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CURRENT EVIDENCE ON KNOWLEDGE, ATTITUDE, AND PRACTICE REGARDING MEDICATION SAFETY AMONG PAEDIATRIC CAREGIVERS: A NARRATIVE REVIEW

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ABSTRACT

Background: Children rely on caregivers for almost all aspects of medication use, but documented gaps in a caregiver's knowledge, attitudes and practices (KAP) do not always correspond to safe practices. **Objective**: To review the evidence of caregiver medication related KAP, look at factors associated with it and explore interventions to ensure paediatric medication safety. **Methods**: Multiple databases were searched for studies on paediatric caregivers and medication safety. A total of 35 articles were retained for synthesis of 45 articles screened. **Results:** Knowledge of the caregivers was satisfactory for routine activities, but there was a lack of knowledge regarding antibiotic identification and safe storage/disposal. Overall, the attitude toward professional guidance was largely positive; while a minority advocated self-medication and re-use of antibiotics. Measurement of doses was not always accurate, and antibiotic self-medication was common, associated with home storage. The most consistent determinants were education and health literacy. Multi-component counseling decreased dosing errors and digital tools provided some preliminary but encouraging evidence. **Conclusion**: An improvement in knowledge and attitudes did not always result in good practice. While education alone may play an important role, some interventions specifically addressing practice barriers will likely be needed to improve paediatric medication safety in the future.

KEYWORDS: paediatric caregivers; medication safety; knowledge, attitude, and practice (KAP); antibiotic misuse; medication errors; self-medication; caregiver education; medication-safety interventions.

1. INTRODUCTION

Children rely solely on caregivers to take care of their medications, and there have been documented gaps in knowledge that threatens to compromise this responsibility. Parents have tendency to overestimate efficacy of antibiotic treatment for viral illnesses[1-4]; parents of children with epilepsy have limited knowledge of epilepsy[7]; parents of chronically ill children were able to describe the dose but not the medication of the chronically ill children[8]; and fewer half of parents received formal instructions on medication storage/disposal.[5,6] Prescription interpretation, dose measurement, compliance and when to seek professional advice is a direct responsibility of the caregiver. Medication errors in outpatient and home settings are prevalent[9] and most frequently remembered to take the wrong med, errors in communication and errors in dosage.[17] Household devices like teaspoons are often

not accurate regardless of the age, education and experience of the caregiver.[18] Errors are exacerbated by medical jargon, unclear instructions[23] and limited health literacy.[25]

A popular framework for describing caregiver's medication behavior is knowledge, attitude, and practice (KAP). There is a high variability in attitudes towards the need for antibiotics, safety and efficacy, with many parents believing that antibiotics are needed for "self-limiting" illnesses[10,11,13–16] and many caregivers self-medicating, keeping out old prescriptions or reusing them.[12,19–22] The idea that attitudes and beliefs predict safer practices is not always true: risk-preventability beliefs are better correlated with safety practices than general awareness[24] and unsafe practices like inducing vomiting after suspected poisoning persist despite awareness.[26] There were variable relationships between sociodemographic factors (education, employment, income, gender, residence) with KAP.[1,3,27,28] and disease-specific knowledge also is important: those who had more knowledge about epilepsy were more supportive of adherence.[29] These associations are context dependent and seem to be mostly specific.

A lack of awareness of knowledge gaps has not influenced the behaviours of caregivers and structured interventions are being evaluated. Several trials have demonstrated that advanced counseling with health-literacy-informed teaching (pictograms, teach-back) and dosing devices that are standardised in their use have decreased dosing errors compared to standard counselling.[30-32] and a systematic review showed that multi-component interventions were more effective than counselling alone, but with significant variations.[33] Digital/mobile health tools are still a fledgling field of research.[34,35] The evidence base is limited by single center, self-reported designs[1,4,7], using a variety of instruments, focusing on high income, English-speaking care settings with inconsistent follow-up[33], only rare data on sustained change[32,33] and by the underrepresentation of low resource, linguistically diverse caregivers.[17,25,33,35] This review was therefore designed to pool the KAP evidence among paediatric caregivers, ascertain factors associated with different levels of the KAP dimensions, as well as assess interventions that can be used to enhance paediatric medication safety.

