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Highlights

- This review provides compelling evidence that there is a lack of understanding of infection prevention and control precautions and appropriate antimicrobial use by parents, children and nurses in paediatric settings.
- Identified practice gaps highlight health-care workers', parents' and children's vulnerability to pathogen exposure in the context of pandemic spread of highly contagious pathogens.
- Parents and children had limited knowledge in relation to antimicrobials, and thus were making poor decisions on antibiotic use.
- Nurses were unaware of their leadership role in antimicrobial stewardship but they nevertheless had a good understanding of antimicrobial stewardship principles and the barriers to good antimicrobial stewardship.

Paediatric nurses', children's and parents' adherence to infection prevention and control and knowledge of antimicrobial stewardship: a systematic review

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Abstract

Introduction

Infection prevention and control precautions help to decrease microbial transmission, and through the appropriate use of antibiotics, Antimicrobial Stewardship programs aim to decrease the prevalence and emergence of Antimicrobial Resistance.

Methods

A systematic review was undertaken to critically appraise and synthesise evidence for nurses', children's and parents' knowledge and understanding of antimicrobial stewardship, and of infection prevention and control in acute paediatric care settings. The Preferred Reporting Items for Systematic reviews and Meta-Analyses guided the review. Studies were included if they examined the factors that contributed to nurses' adherence to, or consumers' practice in relation to, antimicrobial stewardship and infection prevention and control.

Results

Of the 16,957 papers identified, 50 studies conducted in acute paediatric settings met the eligibility criteria, and were included. Most studies were of low methodological quality. Fourteen studies evaluated nurses' knowledge and self-reported adherence to Infection Prevention and Control principles and identified consistent practice gaps by nurses. Six studies evaluating the effectiveness of education programs reported modest improvements in nurses' knowledge and adherence to infection prevention and control. There were 15 studies, that investigated consumers' involvement in infection prevention and control that identified the following themes: Consumer knowledge and attitudes to infection prevention and control and transmission-based precautions, and parents' willingness to take an active role in infection prevention. Six studies focused on paediatric nurses' role in antimicrobial stewardship, exploring the following themes: (1) nurses' understanding and beliefs of antimicrobial stewardship roles, and (2) barriers to nurses taking a greater role in antimicrobial stewardship. Nine studies explored the role of consumers in antimicrobial stewardship and identified consumers' misconceptions about the benefits and downplayed concerns regarding antibiotic use.

Discussion

Although consumers articulated a willingness to be actively involved in infection prevention, observed practice remained lower than that required to consistently prevent infection transmission.

Conclusion

These findings highlight a critically important gap in current practice. In relation to optimal use of antimicrobials, although paediatric nurses were involved in supporting antimicrobial stewardship processes and educating consumers, they identified limited antimicrobial stewardship knowledge. Consumers appeared to lack understanding about the benefits of antibiotics and negated concerns regarding antibiotic use.

Keywords:

- Infection prevention and control
- Antimicrobial Stewardship
- Systematic Review
- Consumers
- Parent and Children
- Paediatric Nurses
- Hand Hygiene
- Transmission-based precautions
- Personal Protective Equipment

Conflict of interest statement

The authors have no conflict of interest to declare.

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Introduction

Infection prevention and control (IPC) precautions help to decrease microbial transmission, and through the appropriate use of antibiotics Antimicrobial Stewardship (AMS) programs aim to decrease the prevalence and emergence of Antimicrobial Resistance (AMR). In combination, IPC and AMS programs can decrease the prevalence and transmission of AMR within health care settings.¹ In the context of pandemics of infectious disease, it is important to understand what is already known about nurses' and consumers' role in IPC and AMS in paediatric acute care settings.

