

Health Beliefs and Self-Reported Infection-Prevention Practices among Mothers of Children Receiving Chemotherapy in Pakistan: A Cross-Sectional Study

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Received: August 18, 2026; Manuscript No: JGPH-26-7745; Editor Assigned: August 20, 2026; PreQc No: JGPH-26-7745 (PQ); Reviewed: August 31, 2026; Revised: August 31, 2026; Manuscript No: JGPH-26-7745 (R); Published: October 16, 2026

Citation: Farooq A, Jamshed J, Farooq H, Manzoor R, Mehmood A (2026). Health Beliefs and Self-Reported Infection-Prevention Practices among Mothers of Children Receiving Chemotherapy in Pakistan: A Cross-Sectional Study. J. Glob. Pub. Hea. Healthc. Innov. Vol.1 Iss.1, October (2026), pp:70-80.

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ABSTRACT

Background

Children receiving chemotherapy are at increased risk of infection, and prevention depends not only on hospital-based care but also on caregivers' ability to implement recommended practices at home. In Pakistan, evidence on infection-prevention practices among mothers of children receiving chemotherapy and the behavioural factors associated with these practices is limited.

Objectives

To assess infection-prevention practices among mothers caring for children receiving chemotherapy and to examine their associations with knowledge, attitude, and Health Belief Model (HBM) constructs.

Methods

We conducted a hospital-based, cross-sectional analytical study among mothers aged ≥ 18 years who were the primary caregivers of children aged 0–14 years receiving chemotherapy at the Department of Paediatric Oncology, Children's Hospital, Pakistan Institute of Medical Sciences (PIMS) Islamabad, Pakistan. Mothers were consecutively recruited between May and December, 2025. Data were collected through face-to-face, interviewer-administered interviews using a standardised Urdu-language questionnaire. The primary outcome was a continuous self-reported infection-prevention practice score derived from 15 behaviour-based items and standardised to a 0–100 scale. Knowledge, attitude, and six HBM constructs were assessed using corresponding standardised scores on the same scale. Associations with infection-prevention practice scores were determined using univariable and multivariable linear regression, with continuous predictors expressed per 10-point increase in score. Effect estimates are reported as β coefficients with 95% CIs.

Results

A total of 86 mothers were included. The mean infection-prevention practice score was 53.6 (SD 18.7). Mean knowledge and attitude scores were 60.9 (18.2) and 56.8 (17.1), respectively. After adjustment, higher maternal educational attainment was associated with higher practice scores (β 1.54 [95% CI 0.18 to 2.90]; $p=0.027$), as were greater perceived benefits (β 0.96 [0.02 to 1.90]; $p=0.046$) and self-efficacy (β 1.22 [0.32 to 2.12]; $p=0.01$). Greater perceived barriers were associated with lower practice scores (β -1.02 [-1.91 to -0.13]; $p=0.025$). Knowledge, attitude, perceived susceptibility, perceived severity, and cues to action were not statistically associated with practice scores after adjustment.

Conclusion

In this single-centre cross-sectional study, mothers reported a mean infection-prevention practice score of 53.6 on a 0–100 scale. Higher educational attainment, greater perceived benefits, and higher self-efficacy were associated with higher reported practice, whereas greater perceived barriers were associated with lower practice. These findings suggest that caregiver-centred infection-prevention strategies should extend beyond information provision to address practical barriers and strengthen caregivers' confidence in implementing recommended behaviours.

Keywords: Paediatric Oncology; Childhood Cancer; Infection Prevention; Caregivers; Mothers; Health Belief Model; Self-Efficacy; Supportive Care; Pakistan

INTRODUCTION

Childhood cancer is a major global health equity challenge [1]. Survival for children with cancer exceeds 80% in many high-income countries (HICs), but remains significantly lower in many low-income and middle-income countries (LMICs) because of delays in diagnosis, limited access to effective treatment and supportive care, and interruptions in care [2]. The WHO Global Initiative for Childhood Cancer aims to increase childhood-cancer survival to at least 60% globally by 2030 [3]. Achieving this goal requires not only access to anticancer treatment but also effective prevention and management of treatment-related complications, including infection.

Infection is a major complication of chemotherapy-induced immunosuppression and contributes to morbidity, treatment interruption, and treatment-related mortality in children with cancer [4]. Infection prevention and control (IPC) within health-care facilities is essential, but many preventive behaviours are implemented at home, where mothers and other caregivers translate clinical guidelines into daily practice [5]. Infection prevention in children receiving chemotherapy extends beyond hospital-based measures and includes caregiver practices such as hand hygiene, safe food and water handling, appropriate household hygiene, minimising exposure to infectious contacts, recognising early signs of infection, and seeking timely advice from the oncology team [6-11].