2. METHODS

A literature review was carried out to synthesize evidence on medication safety among child caregivers (parents, guardians and other primary caregivers) in terms of knowledge, attitudes and practices (KAP), along with other determinants and interventions. Literature was identified with paediatric/child/children and caregiver/parent/guardian and medication safety/error/administration/knowledge/attitude/practice/ KAP terms on PubMed/MEDLINE, PMC, SpringerLink, Scopus, Web of Science, Google Scholar, ScienceDirect, DOAJ, PLOS ONE, EMBASE, PsycINFO, Cochrane, CINAHL, BMJ, JAMA Network, Wiley, Cambridge Core, Literature, and ClinicalTrials.gov, PakMediNet, WHO-EMRO Index Medicus, Magiran, and SID. Studies were eligible for inclusion if they assessed medication safety in relation to paediatric caregivers (knowledge, attitude, practice, determinants, or interventions) and if studies included only healthcare professionals were excluded, editorials/commentaries, duplicates, and studies lacking relevant outcomes were excluded. Of 45 articles screened, 35 (2008–2026, 34 from 2016–2026) met inclusion criteria. There was no formal quality scoring or statistical pooling of data due to the heterogeneity of populations, instruments, and outcome measures; data were extracted onto structured sheets and synthesized narratively.

3. RESULTS

3.1 Knowledge Regarding Paediatric Medication Safety

In the eight studies examined, caregiver knowledge was inconsistent, with most tasks related to routine administration being well executed, but with persistent gaps in antibiotic knowledge, identification of medication and safe storage/disposal.[1,3–8] The most frequently investigated and consistently poor aspect was antibiotic knowledge, which is frequently moderate to poor, despite having an understanding of antimicrobial resistance, in some studies.[1,3,4] A common finding was that someone could carry out a task without knowing the precise knowledge to use it in a new context, such as stating the name of an antibiotic or determining whether or not it was necessary in the case of a viral disease.[2–4,8] The results of 4 studies (Egypt, India, Bangladesh, Iraq) were generally similar with caregivers scoring more favorably than the parents of Iraq (Egypt 30.2% good, 9% poor; Bangladesh 44% good, 44% poor)[1–4] and most of the parents in Bangladesh and about half of those in Iraq did not recognize amoxicillin as an antibiotic. There was no correlation between conceptual understanding of resistance and the ability to make accurate judgments of the need for antibiotics: 32% of Indian caregivers made the correct judgment that antibiotics are not necessary for COVID-19 symptoms, with most Iraqi parents holding the view that antibiotics are necessary for viral URI.[2,4] This gap between theory and practice was also found to exist among Malaysian caregivers of chronically ill children, with most of them saying that they do the dosage well, but less than half of them could identify the drug that was given.[8] The knowledge level was significantly lower in caregivers of children with epilepsy, with only 13.3% getting all the answers right, and the presence of misconceptions.[7]

In both studies (Saudi Arabia, Libya) less than half of caregivers reported to have received formal instructions on storage/disposal, and awareness of the environmental and health consequences was low, with medical staff and pharmacists being the primary sources of information and many indicating they did not receive any.[5,6] Task-

based knowledge was generally higher than applied knowledge.[3,4,8] and knowledge as composite categories was often reported instead of per item proportions.[1–6] The safety impacts of these gaps are unambiguous: lack of antibiotic identification can contribute to inappropriate use of antibiotics and lead to antibiotic resistance[2–4]; lack of ability to name medicines can result in dosing confusion when taking more than one medicine; and limited knowledge of storage/disposal can increase risk of poisoning or harm to the environment.[5,6]

Table 1: Summary of Key Knowledge Findings Among Paediatric Caregivers.