Effective and vigilant adherence to the principles of IPC, especially transmission-based precautions and optimal use of appropriate Personal Protective Equipment (PPE), are fundamental to preventing infection spread and minimising clinician exposure to infectious diseases in all clinical settings.² The prevention of infections is also the foundation for reducing inappropriate antimicrobial use.³ Standard Precautions are the first line measure for preventing infections and the associated emergence of antimicrobial resistant organisms. The National Health and Medical Research Council reports that awareness of nosocomial infections is essential for all health professionals, including the chain of infection and modes of transmission.⁴ It is this awareness that can assist in preventing the transmission of infection and recognising the need for standard and transmission-based precautions. The World Health Organization recognises hand hygiene as the primary IPC measure to reducing nosocomial infections.⁵ However, suboptimal adherence by health care workers results in an increased risk of cross infection throughout all health care settings. Standard 3 in the Australian National Safety and Quality Health Service Standards reinforces that Hand Hygiene is a national priority. Hand hygiene is a vital procedure to stop the spread of micro-organisms through cross infection.⁴ The Five Moments for Hand Hygiene initiative was introduced in hospitals across Australia in 2009.⁶ The World Health Organization defines the five moments as 'before touching a patient', 'before clean/aseptic procedures', 'after body fluid exposure/risk', 'after touching a patient', and 'after touching patient surroundings'. These five moments are critical to improving hand hygiene practices.⁵

Nurses are in a unique position to make a significant contribution to the successful implementation of the principles of AMS into clinical practice.⁷ It has however, been suggested that nurses have insufficient knowledge of AMS,⁸ and until recently, their

contribution has been under recognised.^{9, 10} Nevertheless, nurses play a key role in AMS activities by: supporting system processes, monitoring for patient safety and optimal antibiotic use and providing consumer education about optimal antibiotic use.¹¹⁻¹³ It is now recognised that empowering bedside nurses to actively engage in AMS programs could improve program uptake and consequently facilitate healthcare institutions' capacity to confront the emergence of antimicrobial resistance.¹⁴

Engaging consumers (patients, family members, and carers) in the implementation and promotion of IPC and AMS in acute care settings is emerging as an additional strategy to support consistent implementation of these principles in practice. The inclusion of consumers in IPC and AMS programs ensures that not only do they receive correct information regarding the principles of hand hygiene, aseptic technique, and appropriate use of antimicrobials, they also take an active role in preventing the spread of infection and the emergence of AMR in clinical practice and community settings.

Acute paediatric settings generate unique challenges in the consistent implementation of IPC and AMS recommendations into practice,¹⁵ due to the vulnerability and complexity of the patient population and the need to engage both parents and children in the implementation of IPC practices and in decision-making around optimal antimicrobial use.¹⁶ Paediatric nurses are in a unique position to partner with both parents and children to ensure that consumers are fully informed and provided with opportunities to be active participants in these critically important aspects of their care.^{11, 17} This is the first known review that has explored current evidence for consumers' and nurses' involvement in both AMS and IPC in paediatric acute care settings. The purpose of this systematic review was to explore and synthesise the existing research evaluating nurses' and consumers' knowledge and understanding of AMS, and adherence to IPC best practice guidelines in acute paediatric care settings. The outcomes of this review will identify and highlight important gaps in current practice that need to be addressed to optimise infection prevention in acute care settings.

Methods

Search Strategy

A search of the literature was conducted using electronic library databases: MEDLINE (Ovid), EMBASE, CINAHL, and PsycINFO from inception to end June 2020. Reference lists of eligible articles were reviewed for possible additional articles that could be included. The following keywords were used: infection prevention and control, infection prevention, infection control, antimicrobial stewardship, antimicrobial resistance, antibiotic resistance, consumer, consumers, parent, parents, parental, paediatrics, paediatrics, paediatric, paediatric, children, infant, adolescent, nurse, nurses, nursing. The research protocol was registered with PROSPERO (CRD42019127759). A full search strategy is available in table S1.

Inclusion and Exclusion Criteria

In order to ensure a comprehensive overview of the research in the area, no start date limits were applied. Studies written in English and French were included. Studies were excluded if they were not original research, were case studies or conference abstracts. Key inclusion criteria were original research conducted in an acute care setting in a middle or high income country. Studies conducted in low income countries in accordance with the International Monetary Fund's definition were excluded as the resources available to the clinician and the type of conditions treated may not be equivalent.^{18, 19} Studies were excluded if they were not original research or were not published in peer reviewed journals. In this review, the term consumers refer to children and their parents or guardians.