Caregiver infection prevention is both a behavioural and a health-systems issue. Knowledge and positive attitudes may be necessary but might not be sufficient when caregivers face barriers to implementing recommended behaviours [12]. The HBM provides a framework for examining perceived susceptibility, perceived severity,

perceived benefits, perceived barriers, self-efficacy, and cues to action [13]. In Pakistan, household circumstances, competing caregiving responsibilities, financial constraints, transport difficulties, distance to treatment, and access to health services can affect the feasibility of recommended care [2]. Understanding which behavioural domains are associated with reported practice could therefore help identify targets for caregiver-centred supportive-care strategies.

Existing evidence from Pakistan has highlighted the burden of infection and challenges in the management of febrile neutropenia (FN). Studies from paediatric oncology settings have reported gaps in caregiver awareness, delayed presentation, prolonged hospitalisation, and increased treatment burden. In the Children's Hospital Lahore experience, only 19% of caregivers had adequate awareness of FN management and another study reported adequate awareness in 44% of parents. These studies addressed recognition and acute management of FN rather than the broader range of routine infection-prevention behaviours undertaken at home [14,15]. Global evidence is also heterogeneous. A Thai study of caregivers of children with cancer undergoing chemotherapy reported generally high infection-prevention behaviours and identified health literacy as a significant predictor, whereas a recent HBM-based study among family caregivers in South Korea found that hand-hygiene practice was associated with perceived benefits, perceived barriers, knowledge, age, and habitual hand-sanitiser use [12,16]. These differences in setting, outcomes, and measurement highlight the need for context-specific evidence.

We therefore assessed infection-prevention knowledge, attitude, self-reported practices, and HBM constructs

among mothers who were primary caregivers of children receiving chemotherapy at a tertiary paediatric oncology centre in Islamabad, Pakistan. We examined the cross-sectional associations of knowledge, attitude, and individual HBM constructs with the continuous self-reported infection-prevention practice score after accounting for selected maternal and child characteristics. The objective was to identify potentially modifiable behavioural domains that could inform future caregiver-centred interventions.

MATERIALS AND METHODS

Study Design and Setting

We conducted a hospital-based, cross-sectional analytical study in the Department of Paediatric Oncology, Children's Hospital, Pakistan Institute of Medical Sciences (PIMS) Islamabad, Pakistan. Mothers were consecutively recruited from the paediatric oncology outpatient department (OPD) between May and December, 2025. Each participant completed one study assessment before exposure to any study-specific educational or behavioural intervention. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies.

Participants and recruitment

Eligible participants were mothers aged 18 years or older who were the primary caregivers of children aged 0–14 years with a confirmed malignancy and receiving chemotherapy at the study centre. Mothers were required to be responsible for day-to-day home care, to have been involved in the child's care since initiation of cancer treatment, to communicate sufficiently in Urdu to complete the questionnaire, and to provide written informed consent. Mothers were excluded if cognitive or communication impairment prevented reliable questionnaire completion, if they were not primarily responsible for home care, or if the child was receiving exclusively palliative treatment. Only one mother was enrolled per child. A trained member of the research team assessed eligibility, obtained consent, and administered the questionnaire. A total of 86 eligible mothers completed the assessment and were included in the analysis.

Study measures

The questionnaire was developed from a structured review of literature on infection prevention in paediatric oncology, published KAP instruments, HBM measures, and relevant infection-prevention guidance [17–19]. A multidisciplinary expert panel comprising specialists in paediatric oncology, infection prevention and control, epidemiology, and public health reviewed the instrument for relevance, clarity, comprehensiveness, and cultural appropriateness. The questionnaire was pilot tested in five eligible mothers who were not included in the analytical

sample, and minor wording and sequencing changes were made.

The questionnaire had three sections including maternal sociodemographic and child clinical characteristics, infection-prevention knowledge, attitude, and practices and HBM constructs. Maternal variables included age, educational attainment, employment, household income, household size, residence, and distance from the treating hospital. Child variables included age, sex, primary diagnosis, treatment phase, previous infection-related hospitalisation, previous FN, and central venous catheter status [20–22].

The primary outcome was a continuous self-reported infection-prevention practice score based on 15 behaviour-based items scored as always (2), sometimes (1), or never (0). The raw score was linearly transformed to a 0–100 scale, with higher scores indicating more frequent reported adherence. For descriptive purposes only, scores were grouped as <50, 50–74.9, or ≥75. These were study-defined descriptive categories and not validated clinical or behavioural thresholds. The continuous score was used for regression analyses. Because the outcome was self-reported, it is described throughout as self-reported infection-prevention practice.

Knowledge was assessed using 20 dichotomous items, with correct responses scored 1 and incorrect or “don't know” responses scored 0, and transformed to 0–100. Attitudes were assessed using 12 five-point Likert-scale statements and negatively worded items were reverse-coded and the resulting score was transformed to 0–100. Six HBM constructs including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, self-efficacy, and cues to action were assessed with five-point Likert-scale items and transformed to 0–100. For perceived barriers, higher scores represented greater perceived barriers. Cronbach's α was used to assess internal consistency; it was not interpreted as evidence of construct validity.