Ref.	Country	Key Knowledge Finding	Clinical Implication
[1]	Egypt	Good knowledge in 30.2% of caregivers; notable weakness recognizing antibiotic side effects (31% poor).	Underestimating adverse effects may increase unsafe or unmonitored antibiotic use.
[2]	India	Only 35% correctly disagreed that antibiotics were essential for managing COVID-19 symptoms.	Misplaced belief in antibiotic necessity for viral illness may drive inappropriate use.
[3]	Bangladesh	63% did not recognize amoxicillin as an antibiotic; 83% had combined poor-to-moderate overall knowledge.	Poor antibiotic identification raises risk of misuse and resistance.
[4]	Iraq	60% incorrectly believed antibiotics were needed for viral, self-limiting upper respiratory infections.	Persistent misconceptions may sustain unnecessary antibiotic requests.
[5]	Saudi Arabia	Only 44.8% had ever received advice on safe medication storage; 26.3% unaware of disposal's environmental/health impact.	Gaps in storage/disposal knowledge may increase unintentional poisoning risk.
[6]	Libya	35.6% of parents reported receiving no information on medication storage or disposal.	Lack of guidance may perpetuate unsafe home medication-keeping practices.
[7]	Ethiopia	Only 13.3% answered all epilepsy-related knowledge items correctly; misconceptions such as spirit possession persisted.	Poor disease-specific knowledge may affect treatment adherence and care-seeking behavior.
[8]	Malaysia	71.6% had adequate overall knowledge, but only 46.8% could correctly name the medication administered.	Inability to identify medications may increase risk of dosing or administration errors.

3.2 Attitudes Toward Paediatric Medication Use and Safety

The attitudes of caregivers were found to be positive across nine studies but there was a consistent minority who preferred self-medication, re-use of antibiotics, and unsupervised OTC use.[8-16] The majority of caregivers felt that antibiotics were being used too frequently and agreed that education should be given about their use, and that they would not pressure prescribers.[10,13,15,16] The composite scores of attitudes were mostly moderate to favourable with a small minority of weak attitudes in some settings.[11,13,16] High compliance with paediatrician advice, for example during the COVID-19 pandemic.[15,16] suggests trust in the medical professional's judgment, but compliance with paediatricians' advice on prescribing was not high for everyone in Jordan[10] and would be low for some.

However, attitudes towards reusing and self-medication were more alarming; more than half of the Jordanian caregivers would reuse antibiotics for the same symptoms, while a small percentage in Greece reported reusing antibiotics occasionally, and most Omani caregivers reported never reusing them for a similar issue.[10,13,15] There was disagreement among Palestinian caregivers about the safety/effectiveness of self-therapy unadvisedly.[12] Most people deemed OTC Paracetamol/Ibuprofen as acceptable in Saudi Arabia, although most correctly avoided co-administration of these. Some of the variation is due to the different instruments used (validated Likert scales versus yes/no questions or adherence proxies.[8,11,13,14,16] Higher levels of illiteracy and living in rural areas correlated with lower attitude scores in Iran and Turkey[11,16] and the local context of healthcare access in Oman was associated with a very low level of leftover antibiotic use, indicating that attitudes can be influenced by the local healthcare-access context.[13] While positive attitudes towards professional guidance help to support stewardship[15,16], negative attitudes towards reuse, self-medication and unsupervised OTC use could counteract these positive influences[10,12,14,15] indicating targeted intervention to be directed at attitudes towards self-medication and attitudes towards reuse.

Table 2: Summary of Key Attitude Findings Among Paediatric Caregivers.