Selection of the Literature

After duplicates were removed, two members of the research team independently screened studies at the title and abstract level using Rayyan platform.²⁰ Any discrepancy about studies meeting the inclusion criteria was resolved with discussion with all members. Full texts of potentially relevant studies were retrieved. Two members of the research team then independently examined each study to determine eligibility. Any disagreements between reviewers were resolved with consultation of a third member of the research team.

Data Extraction

Data were extracted from each studies on the study design, and the context in which each study was undertaken. Information was also gathered on the data collection processes, and the participants and sample size of each study.

Quality Assessment

The quality of included studies was independently assessed, according to design, using either the Critical Appraisal Skills Programme Qualitative Research assessment tool, the Effective Public Health Practice Project Quantitative Studies assessment tool, or McGill University's Mixed Methods Appraisal Tool (MMAT).²¹⁻²³ The assessment was conducted independently by two members of the research team using the online survey software, Qualtrics™. The quality assessment was then transferred to a Microsoft Excel spreadsheet. Any disagreements were resolved by consulting a third member of the research team. Studies were not excluded on the basis of the quality assessment. The quality assessment informed evaluation of the strengths and limitations of included studies, and whether or not there was a potential for bias that could influence the interpretation of findings.

Data synthesis

Review outcomes were summarised according to four topics (1) nurses and IPC, (2) consumers and IPC, (3) nurses and AMS, and (4) consumers and AMS.

For observational and interventional studies, summary outcomes measures were extracted using the following steps: 1) two researchers reviewed the included studies and extracted data independently, 2) any discrepancies in the data extraction were reviewed by all members of the research team who then returned to the original publication for clarification and resolution through consensus, 3) study outcomes were summarised according to the above topic areas and the study outcome measures used. As study outcomes around the topic area were heterogeneous, meta-analysis was deemed inappropriate and study outcomes are summarised and compared descriptively.

For qualitative studies, data synthesis was undertaken through a thematic approach. Key themes identified in qualitative studies were summarised using the following steps. 1) topics explored were identified 2) reported themes were summarised 3) thematic synthesis was used to summarise the themes.

The final step in the data synthesis involved reviewing the key findings of both empirical and qualitative study to identify common themes.

Results

A total of 24,795 records were retrieved, of which, once duplicates were removed, 16,957 were screened for possible inclusion in the review. After exclusion based on criteria, 458 full-text articles were screened for potential eligibility for review. Of these, 50 studies were included in the review (Figure 1). Quality appraisal of each of the included studies was performed by two independent researchers using the relevant quality appraisal checklist.

[Figure 1 here]

Fifteen studies evaluated nurses' knowledge and self-reported adherence to IPC and six studies evaluated the effectiveness of education and quality improvement programs to improve nurses' IPC knowledge and adherence. There were 15 studies, that investigated consumers' involvement in IPC. Seven studies focused on paediatric nurses' role and 10 studies explored the role of consumers in antimicrobial stewardship. Three studies investigated several topics. For example Olivier et al. and Macqueen both investigated consumers and nurses IPC knowledge and self-reported adherence,^{24, 25} while Kilpatrick et al. investigated nurse's knowledge and understanding of IPC and AMS principles.¹¹

The quality assessment of qualitative studies showed that majority were of good quality (Table 7). For studies of a quantitative design, 10 were of moderate quality, and 26 of low quality (Table 8). For mixed methods studies, the quality assessment showed one study with a score of 75%,²⁶ and one with a score of 25%.²⁷

Nurses and Infection Prevention and Control

There were 21 studies, (one mixed methods, five qualitative, and 15 quantitative), that investigated various aspects of nurses' knowledge and adherence to IPC best practice (Tables 1). Three themes were identified: (1) Gaps in nurses' knowledge of IPC principles, (2) Hand Hygiene compliance varied according to perceived patient acuity and (3) Targeted education increased knowledge and adherence.