Data collection and quality assurance

Two research assistants received standardised training in recruitment, eligibility assessment, questionnaire administration, confidentiality, ethics, and non-directive interviewing. Interviews were conducted face-to-face in a private area of the oncology OPD [23]. Interviewers clarified wording when requested but did not suggest responses. Questionnaires were checked after completion for completeness and internal consistency. Data were entered into a password-protected database using unique study identifiers, direct identifiers were removed before analysis, and the dataset was checked for transcription errors, duplicate records, inconsistent responses, and values outside prespecified allowable ranges.

Statistical analysis

Analyses were performed using IBM SPSS Statistics version 24. Continuous variables were summarised with means and SDs or medians and IQRs as appropriate; categorical variables were summarised with frequencies and percentages. Internal consistency was assessed with Cronbach's α for KAP domains and individual HBM constructs. Associations with the continuous infection-prevention practice score were examined using linear regression. For continuous KAP and HBM measures, coefficients represent the mean difference in practice score associated with a 10-point increase in the predictor. For categorical variables, coefficients represent mean differences relative to the stated reference category. Estimates are reported with 95% CIs. Because the study was cross-sectional, coefficients were interpreted as associations rather than causal effects.

Given the sample size of 86, predictor selection for the adjusted analysis was guided by the study's prespecified conceptual framework and the potential relevance of maternal, child, clinical, and psychosocial factors to infection-prevention practices, rather than by univariable statistical significance or automated stepwise selection. The adjusted model included maternal age, educational attainment, employment, household income, residence, child age, child sex, treatment phase, previous infection-related hospitalisation, previous febrile neutropenia, central venous catheter status, and eight psychosocial measures (knowledge, attitude, and six HBM constructs). Treatment phase was represented using indicator variables. This specification resulted in approximately 20 estimated predictor parameters, corresponding to approximately 4.3 participants per estimated parameter (86/20). We therefore considered the multivariable analysis exploratory and recognised that the available sample provided limited information for estimating a model of this complexity.

Because several HBM constructs are conceptually related and were measured on the same 0–100 scale, attenuation of individual associations after mutual adjustment was anticipated as a potential consequence of correlation among predictors. Multicollinearity and influential observations were assessed before interpretation, and genuine observations were not excluded solely because they were statistically unusual. No automated variable-selection procedure was used, and no formal penalised regression or shrinkage procedure was undertaken. Accordingly, the adjusted coefficients should not be

interpreted as definitive independent effects or as a ranking of the relative importance of the HBM constructs.

The final model was therefore interpreted primarily in terms of the direction and magnitude of associations and the precision of the 95% CIs rather than statistical significance alone. The participant-to-predictor ratio and the potential for model overfitting and correlated psychosocial measures were explicitly considered when interpreting the adjusted estimates. All tests were two-sided, with $p < 0.05$ considered statistically significant.

Ethics

The study protocol was approved by the Institutional Review Board of PIMS Islamabad (approval number F. 1-1/2015/ERB/SZAMBU/1416). Written informed consent was obtained from all participants before enrolment. Participation was voluntary, and withdrawal did not affect the child's clinical care. Confidentiality and privacy were maintained throughout recruitment, data collection, data management, and analysis. The study was conducted in accordance with the Declaration of Helsinki and applicable national and institutional ethical requirements.

RESULTS

A total of 86 mothers were included. Median maternal age was 30 years (IQR 25–35; mean 30.0 [SD 5.9]); 45 (52.3%) were aged 26–35 years. Most mothers were housewives (71 [82.6%]) and lived in rural areas (55 [64.0%]). Twenty-three (26.7%) had no formal education, 25 (29.1%) had primary education, 25 (29.1%) had secondary education, and 13 (15.1%) had higher secondary education or above. Household income was below PKR 30 000 in 33 (38.4%) households, PKR 30 000–60 000 in 35 (40.7%), and above PKR 60 000 in 18 (20.9%). Median distance from the treating hospital was 54 km (IQR 22–118).

Among children, 52 (60.5%) were boys and mean age was 7.2 years (SD 3.3). Acute lymphoblastic leukaemia was the most common diagnosis (50 [58.1%]), followed by lymphoma (18 [20.9%]), acute myeloid leukaemia (10 [11.6%]), and solid tumours (8 [9.3%]). At enrolment, 40 (46.5%) children were receiving induction therapy, 36 (41.9%) consolidation, and 10 (11.6%) maintenance or other treatment. Previous infection-related hospitalisation was reported for 35 (40.7%) children and previous FN for 22 (25.6%); 12 (14.0%) had a central venous catheter.