Ref.	Country	Key Attitude Finding	Clinical Implication
[10]	Jordan	88.3% agreed antibiotics are overused, yet 55.5% considered it acceptable to reuse the same antibiotic for similar past symptoms.	Favorable general attitude toward stewardship coexists with risky reuse beliefs.
[11]	Iran	Attitude predominantly moderate (48%) with a substantial weak-attitude subgroup (39%), markedly worse among illiterate and rural parents.	Education- and residence-linked attitude gaps may need targeted intervention.
[12]	Palestine	51.8% inappropriately believed medicine chosen without professional advice was effective and safe.	Favorable self-medication beliefs may increase risk of inappropriate treatment choices.
[13]	Oman	Median attitude score moderate (60%); 75.8% had never reused leftover antibiotics.	Restrictive antibiotic-access context may reinforce favorable reuse-related attitudes.
[14]	Saudi Arabia	70.4% believed OTC paracetamol/ibuprofen were fine without a prescription, though 85% correctly avoided combining them.	Mixed OTC attitudes indicate selective, not uniform, safety awareness.
[15]	Greece	93% always complied with paediatrician recommendations; 13.6% sometimes used leftover antibiotics.	High professional trust may not fully prevent occasional unsupervised antibiotic use.
[16]	Turkey	64.6% agreed antibiotics are overused; only 6.3% reported pressuring their paediatrician to prescribe.	Low prescriber pressure may support appropriate antibiotic stewardship.

3.3 Medication-Related Practices Among Paediatric Caregivers

Overall, caregivers achieved well in the studies with regard to storage location and use of package information but did not achieve good results in measuring doses or high rates of self-medication, especially with antibiotics, which were closely associated with having leftover medicines at home, with 8 of the 8 studies showing this pattern.[9,12,17–22] Wrong timing was the most frequent error among Indian caregivers (around 1/3)[9] and dosage errors were most common (2%–1/3) in a systematic review of mostly home caregivers[17] for administration errors. Household teaspoon measurement was a particular challenge (less than 1/4 of the Pakistani parents were able to measure an accurate dose of 5 mL), while standardized devices like cups or droppers were more accurate for Indian caregivers.[9,18]

Adherence and storage practices were variable. Less than half of Indian parents who began antibiotics finished the course and most Palestinian parents reported that they had given the correct doses and at the right time; however, a substantial minority reused medicine that had already been used without consulting the health care worker.[12,21] Although most of the Indian caregivers reported safe general handling, many of them did not know the duration of storage after reconstitution and almost half of them discarded the remaining doses inappropriately.[9] Self-medication—particularly with antibiotics—was the most consistently worrisome practice: Palestinian parents self-medicated their children on average (most commonly antipyretics), while Indian parents used to do so by a significant minority and caregivers across three provinces of China by almost half (antimicrobials).[12,20,21] This was closely related to self-storage of antibiotics at home for Chinese samples and parents who self-prescribed antimicrobials were more likely to ask physicians for the same, and more likely to receive them.[19,20,22] The findings have a direct safety implications: improper dosage measurement and measuring at the wrong time can lead to under/over dosing, and require standardized dosing equipment and proper technique.[9,17,18] Because of the relationship between the use of antibiotics at home, self-medication, and over-prescription by doctors, reducing the availability of antibiotics at home and non-prescription use may help to decrease inappropriate antibiotic use and resistance.[19,20,22]

Table 3: Summary of Evidence on Medication-Related Practices Among Paediatric Caregivers.

Ref.	Country	Key Practice Finding	Clinical Implication
[9]	India	44.6% of caregivers reported a medication error in the past year, most commonly wrong timing (31.6%).	Errors highlight need for improved caregiver counseling on administration technique.
[17]	Systematic review (mostly USA; 12 countries)	Dosage errors were the most common home medication administration error; carer error rates ranged 1.9–33%.	Home medication administration errors represent a widespread, under-addressed safety issue.
[18]	Pakistan	Only 22.3% of parents measured an accurate 5 mL dose using a household teaspoon.	Household teaspoons are unreliable; standardized dosing devices should be prescribed.
[19]	China	48.1% kept antibiotics at home; this increased odds of remedial self-medication nearly 5-fold.	Home antibiotic storage is a major driver of paediatric self-medication.
[12]	Palestine	73.4% self-medicated their child without professional advice, most often with antipyretics.	High self-medication prevalence signals need for targeted parent education.
[20]	China	48.2% reported non-prescription antibiotic use for their child in the past 6 months.	Non-prescription antibiotic use remains common despite regulation.
[21]	India	22.8% prevalence of non-prescriptional parental antibiotic use; 25.6% changed the antibiotic mid-course.	Self-directed antibiotic changes raise resistance and safety concerns.
[22]	China	Parental self-medication with antibiotics strongly predicted subsequent physician antibiotic prescribing (aOR 7.79).	Self-medication may reinforce inappropriate antibiotic prescribing in clinical encounters.