Seven studies evaluated nurses' knowledge, understanding or self-reported adherence to best practice guidelines for hand hygiene and IPC using survey methods^{24, 26-31} and five used semi-structured interviews or focus groups to explore this topic^{11, 25, 32-34}. The effectiveness of educational interventions to improve hand hygiene and IPC compliance and knowledge was evaluated in six studies³⁵⁻⁴⁰. Three studies comprised observation audits of hand hygiene practices⁴¹⁻⁴³.

[Table 1 here]

Gaps in nurses' knowledge of infection prevention and control principles

Gaps in nurses' knowledge of infection transmission and prevention were consistently identified.^{26, 27} Dramowski et al. found that nurses had limited knowledge of infection transmission routes with 85% incorrectly identifying the environment as the main source of infections and 55% of nurses reporting that they felt obliged to come to work when sick.²⁶ Lugg et al. compared adult and paediatric nurses' knowledge of IPC related to MRSA prevention and identified that adult nurses had better knowledge and practices than paediatric nurses (Adult 75% versus Paediatric 63%).²⁷ Ullman et al. reported nurses' knowledge of catheter-related bloodstream infection prevention was poor with an average knowledge score of 55% and that there was a wide variation in practice with inconsistent adherence to guidelines.³¹ This finding was consistent with the study by Ray-Barruel et al. that found differences in beliefs about the optimal frequency of line changes between paediatric and oncology nurses in the same institution, and that nurses based their practice recommendations on beliefs rather than research evidence.³⁴

Common misperceptions regarding infection transmission also emerged in the reported qualitative findings. Macqueen observed nurses' lack of understanding of preventive IPC care, the idea of 'dirtiness' (the potential to spread infection), varied depending on the type of bodily fluid, and from whom.³² Macqueen noted that babies were considered less "polluting" than older children and therefore nurses believed hand hygiene was less likely to be needed.³² Similarly, Kilpatrick et al. found that nurses caring for children with atopic dermatitis were using PPE as self-protection, rather than to prevent cross-infection between patients.³² Kilpatrick et al. found that nurses saw their IPC role primarily as educators, focusing on the importance of educating family members about IPC

strategies including the bacterial load of *Staphylococcus aureus* on the skin, and use of aseptic techniques within the home.¹¹

Gaps in nurses' knowledge and understanding of optimal hand hygiene practices and strategies to prevent infection transmission and correct use of personal protective equipment (PPE), were consistently documented.^{26, 28} Galway et al. found that 76% of nurses agreed on the correct procedures for clean handwashing, that there was a high degree of variability in regards to the duration of an aseptic hand wash (ranging from 15 seconds to three minutes and that there was significant variation between nurses self-reported practice and hospital policies ($p < .01$).²⁸ Parker et al. investigated the most effective strategies to prevent viral transmission of the the SARS coronavirus (SARS-CoV) and found heterogeneity in recommendations between different professional groups for the use of PPE ($p = .002$), use of negative pressure rooms ($p = .03$) and limiting access of patients to the emergency department ($p = .03$), nurses endorsing these recommendations more than trainees or physicians.³⁰ The reported lack of clinician consensus regarding evidence-based IPC strategies highlights the potential for inconsistent practices that have the potential to place both patients and clinicians at risk.

Hand hygiene compliance varied according to perceived patient acuity

Hand Hygiene compliance was evaluated in four observational audits that found inconsistencies in practice and that compliance was influenced by perceived patient acuity.^{24, 29, 41, 42} Morritt et al. observed variation between policies and practice for the duration of both clean and aseptic handwashing and that 40-59% of nurses exceeded the necessary duration of handwashing, potentially increasing their risk of developing adverse effects such as dermatitis.²⁹ Scheithauer et al. and Olivier et al. reported higher reported hand hygiene compliance rates in neonatal wards than paediatric wards: 51.4% vs 10%, and 61% vs 53% respectively.^{24, 42} In relation to the five moments of hand hygiene, Donnellan et al. reported nursing hand hygiene compliance rates were 90% pre-care or pre patient contact and between 76% and 97% post care or post patient contact.⁴¹

Table 1
Studies Evaluating Nurses' Knowledge and Adherence to Infection Prevention Strategies and the Effectiveness of Educational Interventions.