Characteristic	Category	n (%)
Maternal age, years	Mean (SD)	30.0 (5.9)
	Median (IQR)	30 (25–35)
	18–25	24 (27.9)
	26–35	45 (52.3)
	≥36	17 (19.8)

Educational attainment	No formal education	23 (26.7)
	Primary (1–5 years)	25 (29.1)
	Secondary (6–10 years)	25 (29.1)
	Higher secondary or above (≥ 11 years)	13 (15.1)
Employment status	Housewife	71 (82.6)
	Employed/self-employed	15 (17.4)
Household monthly income, PKR	<30 000	33 (38.4)
	30 000–60 000	35 (40.7)
	>60 000	18 (20.9)
Place of residence	Urban	31 (36.0)
	Rural	55 (64.0)
Household size, persons	≤ 4	19 (22.1)
	5–7	43 (50.0)
	≥ 8	24 (27.9)
Distance to treating hospital, km	Median (IQR)	54 km (IQR 22–118)
Child's age, years	Mean (SD)	7.2 (3.3)
	0–4	29 (33.7)
	5–9	35 (40.7)
	10–14	22 (25.6)
Sex	Male	52 (60.5)
	Female	34 (39.5)
Primary diagnosis	Acute lymphoblastic leukaemia (ALL)	50 (58.1)
	Acute myeloid leukaemia (AML)	10 (11.6)
	Lymphoma	18 (20.9)
	Solid tumour	8 (9.3)
Treatment phase at enrolment	Induction	40 (46.5)
	Consolidation	36 (41.9)
	Maintenance/other	10 (11.6)
Previous infection-related hospitalisation	Yes	35 (40.7)
	No	51 (59.3)
Previous febrile neutropenia	Yes	22 (25.6)
	No	64 (74.4)
Central venous catheter present	Yes	12 (14.0)
	No	74 (86.0)

Table 1: Socio-demographic and clinical characteristics of mothers and children included in the analysis (N=86)

The mean knowledge score was 60.9 (SD 18.2), with a median of 62.5 (IQR 50.0–75.0). The mean attitude score was 56.8 (17.1), with a median of 58.3 (45.8–66.7). The mean self-reported infection-prevention practice score was

53.6 (18.7), with a median of 53.3 (40.0–66.7). Using the study-defined descriptive categories, 32 (37.2%) mothers scored <50, 43 (50.0%) scored 50–74.9, and 11 (12.8%) scored ≥ 75 . Internal consistency was acceptable across the KAP domains and HBM constructs, with Cronbach's α values ranging from 0.76 to 0.86.

Domain	Possible score	Mean (SD)	Median (IQR)	Descriptive category	n (%)	Cronbach's α
Knowledge	0–100	60.9 (18.2)	62.5 (50.0–75.0)	<50	27 (31.4)	0.80
				50.0–74.9	42 (48.8)	
				≥ 75	17 (19.8)	
Attitude	0–100	56.8 (17.1)	58.3 (45.8–66.7)	<50	29 (33.7)	0.78
				50.0–74.9	46 (53.5)	
				≥ 75	11 (12.8)	
Self-reported infection-prevention practice	0–100	53.6 (18.7)	53.3 (40.0–66.7)	<50	32 (37.2)	0.82
				50.0–74.9	43 (50.0)	
				≥ 75	11 (12.8)	

Table 2: Knowledge, attitudes, and self-reported infection-prevention practice scores (N=86)

Scores were standardised to 0–100. Practice categories were descriptive study-defined groupings and were not validated clinical or behavioural thresholds. IQR=interquartile range; SD=standard deviation.

Among HBM constructs, perceived barriers had the highest mean score (66.2 [SD 14.3]), followed by perceived severity (64.9 [13.2]) and perceived benefits (59.7 [15.1]). Mean scores were 55.8 (14.6) for perceived susceptibility, 50.8 (16.2) for cues to action, and 46.9 (15.8) for self-efficacy.

HBM construct	Possible score	Mean (SD)	Median (IQR)	Cronbach's α
Perceived susceptibility	0–100	55.8 (14.6)	56.7 (46.7–66.7)	0.76
Perceived severity	0–100	64.9 (13.2)	66.7 (56.7–73.3)	0.81
Perceived benefits	0–100	59.7 (15.1)	60.0 (50.0–70.0)	0.84
Perceived barriers	0–100	66.2 (14.3)	66.7 (56.7–76.7)	0.78
Self-efficacy	0–100	46.9 (15.8)	46.7 (36.7–56.7)	0.82
Cues to action	0–100	50.8 (16.2)	50.0 (40.0–60.0)	0.79

Table 3: Health Belief Model construct scores (N=86)

Higher scores indicate greater endorsement of the corresponding construct. For perceived barriers, higher scores indicate greater perceived barriers to recommended infection-prevention practices.

In univariable analyses, higher educational attainment and household income were positively associated with practice. Knowledge, attitude, perceived susceptibility, perceived benefits, self-efficacy, and cues to action were also positively associated, whereas perceived barriers were inversely associated. Knowledge had the highest univariable association among the continuous psychosocial measures: a 10-point increase was associated with a 2.26-point higher practice score (95% CI 1.35–3.17; $p < 0.001$).

The prespecified exploratory multivariable model included 20 estimated predictor parameters across 86

participants. After adjustment, higher educational attainment remained associated with higher practice scores (β 1.54, 95% CI 0.18–2.90; $p = 0.027$). Perceived benefits (β 0.96, 0.02–1.90; $p = 0.046$) and self-efficacy (β 1.22, 0.32–2.12; $p = 0.009$) were positively associated with practice, whereas perceived barriers were inversely associated (β –1.02, –1.91 to –0.13; $p = 0.025$). Associations for knowledge, attitude, perceived susceptibility, perceived severity, and cues to action were attenuated after adjustment and were not statistically significant. Given the exploratory nature and relatively high model complexity, these adjusted estimates were interpreted cautiously, with emphasis on effect estimates and confidence intervals rather than statistical significance alone.

