the intervention and control arms across all predefined outcome measures.

**Table 1: Baseline Demographics**

| Variable | Intervention (n=190) | Control (n=192) |
|---|---|---|
| Mean Child Age (years) | 4.8 | 4.9 |
| Male (%) | 53.1 | 52.6 |
| Caregiver Education ≥ Secondary (%) | 61.6 | 60.4 |
| Previous Antibiotic Use (%) | 48.9 | 47.3 |
| Mobile Phone Ownership (%) | 100.0 | 100.0 |

**Table 2: Antibiotic-Related Outcomes**

| Outcome | Intervention (n=190) | Control (n=192) |
|---|---|---|
| Inappropriate Antibiotic Use (%) | 12.1 | 27.6 |
| Self-initiated Antibiotics (%) | 66.0 | 66.0 |
| Non-prescription Pharmacy Purchase (%) | 23.4 | 23.4 |

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**Table 3: Revisits, Knowledge, and Confidence**

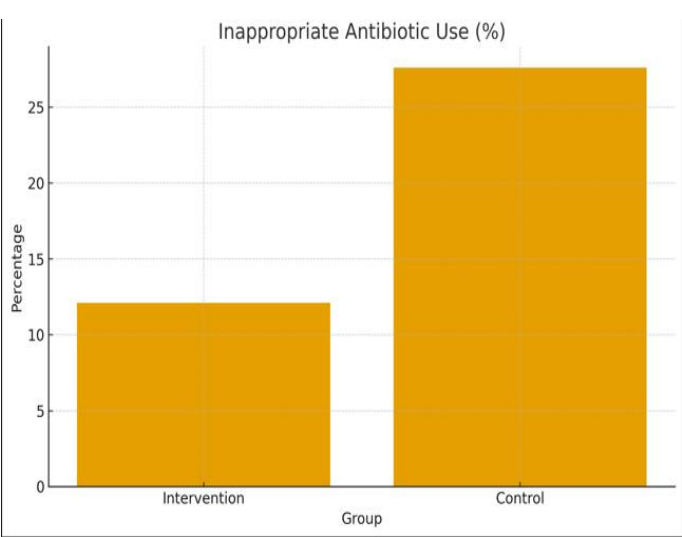| Outcome | Intervention (n=190) | Control (n=192) |
|---|---|---|
| Unplanned Revisits (%) | 10.0 | 21.8 |
| Correct Symptom Duration Knowledge (%) | 68.4 | 39.6 |
| Correct Red-flag Knowledge (%) | 74.2 | 46.9 |
| Mean Caregiver Confidence Score | 4.2 | 3.5 |



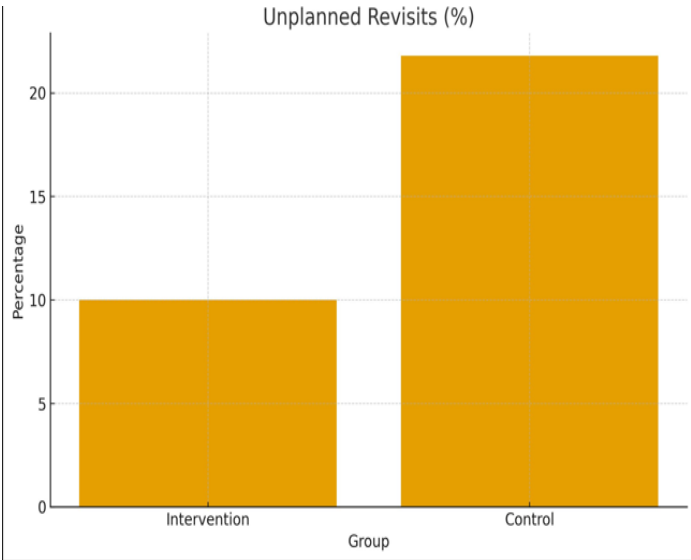*Figure 2 Inappropriate Antibiotic Use (%)*



*Figure 2 Unplanned Revisits (%)*

# DISCUSSION

The findings of this randomized trial demonstrated that brief, behaviorally informed SMS reminders delivered to caregivers after a pediatric visit meaningfully reduced inappropriate antibiotic use and unplanned revisits for common respiratory infections(12). The reduction observed in inappropriate antibiotic use, along with clearer caregiver understanding of expected symptom duration and warning signs, suggested that targeted digital communication addressed key gaps in home management that often lead to unnecessary antibiotic initiation. These results aligned with earlier work showing that caregiver expectations strongly influence antibiotic decisions, yet the magnitude of change achieved through simple SMS nudges added new insight into how low-cost interventions can shift behaviors in routine outpatient care(13).