Author Design Country	HH opportunities	Sample Size	Measured Outcomes	Key Findings			Comments
Donnellan, R. A (2011)			HH Compliance with hospital's local HH policy and procedure.	HH Compliance Rate Pre-care	HH Compliance Rate Post Care	Combined HCW HH Compliance	
Observation annual cross-sectional audits for 6 years.	<i>n</i> = 571		HH Compliance before and after care provision.	> 90% each year over 6 years	Range over 6-year follow-up 76%-97%	Compliance 86% for Basic Hand hygiene before and after care.	Only 30% of nursing staff were aware that their HH was being observed.
Australia			HH Duration			Compliance 66% for procedural HH.	
Morritt, M-J (2006)				Clean wash – Duration	Aseptic hand washing		
Observational – Cross-sectional survey		<i>N</i> = 30	Clean and aseptic handwashing practices against local policies. Duration of handwashing for specific procedures.	15 secs – 30% 30 secs – 47% Range: 0- 2 mins	1 min - 30% 2 min – 53% Range: 30 secs to 3 mins.	40 -59% of nurses exceeded the necessary duration handwashing.	Identified variation between nurses' practices and local policies
Australia							
Scheithauer, S (2011)	<u>Total</u> <i>N</i> = 2,060			Overall HH Compliance Rates	NICU Compliance Rates	PICU Compliance Rates	
Observational cross-sectional audit	<u>NICU</u> <i>n</i> = 778		Opportunities, behaviour, and compliance rates of HH	<u>NICU</u> 61%	Nurses – 66% Doctors – 52%	Nurses – 57% Doctors – 29%	Compliance rates were higher before patient contact and aseptic tasks than after patient contact (including contact with patient's bodily fluids, and the surroundings)
Germany	<u>PICU</u> <i>n</i> = 1,284			<u>PICU</u> 53%			
Olivier, C (2018)				Opportunities for HH	HH Compliance Rates		
Observational - Cross-sectional - Point prevalence survey at 4 sites	<u>Total</u> <i>N</i> = 493 <u>Nurses</u> <i>n</i> = 263		WHO 5 Moments for Hand Hygiene – compliance	Overall HH Neonatal wards 125/ 243 51.4%			The most regularly missed HH moments: • Before an aseptic task • After touching patient surroundings
South Africa				Overall HH Paediatric wards 25 / 250 10%	Mothers – 43% Nurses – 27.8% Doctors – 27.4%		
				Difference 41.4% <i>p</i> < .001			