Predictor	Univariable β (95%CI)	p value	Adjusted β (95% CI)	p value
Maternal educational attainment, per category increase	2.15 (0.72 to 3.58)	0.004	1.54 (0.18 to 2.90)	0.027
Household income, per category increase	1.63 (0.08 to 3.18)	0.04	0.91 (−0.57 to 2.39)	0.225
Knowledge score, per 10-point increase	2.26 (1.35 to 3.17)	<0.001	0.79 (−0.16 to 1.74)	0.102
Attitude score, per 10-point increase	1.78 (0.72 to 2.84)	0.001	0.63 (−0.39 to 1.65)	0.223
Perceived susceptibility, per 10-point increase	1.34 (0.30 to 2.38)	0.012	0.48 (−0.49 to 1.45)	0.328
Perceived severity, per 10-point increase	0.91 (−0.08 to 1.90)	0.071	0.27 (−0.65 to 1.19)	0.562
Perceived benefits, per 10-point increase	1.69 (0.68 to 2.70)	0.001	0.96 (0.02 to 1.90)	0.046
Perceived barriers, per 10-point increase	−1.48 (−2.43 to −0.53)	0.003	−1.02 (−1.91 to −0.13)	0.025
Self-efficacy, per 10-point increase	1.98 (1.04 to 2.92)	<0.001	1.22 (0.32 to 2.12)	0.009
Cues to action, per 10-point increase	1.55 (0.65 to 2.45)	0.001	0.71 (−0.14 to 1.56)	0.101

Table 4: Univariable and multivariable associations between maternal and psychosocial factors and self-reported infection-prevention practice score

β = regression coefficient; CI = confidence interval.

Note: β coefficients represent the mean difference in infection-prevention practice score (0–100). Continuous psychosocial measures are expressed per 10-point increase; maternal education and household income are expressed per category increase. The adjusted model included 20 estimated predictor parameters across 86 participants and additionally included maternal age, employment, residence, child age, child sex, treatment phase, previous infection-related hospitalisation, previous febrile neutropenia, and central venous catheter status. The adjusted model was prespecified from the study's conceptual framework and was not selected using automated stepwise procedures. Given the sample size and correlation among psychosocial measures, adjusted estimates should be considered exploratory and interpreted with attention to their confidence intervals and potential model instability.

DISCUSSION

In this single-centre cross-sectional study of mothers caring for children receiving chemotherapy in Pakistan, the mean self-reported infection-prevention practice score was 53.6 on a 0–100 scale. After adjustment, higher educational attainment, greater perceived benefits, and greater self-efficacy were associated with higher practice scores, whereas greater perceived barriers were associated with lower scores. Knowledge showed a strong univariable

association but was attenuated after adjustment and was no longer statistically significant. The central interpretation is therefore not that knowledge is unimportant, but that reported preventive behaviour might depend on whether caregivers perceive the behaviours as useful, feel able to perform them, and can overcome barriers to implementation. These findings are exploratory and do not establish causal relationships.

The study adds a new behavioural dimension to the existing Pakistani literature on infection-related complications in paediatric oncology. Previous studies have reported significant burdens related to FN, including delayed presentation, travel-related barriers, and gaps in caregiver awareness. In the Children's Hospital Lahore experience, only 19% of caregivers had adequate awareness of FN management; another study reported adequate awareness in 44% of parents [14, 15]. Our study addresses a different point in the care pathway including routine infection-prevention behaviour before clinically apparent FN or infection. The finding is important because recognition of fever and timely presentation are not equivalent to consistently implementing preventive behaviours at home. The findings therefore complement rather than contradict the Pakistani FN literature by shifting attention from acute response to the behavioural and contextual conditions under which prevention is enacted.

The contrast with global evidence is informative but should be interpreted cautiously because measurement instruments and score ranges differ across studies. In Thailand, Klaisuban and colleagues studied 80 caregivers

of children with cancer undergoing chemotherapy and reported high overall infection-prevention behavior and health literacy was the only significant predictor [12]. In our Pakistani sample, the mean practice score was more modest and knowledge was not independently associated with practice after adjustment. These apparently different findings could reflect differences in health-system context, caregiver characteristics, measurement instruments, or the domains of infection prevention assessed. They should not be interpreted as evidence that health literacy or knowledge is unimportant. Rather, they support the value of examining knowledge alongside implementation-related and contextual determinants.