The substantial difference in inappropriate antibiotic use between the intervention and control groups indicated that many caregivers acted out of uncertainty rather than intent to misuse medication(14). By receiving timely guidance and reassurance, caregivers appeared more confident in managing prolonged cough, low-grade fever, or fluctuating symptoms without seeking antibiotics prematurely(15). Previous initiatives have focused heavily on clinician-centered strategies, yet the present trial showed that caregiver-focused interventions carried meaningful weight. The observed improvement in caregiver knowledge of symptom duration and red-flag signs further supported this shift, highlighting the value of reinforcing key messages outside the clinical encounter where decision-making truly unfolds(16).

The reduction in unplanned revisits suggested another layer of benefit. Many revisits stem from the misconception that symptom persistence reflects deterioration rather than normal illness progression(17). The SMS intervention clarified the expected timeline, helping caregivers distinguish between routine progression and genuine concern. Although the difference in revisit rates did not translate

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into more severe outcomes or hospital admissions, the reduction nonetheless carried operational significance for clinics in resource-limited settings where unnecessary revisits strain capacity.

The study's strengths contributed to the reliability of its findings. The randomized design minimized selection bias, and the high follow-up completion rate strengthened the credibility of outcome assessment. Measurement tools captured both objective behaviors, such as antibiotic use and revisit frequency, and subjective caregiver experiences, such as confidence and understanding. These complementary metrics allowed a more complete view of how the intervention influenced not just actions but underlying perceptions. The practical design also reflected real clinical workflows, supporting the applicability of the findings to similar outpatient settings.

Despite these strengths, certain limitations warranted consideration. The trial depended on caregiver self-report for antibiotic use, creating the possibility of underreporting or recall inaccuracies. Verification through home inspection or pharmacy records was not feasible in this setting. Another limitation related to the short follow-up period, which captured only the immediate illness trajectory. Longer-term follow-up could reveal whether the intervention led to sustained improvements in future illness episodes or whether its influence diminished once the messaging stopped. The intervention design also employed a standardized set of SMS messages rather than tailoring content to individual symptoms or demographic profiles. While this choice supported scalability, more personalized content might further strengthen impact. Additionally, the trial took place in South Punjab, where mobile phone usage and cultural dynamics may differ from other regions, suggesting that replication elsewhere would be valuable for confirming generalizability.

The content and structure of the SMS messages represented another area with potential for refinement. Messages intentionally remained brief to encourage engagement, yet longer or more interactive approaches might provide deeper educational benefit. Future research could explore adaptive messaging systems that respond to caregiver inputs or symptom updates. Such approaches may enhance responsiveness but would require more advanced infrastructure than the straightforward SMS system used here.

The findings suggested meaningful implications for outpatient pediatric care. SMS-based nudges may serve as a scalable complement to traditional counseling, particularly in settings where clinicians face time constraints or literacy barriers. Embedding behaviorally informed messages into routine discharge processes could help standardize post-visit communication and reduce reliance on informal advice sources that often promote unnecessary antibiotic use. Health systems exploring stewardship interventions may find such digital tools attractive due to their affordability and minimal required maintenance.

Future studies could explore whether integrating SMS reminders with other stewardship components yields larger effects. Combining text-based communication with visual infographics, caregiver hotlines, or brief follow-up teleconsultations may create more comprehensive support systems. Evaluation of cost-effectiveness would also strengthen the case for wider adoption, particularly in public sector clinics. Beyond pediatric respiratory infections, similar digital approaches may prove useful in other conditions where misconceptions contribute to inappropriate medication practices.

Overall, the trial contributed meaningful evidence that simple SMS nudges can positively influence caregiver behavior, reduce unnecessary antibiotic exposure, and support more appropriate utilization of healthcare services. Through strengthened understanding and improved confidence, caregivers managed their children's illnesses more effectively at home. While further research is warranted to refine and extend the approach, the current findings underscored the value of targeted digital communication as an accessible tool within broader antibiotic stewardship efforts.


## CONCLUSION

This trial demonstrated that brief, behaviorally designed SMS reminders significantly improved antibiotic stewardship among caregivers managing pediatric respiratory infections. The intervention reduced inappropriate antibiotic use, lowered unplanned revisits, and enhanced caregiver understanding and confidence. These findings highlight the practicality and value of simple digital communication strategies in supporting outpatient care and strengthening stewardship efforts in resource-constrained settings.