3.4 Factors Affecting Caregiver Knowledge, Attitudes, and Practices

Caregiver KAP is multifactorial, shaped by sociodemographic characteristics, healthcare/information exposure, child- and medication-related characteristics, and contextual/care-setting factors, with no single dominant determinant.[1,2,3,5,6,8,9,14,15,16,19–22,24–29] Several factors showed strong associations with knowledge and/or attitude but weaker or inconsistent associations with practice.

Caregiver-related factors. Education was the most studied determinant, with moderate but inconsistent relation to knowledge/attitude: higher education was associated with higher antibiotic knowledge in Egypt and Saudi Arabia, with greater knowledge and favourable attitudes in Turkey.[1,14,16] and with higher poisoning/asthma-knowledge scores in Sri Lanka and China.[26,28] Its link to practice was less consistent: no association with self-medication in one Indian study[15], independently associated with home antibiotic storage in China[19], and low education and low income characterised a misuse-linked carer profile elsewhere.[21] Age and gender associations were less consistently examined: carers aged 31-45 had the highest COVID-19 knowledge in India, while younger carers (18-24) were more likely to store medicines at home in Saudi Arabia[2,5]; sex/gender associations differed by country, with some patterns being associated with male sex in Bangladesh, female carers more likely to store leftover antibiotics in China, and female parents scoring higher on asthma knowledge in China[3,19,27]; self-medication was more common among mothers and nuclear families in India.[21]

Health- and information-related factors. Healthcare-related exposure was consistently related to increased knowledge: antibiotic-safety knowledge was predicted by family healthcare employment in China, and more educated Saudi carers were more likely to have been advised on storage.[5,20] In a US-based review, poor health literacy was consistently associated with dosing errors[23] and in a qualitative study with structural dosing barriers.[25]

Child-, medication-, and context-related factors. Caregivers managing 2+ chronic conditions were more likely to be non-adherent[8]; better asthma/allergy management was linked to older child age in China, and better disease knowledge to higher anti-seizure medication uptake in Ethiopia and higher safety-practice scores in Uganda[24,28,29]—suggesting disease-specific knowledge may translate into practice more directly than general demographics. Setting and residence mattered inconsistently: outpatient caregivers in India had higher error rates than caregivers of admitted children[9], while urban residence was linked to more self-medication in China but not to storage/disposal in Libya.[6,22] Two broader syntheses confirmed medication practices arise from interacting factors, including a distinct low-education/low-income/high-misuse caregiver profile.[15,17]

Overall, education and knowledge/attitude were consistently linked, but this did not reliably extend to practice[1,14,15,16,19,21,26,28]; practice was more consistently predicted by proximal, condition-specific factors.[8,24,29] Sex-related associations varied by context[3,6,19,22,27], and most rest on single cross-sectional samples with limited

adjustment.[1,2,5,9,14,16,18,21,26] This suggests interventions should target vulnerable caregivers—lower health literacy, limited provider contact, or complex regimens—rather than general education alone.[1,8,15,19–21,24,25,29]

Table 4: Factors Associated with Medication-Safety KAP Among Paediatric Caregivers.