Dramowski, A (2016)	Mixed methods Observational – cross-sectional survey	n = 95	Paediatric HCWs knowledge, attitudes, and practices regarding HAI	HAI Sources	IPC Precautions	PPE Use	HCWs lacked knowledge infection transmission routes, correct HH and cleaning practices.
				85% of nurses incorrectly identified the environment as the main source for HAI.	55% of nurses feel obligated to come to work when sick	96% of nurses always use PEE when caring for patients with infectious conditions	
				Use of Alcohol Hand rub	91% of nurses believed those who ignored IPC recommendations be reprimanded.		
South Africa				55% incorrect use			
Galway, R (2003)	Observational – Cross-sectional survey	n = 67	Paediatric nurses' knowledge of: Types of handwashing - 'clean and 'aseptic' Indications / conditions - handwashing practices in relation to different procedures / devices.	HH Knowledge	Policy Adherence	HH v. Policy Comparison	There was a lack of consistency between policies and clinical practice.
				76% of nurses agreed on procedures for clean handwashing	Aseptic HH policy adherence ranged from 3% to 88%.	Significant differences between nurses self-reported practice and hospital policy for:	
				High degree of variability - duration of aseptic hand washing ranged from 15 secs to 3 mins.		extent of wash ($p < .01$) and solution used ($p .01$); for both clean and septic washes.	
Lugg, GR (2008)	Mixed method Observational Cross-sectional survey	Total N = 95	Knowledge and self-reported practices of IPC related to MRSA	Mean Practice Score	Mean Knowledge Score	Correlation between higher knowledge score and higher practice scores ($p = .003$).	Adults' nurses showed to have statistically significantly better knowledge and practice than children's nurses regarding MRSA.
		Adult Nurses n = 29		Adults' Nurses 9.7/11	Adults' Nurses 12 /16		
		Paediatric Nurses n = 66		Children's Nurses 8.24 /11	Children's Nurses 10.1 /16		
Parker, MJ (2006)	Cross-sectional survey	Total N = 116	Understanding of effectiveness and current use of IPC measures against a novel respiratory virus (SARS)	Highest rated protection:	Difference between professional groups, environmental strategies	Differences between groups for use of PPE	<ul style="list-style-type: none"> Nurses gave high effectiveness ratings for almost all IPC measures. 3.7 out of 5 - Mean score for wearing gloves to prevent transmission of pathogens when examining patients
		Nurses n = 48		<u>Using Negative pressure rooms</u> 4.6/5	<u>Negative pressure rooms</u> $p = .03$	<u>Wearing gloves when examining patients</u> $p = .002$	
				<u>Wearing N95 masks when exam patients</u> 4.5/5	<u>Limiting access of patients to ED</u> $p = .03$	<u>Using Eye protection</u> $p = .002$	
Canada				<u>Hand Hygiene</u> 4.5/5	<u>Making visitors wear a mask</u> $p = .01$	<u>Using N95 mask when exam patients</u> $p < .001$	

Ullman, A (2014)				Mean total knowledge score 5.5/10 (SD = 1.4)			
Observational cross-sectional survey	N = 253	Evidence-based strategies aimed at preventing catheter-related bloodstream infections	Highest scoring item Recommended CVC dressing - 95.7%	Lowest scoring items Use of antibiotic ointment recommended 18.6%	18% identified all items necessary precautions for a maximum sterile barrier during the insertion of CVCs	Reported barriers to implementing recommendations for reducing HAI: • Lack of resources • 'too hard' • Lack of within hospital communication was identified.	• Lack of knowledge about catheter-related bloodstream infection prevention. • Widespread variation in practice, with inconsistent adherence to recommendations.
Australia and New Zealand				5 items to delivery maximum sterility during insert 18.2%			
Gras-Valenti, P (2020)							
Observational cross sectional study repeated over time	n = 5215	N = 9226	Degree of compliance with HH	Nurses overall adherence to HH over 13 years was 65.5% (3417/5251)	HH compliance increased straight after an intervention (2005 to 2008) and then showed gradual decline.		Adherence higher for moments 3, 4 and 5. Progressive decline in adherence from 2013 to 2017
Spain							
Macqueen, S (1995)							
Qualitative – phenomenology	Paediatric Patients/Parents n = 7	The influences culture has on the application of IPC practices	Dirtyness varied depending on the type of bodily fluid	Bodily fluids from an infant were 'less polluting' requiring less frequent and thorough hand washing.	The lower half of the body was thought to be 'more dirty' than the upper half.	Preventive IPC care was being abused by doctors and nurses and seen as unimportant.	
United Kingdom							
Kilpatrick, M (2019a)							
Qualitative exploratory descriptive	N = 16	Paediatric nurses' knowledge and attitudes AMS and IPC role when caring for children with AD	Primary themes Education and advocacy were part of the nurses' role, there was a practice-to-theory gap for nurses AMS knowledge and self-protection was used instead of IPC.	• Nurses' perceptions of their role were to provide family members with sufficient education. • Self-protection by nurses further expanded in their other paper.			
Australia							
Kilpatrick, M (2019b)							
Qualitative exploratory descriptive	N = 16	IPC precautions utilised when caring for children with AD	Primary Themes IPC is required for managing AD, nurses focused on self-protection, and nurses educate families on IPC.	• Self-protection as opposed to reducing infection risk was reported by nurses. • Nurses' viewed their role as limiting cross-infection between patients.			
Australia							
Isaac, R (2019)							
Ethnographic study	N = 29 Observed nurses n = 23 Interviewed nurses n = 6	Explore the challenges clinical staff face when utilising an aseptic non-touch technique during intravenous therapy	Nurses lacked knowledge in the implementation of aseptic non-touch technique, including failure to protect the key parts.	Significant factors to improve infection prevention control behaviour are effective education, motivation and system change		Utilise a mixture of observations, field notes, audit questionnaire and semi-structured interviews	
United Kingdom							