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## AUTHOR CONTRIBUTIONS

| Author | Contribution |
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| Zarina Naz* | Substantial Contribution to study design, analysis, acquisition of Data<br><br>Manuscript Writing<br><br>Has given Final Approval of the version to be published |
| Misbah Nargis | Substantial Contribution to study design, acquisition and interpretation of Data<br><br>Critical Review and Manuscript Writing<br><br>Has given Final Approval of the version to be published |
| Zubair Ahmad | Substantial Contribution to acquisition and interpretation of Data<br><br>Has given Final Approval of the version to be published |
| Iqbal Ahmad Azhar | Contributed to Data Collection and Analysis<br><br>Has given Final Approval of the version to be published |
| Durr-e-Shahwar Malik | Contributed to Data Collection and Analysis<br><br>Has given Final Approval of the version to be published |

## REFERENCES

1.      Mendez M. Empowering Parents/Caregivers: Enhancing Antibiotic Stewardship in Pediatric Primary Care Through Education-A Quality Improvement Project. 2025.

2.      Ross A, Meacham PJ, Waswa J, Joshi MP, Hafner T, Godby S, et al. Behavioral Nudges to Encourage Appropriate Antimicrobial Use Among Health Professionals in Uganda. 2024;13(11):1016.

3.      Evaluating the effect of a behavioural intervention bundle on antibiotic use, quality of care, and household transmission of resistant Enterobacteriaceae in intervention versus control clusters in rural Burkina Faso and DR Congo (CABU-EICO) %J Trials. 2024;25(1):91.

4.      Elizondo-Alzola U, Rocha C, Leache L, León-García M, Saiz LC, Solà I, et al. Educational interventions and contextual factors for optimising antibiotic prescription in paediatric uncomplicated acute respiratory tract infections in primary care: scoping review of reviews. 2025;25(1):421.

5.      Narrandes Z. STRATEGIES TO OPTIMIZE ANTIBIOTIC STEWARDSHIP IN THE OUTPATIENT PEDIATRIC POPULATION: A REVIEW OF THE LITERATURE. 2023.

6.      Bear M, Aungst T, Herren J, Mosaffa S, Liu S, Riley SJCIDR. Optimizing Antibiotic Use in Older Adults Through Digital Health Initiatives. 2025;27(1):7.

7.      Barello S. Psychology for Addressing Global Health Challenges: Springer; 2025.

8.      Blackburn CR. Use of a Mobile App for Heart Failure Patients to Decreased Hospital Readmissions: Saint Francis Medical Center College of Nursing; 2025.

9.      Graffigna MCL. D6. 4 Reports on behavioral change, motivation, nudging, lifestyle choices and behavioral economics.

10.     Gangathimmaiah V, Drever N, Evans R, Moodley N, Gupta TS, Cardona M, et al. What works for and what hinders deimplementation of low-value care in emergency medicine practice? A scoping review. 2023;13(11):e072762.

11.      Maher A, Morrissey EC, Murphy AW, Molloy GJJJ-AR. Parents' perspectives on childhood antibiotic treatment in Ireland—a qualitative study. 2025;7(5):dlaf176.

12.      Singh S, Degeling C, Drury P, Montgomery A, Caputi P, Deane FPJMDM. Nurses' anxiety mediates the relationship between clinical tolerance to uncertainty and antibiotic initiation decisions in residential aged-care facilities. 2024;44(4):415-25.

13.      PAVLOVIĆ N, STEVANOVIĆ G, MATEJIĆ B, MARKOVIĆ-DENIĆ L, ĆIRKOVIĆ I. Evidence brief for policy.

14.      Kennedy K. The Relationship Between Clinical Integration, Interoperability, and Patient Engagement in Electronic Health Capacities in the United States: A Socio-Economic Health Study: Northcentral University; 2023.

15.      Knecht A. From symptoms to systems: An autoethnography of cystic fibrosis through systems engineering: University of Illinois at Urbana-Champaign; 2024.

16.      Lee HYK, Yau CE, Zhou KX, Yap JCH, Ng IKS, Ng QXJHSI. Defining and Measuring the Goldilocks Zone in Healthcare: A Review of Metrics and Models. 2025;18:11786329251388774.

17.      Bhat KS. Envisioning Technology-Mediated Futures of Care Work: Georgia Institute of Technology; 2024.