Factor	KAP Domain(s)	Direction/Pattern of Association	Evidence	Implication
Caregiver education	Knowledge, Attitude (consistent); Practice (inconsistent)	Positive for knowledge/attitude in most studies; no association or linked to unsafe home antibiotic storage in others.	[1,14,15,16,19,21,26,28]	May improve knowledge without ensuring safer practice.
Caregiver age	Knowledge, Practice	Mid-range age (31–45) linked to better knowledge; younger age (18–24) linked to more home storage.	[2,5]	Counseling may need to differ by life stage.
Caregiver sex/gender	Knowledge, Attitude, Practice	Inconsistent direction; varies by country and domain.	[3,19,27]	May reflect differing caregiving roles, not a uniform effect.
Household income	Knowledge, Practice	Positive for knowledge; low income linked to misuse profile.	[1,15]	Economic barriers may compound knowledge gaps.
Healthcare exposure (healthcare relatives, counseling access, health literacy)	Knowledge, Practice	Consistently positive for knowledge; low literacy linked to more dosing errors.	[5,20,23,25]	Health-literacy support may reduce dosing errors.
Chronic-disease burden	Practice (adherence)	Higher burden (2+ conditions) linked to poorer adherence.	[8]	May need additional adherence support.
Disease-specific knowledge / preventability belief	Practice	Positive; better condition understanding linked to safer practice.	[24,29]	Condition-specific education may outperform general messaging.
Care setting (outpatient vs. inpatient)	Practice (errors)	Outpatient status linked to more administration errors.	[9]	Enhanced outpatient counseling may reduce errors.
Residence (urban/rural)	Practice	Inconsistent; positive with self-medication in one study, none in another.	[6,22]	Local regulatory/access context may explain this.

3.5 Interventions to Improve Paediatric Medication Safety

Six interventions were assessed: three structured, personnel delivered counseling trials[30-35] and a systematic review of similar interventions. Advanced counseling, health-literacy-informed education (pictograms, teach-back/show-back) and a standardized dosing instrument at ED/hospital discharge were combined, and typically used in counseling interventions, and there are no usability or comparability data for digital interventions. Advanced counseling, health-literacy-informed education (pictograms, teach-back/show-back) and a standardized dosing instrument at ED/hospital discharge were combined, and typically used in counseling interventions, and there are no usability or comparability data for digital interventions. Generally, multi-component counseling was linked to improved dosing accuracy with some instances of increased adherence, and digital tools were linked to more inconsistent and short-lived engagement.

All three counseling trials were basically similar, but different. MEDS gave one discharge session with a simplified dosing handout, demonstration, and teach-back by a bilingual-research-assistant, until the person was competent, and then provided a take-home syringe.[30] In a predominantly low-literacy, low-SES Hispanic population, HELPix utilized a brief (1.5–3 minute) pictogram-based instruction sheet, standardized syringe and teach-back technique.[31] Carroll et al. provided a similar bundle but in the inpatient setting using hospitalists or research assistants and with a

greater contact time (~5 minutes).[32] The overall outcomes were promising: HELPix and MEDS had greater short-term dosing accuracy than standard counseling, and HELPix also had fewer withdrawals.[30,31] but this improvement in accuracy did not persist at the second follow-up, which was rationalized by corrections made in the standard counseling group after the first call.[30] Carroll et al. reported minimal observed dosing error, and knowledge about doses, duration, and adverse effects were the only knowledge gains (no gains in name, indication, frequency, or storage knowledge).[32]

In a systematic review of seven other intervention studies that aligned with AAP recommendations, multi-component (counseling-plus-device) interventions were found to be more effective in reducing dosing errors (12%–54%) than single-component interventions, with few studies discussing language-concordant care, caregiver empowerment, and medication reconciliation, and no consistent conclusions drawn through the use of meta-analysis because of the interventions' heterogeneity.[33] The two digital-tool sources are not directly comparable to the counseling trials. In one usability study, the BMT4me app was found to be less usable (System Usability Scale 86.15→73.13), less likely to be recommended (87%→64%), and caregivers stopped using the app almost half of the time.[34] A Scoping Review of 62 mHealth Apps revealed mostly positive feedback on e-learning, personalisation and tracking health, with no controlled effectiveness data.[35] The asymmetry (favouring either counselling or single arm/narrative review evidence for digital tools) makes it difficult to draw comparisons and the impact of short follow-up periods (48 hours to approximately a week) is uncertain for counselling trials.[30–32,34,35] Overall, structured multi-component counselling at discharge is linked to fewer dosing errors and, in some studies, better adherence, although this does not consistently show across all knowledge domains, and there is no evidence of longterm effects.[30-33] Different staff members (research assistants, hospitalists, pharmacists, physicians, nurses) delivered interventions which fosters a multidisciplinary approach, not only pharmacist-specific.[31-33] Digital tools seem to be of interest to caregivers but cannot be considered as proven due to lack of controlled evidence.[34,35]

Table 5: Summary of Interventions Targeting Paediatric Caregiver Medication Safety.