The HBM findings provide a more specific behavioural interpretation. Perceived benefits and self-efficacy remained positively associated with practice after adjustment. Self-efficacy was also the lowest-scoring HBM construct in this sample, whereas perceived barriers had the highest mean score. This pattern is compatible with the hypothesis that some caregivers may recognise the importance of prevention but have less confidence or fewer feasible opportunities to perform recommended behaviours consistently. Evidence from Iran provides complementary, although not causal, support for the relevance of self-efficacy that an educational intervention based on self-efficacy theory among 86 mothers of children receiving chemotherapy increased both self-efficacy and caring behavior [20]. Because that study was interventional and ours was cross-sectional, the two studies cannot establish that increasing self-efficacy would improve infection-prevention practice in Pakistan. Together, however, they justify prospective testing of practical, theory-informed caregiver support.

Perceived barriers were inversely associated with practice, making barriers an important potential intervention target. Infection-prevention recommendations or guidelines are implemented in households rather than only in hospitals, so feasibility can depend on the availability of water and hygiene facilities, food-preparation conditions, competing caregiving demands, transport, finances, and access to clinical support. Importantly, our aggregate barrier measure did not identify which of these specific constraints were present. They should therefore not be inferred from the score. This distinction is particularly important in Pakistan, where local paediatric oncology studies have reported increased travel and socioeconomic burdens [2,21-23]. The appropriate response is not to place responsibility for structural constraints on mothers, but to identify which barriers are modifiable at the caregiver, service, and health-system levels. Qualitative and mixed-methods research should be used to disaggregate these barriers before interventions are designed.

Educational attainment remained associated with practice after adjustment. Education is likely to determine several overlapping dimensions, including health literacy, communication, previous exposure to health information,

and socioeconomic circumstances. The finding should not be interpreted as evidence that mothers with less education are intrinsically less capable of prevention. Instead, it supports designing infection-prevention communication so that effectiveness does not depend on reading ability or formal schooling. Demonstrations, teach-back, visual materials, repeated reinforcement during chemotherapy visits, and culturally appropriate problem-solving could be evaluated as ways to make recommendations actionable across educational levels.

Several HBM domains and knowledge and attitude were not statistically significant after adjustment, despite positive univariable associations for some measures. This attenuation is important but should not be interpreted as evidence that these constructs lack behavioural relevance. The adjusted model simultaneously included eight psychosocial measures, several of which are conceptually related components of the same behavioural framework. Consequently, the univariable association between knowledge and practice, although relatively strong (β 2.26 per 10-point increase), was reduced after adjustment (β 0.79, 95% CI -0.16 to 1.74). This pattern may reflect overlap and correlation among knowledge, attitude, and HBM constructs, as well as adjustment for maternal and child characteristics, rather than an absence of a relationship between knowledge and preventive behaviour.

The statistical precision of the adjusted model also warrants particular caution. With 86 participants and approximately 20 estimated predictor parameters, there were only about 4.3 participants per estimated parameter. Although the model was specified a priori from the conceptual framework rather than selected through automated stepwise procedures, this ratio provides limited information for reliably estimating a model of this complexity and increases the possibility of overfitting, imprecise coefficients, and unstable estimates. We therefore regard the adjusted findings as hypothesis-generating rather than as definitive estimates of independent behavioural determinants.

Importantly, the confidence intervals for several adjusted associations included clinically relevant positive or negative values, indicating substantial uncertainty around the magnitude of the associations. The observed pattern should therefore not be interpreted as a definitive ranking of HBM constructs. Larger studies should prespecify a parsimonious conceptual model, limit the number of simultaneously estimated parameters, and, where sample size permits, use appropriate shrinkage or penalised regression approaches to improve estimation stability.

The public-health implication is that caregiver-centred infection prevention should not be framed as an information-delivery problem alone. A feasible intervention in Pakistani paediatric oncology services could combine concise education with demonstration and skills rehearsal, teach-back, personalised action planning,

reinforcement at routine visits, and structured problem-solving around barriers identified by caregivers. Future qualitative or mixed-methods research should disaggregate the aggregate perceived-barrier score to determine which household and service-level constraints are most relevant, such as availability of water and hygiene supplies, food-preparation conditions, competing caregiving responsibilities, transport constraints, financial pressures, and access to timely clinical advice. Such work would help distinguish barriers that can be addressed through caregiver education from those requiring service-level or health-system responses. Where barriers are structural such as transport, supplies, or access to care, service-level or social-support responses will be required rather than additional education alone. These approaches should complement facility-based infection prevention and control, not substitute for it. Their effectiveness should be tested prospectively using objective or repeated measures of behaviour and, where feasible, clinically significant outcomes such as infection-related hospitalisation or treatment disruption.

STRENGTHS AND LIMITATIONS

This study has strengths, including its focus on an underexamined component of paediatric oncology supportive care in Pakistan, recruitment from routine tertiary oncology care, use of a theoretically specified HBM framework, and assessment of practice rather than knowledge alone. The limitations are also important. The cross-sectional design prevents assessment of temporal direction and causality. The practice outcome was self-reported and could be affected by recall and social-desirability bias. The single-centre sample limits generalizability, and although the questionnaire underwent expert review and pilot testing, it was not formally psychometrically validated.

The sample size also constrained the complexity of the multivariable analysis. The adjusted model included approximately 20 estimated predictor parameters among 86 participants, equivalent to approximately 4.3 participants per estimated parameter. This relatively low participant-to-parameter ratio increases the potential for overfitting, imprecise confidence intervals, and instability of adjusted coefficients. In addition, simultaneous inclusion of knowledge, attitude, and six HBM constructs creates the possibility of correlation among predictors and consequent attenuation of individual associations. Although the model was specified from the conceptual framework rather than selected using automated stepwise procedures, no formal penalised or shrinkage approach was undertaken. The adjusted analysis should therefore be regarded as exploratory and hypothesis-generating rather than confirmatory.

The attenuation of the knowledge association after adjustment should similarly be interpreted cautiously and should not be taken to indicate that knowledge is

unimportant; it may partly reflect overlap among psychosocial constructs and limited precision in the multivariable model. Residual confounding is also possible because household resources, health literacy, previous caregiving experience, and access to services were not fully measured. Future studies should use larger multicentre samples with prespecified and more parsimonious adjustment sets, validated instruments, longitudinal designs, and objective or repeated measures of behaviour. Where sample size permits, future analyses could additionally evaluate predictor correlation and use penalised or shrinkage-based regression approaches to improve estimation stability. Qualitative studies should identify the concrete barriers represented by aggregate HBM scores before intervention development.

CONCLUSION

In this single-centre cross-sectional study, self-reported infection-prevention practice among mothers of children receiving chemotherapy was modest. After adjustment, practice was associated positively with educational attainment, perceived benefits, and self-efficacy and negatively with perceived barriers, whereas knowledge was not statistically significant. Because the adjusted model was relatively complex for the available sample and included several conceptually related psychosocial measures, these associations should be regarded as exploratory rather than definitive independent effects. These findings suggest that caregiver-centred infection-prevention strategies should combine information with practical support, confidence-building, and identification of barriers. Because the study is cross-sectional and the adjusted model is exploratory, these behavioural domains should be tested prospectively in larger multicentre studies using prespecified, parsimonious models and, where appropriate, methods designed to improve estimation stability.

DATA AVAILABILITY

The data that support the findings of this study are not publicly available because they contain potentially identifiable participant information and are subject to institutional and ethical restrictions. De-identified data may be made available from the corresponding author upon reasonable request, subject to approval by the relevant institutional ethics committee and applicable data-protection requirements.

CODE AND SOFTWARE AVAILABILITY

The statistical analyses were performed using IBM SPSS Statistics version 24. The analysis syntax, code, or statistical workflow used for the analyses is available from the corresponding author upon reasonable request, subject to institutional and ethical requirements.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGEMENTS

The authors thank the Department of Paediatric Oncology, Children's Hospital, Pakistan Institute of Medical Sciences (PIMS), Islamabad, for facilitating the conduct of the study. The authors also thank the mothers who participated in the study and the research assistants who contributed to participant recruitment, questionnaire administration, and data-quality procedures.

ROLE OF THE FUNDING SOURCE

No external funding was received for this study. Therefore, no funder had any role in the study design, data collection, data analysis, interpretation of findings, or preparation of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICAL APPROVAL AND INFORMED CONSENT

The study protocol was approved by the Institutional Review Board of Pakistan Institute of Medical Sciences (PIMS), Islamabad (approval number F.1-1/2015/ERB/SZAMBU/1416). Written informed consent was obtained from all participants before enrolment. Participation was voluntary, and withdrawal from the study did not affect the child's clinical care. Confidentiality and privacy were maintained throughout recruitment, data collection, data management, and analysis. The study was conducted in accordance with the Declaration of Helsinki and applicable national and institutional ethical requirements.

REPORTING GUIDELINE

The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies.

ARTIFICIAL INTELLIGENCE DISCLOSURE

During preparation of this manuscript, the authors used ChatGPT (OpenAI) as an AI-assisted language and editing tool to improve wording, grammar, clarity, and overall readability. The AI tool was not used to generate, analyse, or interpret the study data, conduct statistical analyses, or make scientific decisions. The authors reviewed and verified all AI-assisted content and remain fully responsible for the accuracy, integrity, originality, and final content of the manuscript.