Ref.	Intervention Type	Target/Setting	Main Outcome	Key Finding
[30]	ED discharge teaching: dosing handout, RA demo, teach-back, take-home syringe	Parents/guardians discharged from an urban paediatric ED on liquid acetaminophen/ibuprofen	Parent-reported safe dosing	Safe dosing higher at 48–72h (71% vs 45%; RR 1.58); not sustained at 5–7 days after control errors were corrected.
[31]	HELPix pictogram counseling with teach-back and standardized dosing instrument	Low-literacy, low-SES caregivers, urban public-hospital ED, liquid medication	Observed dosing error, adherence	Markedly fewer dosing errors (e.g., 5.4% vs 47.8%) and lower nonadherence than standard counseling.
[32]	Health-literacy bundle: pictogram sheet, teach-back, dosing syringe	Caregivers of hospitalized children, new liquid medication	Observed dosing error, knowledge	Reduced dosing error (30.4% vs 54.2%); improved dose/duration/adverse-effect knowledge; no gain in name/indication/frequency/storage knowledge.
[33]	Systematic review of AAP-aligned counseling/dosing-instrument strategies (7 studies)	Caregivers of children discharged on medication from EDs/inpatient wards	Medication knowledge, dosing errors	Combined strategies reduced dosing errors more than single-component approaches; heterogeneous, no meta-analysis.
[34]	BMT4me digital medication app (single-arm usability study)	Caregivers of children post-allogeneic HCT, using app at home	Usability, satisfaction, engagement	Usability and recommendation rates declined over ~100 days; half of caregivers stopped using the app.
[35]	Scoping review of mHealth apps for caregiver decision-making	Caregivers using mHealth apps, maternity/infant and disease-specific settings	App features, caregiver feedback	E-learning, personalization, health-tracking most common; feedback predominantly positive, no controlled effectiveness data.

3.6 Research Gaps and Future Directions

The designs used for causal inference (predominantly cross-sectional, self-reported, single center designs.[1–16,18–24,26–29]) tended to have samples that were largely literate, hospital-attended mothers/parents, and for whom fathers were underrepresented and grandparents and non-English/low-literacy caregivers were even more underrepresented.[1,12,17,19,20,22,23,25,26,30,32,34] Results may be only applicable to the immediate city or region setting.[3–7,9,13,14,16,21,24] There was not always a translation

of knowledge and attitude to safe behavior[1,6,26] and there were modest cross-sectional and limited knowledge–practice correlations.[27] Predictors of safe behavior were sometimes reported, and in some contexts education was a significant predictor.[5,14,16,28] while in others it was not.[6] Short-term evidence of benefit for pictogram-based labeling, teach-back counseling, and combined dosing-tool approaches exists, but data from existing intervention studies are restricted to small-to-moderate U.S. studies following for days, not months, conducted in a single institution, and have been difficult to pool for analysis in a related systematic review; the latter has limited evidence of longer-term retention.[30–33] There is only a small and limited pilot study (n = 14)[34] and a scoping review that identified no strong trials in low-resource, low-literacy contexts[35] of digital-health evidence. Community or school-based interventions led by a pharmacist are often recommended, but rarely evaluated, in a formal manner.[1, 2, 3, 9, 10, 12, 20, 21, 24, 26, 29] Future studies should focus on larger multicenter prospective studies that include fathers, grandparents, rural and low-literacy/non-English-speaking caregivers, standardised, validated KAP instruments that include direct measures of actual practice rather than self-report, direct assessment of the impact of knowledge acquisition on the maintenance of safe practice, and larger, more diverse, and lower resource populations in long-term, controlled trials of pharmacist-led and digital/mHealth interventions.[1,12,17,19,23,25,30–32]