REFERENCES

1. Heck JE, Rashed WM, Sirirungreung A, Mejia-Arangure JM. Childhood cancer: an equity test for global health. *Lancet*. 2026;407(10536):1306-1307.
2. Manzoor R, Shaheen H, Farooq A, Rafique N, Yasmeen N, Jamshed J. Delays in childhood cancer care at a tertiary care centre in Pakistan: a single-centre study. *Ecancermedicalscience*. 2026;20:2141.
3. Bai L, Zhan Y, Zhou Y, Zhang Y, Shi L, Gupta S, et al. Evidence of clinical benefit of WHO essential anticancer medicines for children, 2011–2021. *EClinicalMedicine*. 2023;59:101966.
4. Lehnbecher T, Groll AH. Infectious complications in the paediatric immunocompromised host: a narrative review. *Clin Microbiol Infect*. 2025;31(1):37-42.
5. Rao VN, Anantharaman Rajeshwari R, Rajagopal R, Normen M. Inception of a pediatric cancer caregiver support group guided by parental needs. *Cancer Rep (Hoboken)*. 2022;5(6):e1469.
6. Faizan M, Caniza MA, Anwar S, Kashif RU, Saleem R, Javed H, et al. Infection prevention and control measures at the Children Hospital Lahore: a My Child Matters collaborative project. *JCO Glob Oncol*. 2020;6:1540-1545.
7. Phillips R, Fisher BT, Ladas EJ, Patel P, Robinson PD, Dupuis LL, et al. Use of food restrictions to prevent infections in paediatric patients with cancer and haematopoietic cell transplantation recipients: a systematic review and clinical practice guideline. *EClinicalMedicine*. 2025;81:103093.
8. Rodgers C, Bertini V, Conway MA, Crosty A, Filice A, Herring RA, et al. A standardized education checklist for parents of children newly diagnosed with cancer: a report from the Children's Oncology Group. *J Pediatr Oncol Nurs*. 2018;35(4):235-246.
9. Gelesson DD, Hiraishi LY, Ribeiro LA, Pereira SR, Gutiérrez MG, Domenico EB. The meaning of neutropenia and homecare needs according to caregivers of children with cancer. *Rev Lat Am Enfermagem*. 2009;17(6):933-939.
10. Mueller EL, Cochrane AR, Moore CM, Jenkins KB, Bauer NS, Wiehe SE. Assessing needs and experiences of preparing for medical emergencies among children with cancer and their caregivers. *J Pediatr Hematol Oncol*. 2020;42(8):e723-e729.
11. Dutta A, Flores R. Infection prevention in pediatric oncology and hematopoietic stem cell transplant recipients. In: *Healthcare-Associated Infections in Children: A Guide to Prevention and Management*. Cham: Springer International Publishing; 2018. p. 281-299.
12. Klaisuban T, Srichantanit A, Payakkaraung S. Factors predicting infection prevention behaviors among caregivers of children with cancer undergoing chemotherapy. *Nurs Sci J Thailand*. 2024;42(3):105-118.
13. Lindblom R, Tran NA, Truong DT, Nguyễn HT, Trần TA, Le NK, et al. Caregivers' understanding and response to healthcare-associated infections in hospitalised children in Vietnam: a qualitative study. *BMJ Paediatr Open*. 2026;10(1):e004199.
14. Alam MM, Fadool Z. Febrile neutropenia in pediatric cancer patients: experience from a tertiary health care facility of Pakistan. *Pediatr Infect Dis*. 2014;6(3):89-93.
15. Ahmad A, Khan FS, Shamim W, Ahmad AS. Burden of febrile neutropenia in pediatric oncology: experience from Children's Hospital Lahore Pakistan. *J Fatima Jinnah Med Univ*. 2020;14(4):166-169.

16. Jang DJ, Jang SG. Predictors of hand hygiene performance among family caregivers: a cross-sectional study using the Health Belief Model. *Am J Infect Control*. 2026;54(5): 544-551.
17. Rinke ML, Chen AR, Milstone AM, Hebert LC, Bundy DG, Colantuoni E, et al. Bringing central line-associated bloodstream infection prevention home: catheter maintenance practices and beliefs of pediatric oncology patients and families. *Jt Comm J Qual Patient Saf*. 2015;41(4):177-185.
18. Tan CE, Lau SC, Tan KA, Latiff ZA, Teh KH, Lee CC, et al. Development and validation of a caregiving knowledge questionnaire for parents of pediatric leukemia and lymphoma patients in Malaysia. *Cureus*. 2022;14(10):e30903.
19. Zhou Y, Cui Y, Wang H, Wang F, Lu C, Shen Y. Developing a tool for nurses to assess risk of infection in pediatric oncology patients in China: a modified Delphi study. *J Biomed Res*. 2016;30(5):386-392.
20. Barani M, Hassani L, Ghanbarnejad A, Molavi MA. Effect of educational intervention based on self-efficacy theory on the caring behaviour of mothers who have children with cancer. *J Mother Child*. 2023;27(1):93-101.
21. Ahmad A, Anjum A, Hussain M, Mushtaq AA, Salaam A. Socio-Economic Challenges in Childhood Cancer Care in a Low-Middle-Income Country: The Children's Hospital Lahore Experience. *Pak J Med Health Sci*. 2021;15(6):1234-1236.
22. Fadoo Z, Belgaumi A, Ashraf S, Naqvi A, Nisar MI. P-0071 Reasons for early abandonment of treatment in children with acute lymphoblastic leukemia in a low middle income country. *Pediatr Blood Cancer*. 2013;60(S3):71.
23. Kashif M, Faizan M, Zafar H, Saeed M, Shahid F. Challenges faced by post-treatment childhood cancer patients and families; the Children's Hospital, Lahore experience. *Pak Armed Forces Med J*. 2022;72(3):1055-1059.