4. DISCUSSION

4.1 Overall Interpretation

The overall patterns of KAP were not the same across countries or clinical settings: knowledge, attitude, and practice revealed distinct and sometimes counterintuitive patterns when combined. While caregivers were often able to carry out basic tasks with competence and had positive attitudes towards professional advice, gaps in knowledge, self-medication attitudes and technical practice (mainly related to antibiotics and dose measurement) were observed.[1-22] Many caregivers reported using leftover antibiotics or self-medicating[10,12,15] and even those who reported storing antibiotics carefully used household items to measure doses.[9,18] This reinforces the view that knowledge, attitude and practice are interconnected but separable constructs, where there is not always a correlation between a gap in knowledge and a gap in practice.

4.2 Determinants and Intervention Implications

Household income and carer education were the most consistent positive predictors of knowledge/attitude, but mixed predictors of practice. Education predicted less safe practice (home antibiotic storage) in at least one setting.[1,14,15,16,19,21,26,28] Factors closer to the child's condition were more consistent predictors of practice.[8,24,29] General sociodemographic factors may predict knowledge/attitude better, whereas condition-specific engagement may predict safe practice better. Structured counselling including health-literacy-informed education and a standardised dosing tool consistently reduced dosing errors in three trials and a systematic review, suggesting that skill-based intervention rather than information delivery alone can narrow the dose-measurement component of the practice gap.[30–33] This evidence is, however, limited to high income, English language settings with short follow up and does not address self-medication, reuse or gaps in storage/disposal, or whether gains are sustained.[30–33,35]

4.3 Strengths and Limitations

Strengths include geographic breadth (over a dozen countries) and coverage of multiple related medication safety domains. Persistent weaknesses include cross-sectional, self-reported, single-center designs; non-validated, heterogeneous KAP instruments limiting comparison; under-representation of fathers, grandparents, rural, and non-English-speaking/non-literate carers; and, for interventions, short follow-up with limited testing outside high-income settings.[1-35] All reported associations should be considered associative rather than causal, and contextual rather than universal.

5. CONCLUSION

This review further affirms that medication safety is an ongoing problem in various settings and knowledge, attitudes, and practices vary widely both within and between such settings among paediatric caregivers. Antibiotic use, management of fever, chronic-disease care, epilepsy, and the management of medicines at home were the domains in which caregivers were consistently the primary decision-makers and administrators of the medicines used by children, but no single consistent picture of caregiver competence emerged. Safe practice was not consistently associated with adequate knowledge and favourable attitudes: good general knowledge was found to coexist with specific misconceptions (e.g. use of antibiotics for viral illness, correct dosing of liquids, medication identification) and positive attitudes towards cautious antibiotic use were found to occur alongside unsafe practice (e.g. keeping or re-using leftover antibiotics, using household measures for liquid dosing). The most consistently studied determinants were caregiver education, earnings level, age, and-in some settings-residence and health-related exposure, but relation to outcomes differed from study to study and outcome to outcome suggesting the need for specific targeting and using interventions that are not generic. There was strong evidence that structured counselling, which incorporates advanced counseling, health-literacy-informed teaching and standardized dosing equipment, was more effective than standard counselling, although this evidence was largely limited to high-income, English-language, single-center settings and was not conducive to meta-analytic pooling; digital/mobile health tools were a promising early area, with only small, uncontrolled usability studies supporting this. Some of the major limitations are cross-sectional design, inconsistent KAP measurement, low resource and non-Western caregivers underrepresented, and

limited assessment of retention and behavior change. Longitudinal, multi-component intervention studies with different settings, standardized KAP tools, and controlled digital-health trials with proper follow-up should be emphasized for future research. To improve medication safety for children, it is likely that all knowledge, attitudes and practices and their contextual factors should be addressed together: not one without the other.

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