Ray-Barruel, G
(2019)

Qualitative
Exploratory
descriptive

Australia

N = 38 Adult
n = 22 (Adult setting)
n = 16 (Paediatric
setting)

Decision making process
of paediatric and adult
nurses on intravenous
administration set
replacement for vascular
access device infusions.

In all groups nurses believed that
IPC was the key reason for IV set
replacement.

Paediatric oncology nurses believed that
interrupting a closed circuit for line
changes increased infection risk, and
believed the less line changes the better.

ICU paediatric participants
discussed having uncertainty
of the IPC benefits in
replacing or continuing the
administration set.

Nurses' differing viewpoints were based on belief,
rather than relying on research evidence.

Note. AD = Atopic Dermatitis; AMS = Antimicrobial Stewardship; HH = Hand Hygiene; IPC = Infection Prevention and Control; ICU = Intensive Care Unit; PICU = Paediatric Intensive Care Unit; NICU = Neonatal Intensive Care Unit; PPE = Personal Protective Equipment

The effectiveness of educational interventions to improve hand hygiene and IPC compliance and knowledge was evaluated in six before-and-after studies.³⁵⁻⁴⁰

[Table 2 here]

Three studies evaluated whether educational interventions increased nurses' knowledge of best practice in relation to hand hygiene and IPC, and two reported modest improvements. Galal et al. reported an 8.5% increase in nurses' mean knowledge score and a 9% improvement in nurses' knowledge of different types of hand hygiene.³⁶ McCaskey conducted a multi-component interventional study that included both staff education and audit and feedback and reported only small incremental improvements in hand hygiene knowledge and practices.³⁷ Hatler et al. evaluated an education and awareness raising program to increase knowledge of evidence-based practices for CVC line care and reported no improvement in staff knowledge scores following the intervention.⁴⁰

Three studies used observational audits to evaluate change in hand hygiene adherence following an educational intervention. Belela-Anacleto et al. reported a 9.8% improvement (baseline 27.3% to follow-up 37.1%, $p = .010$) in compliance to the WHO 5 Moments of hand hygiene.³⁵ Similarly, di Martino et al. reported a 9.1% increase in improvement.³⁸ Song et al. showed improvement in hand hygiene compliance 12-months following an educational intervention and highlighted that once barriers were identified and corrected, nurses' hand hygiene adherence increased by 31.4%.³⁹

Table 2
Studies evaluating the effectiveness of educational interventions to improve nurses' adherence.

HH Opportunities	Sample Size	Measured Outcomes	Intervention	Baseline	Follow-up/ Post	Difference	Comments
Belela-Anacleto, A.S.C (2019)	<u>Pre intervention</u> n = 410	World Health Organization guideline HH compliance monitoring	<ul style="list-style-type: none">Organisation and educational interventions.Audit and Feedback	<u>HH Compliance</u>	<u>HH Compliance</u>	<u>Baseline to Post Intervention Phase 2</u> 9.8% Improvement (p = .010)	<ul style="list-style-type: none">Nurses compliance showed an increasing trend.Nurses overall HH compliance - 40.6%Social pressure was the main predictor for HH.
Prospective Before and After Study in 3 phases	<u>Post Intervention 1</u> n = 405			<u>Pre intervention</u> n =112 27.3%	<u>Post phase 1</u> n = 134 33.1%		
Brazil	<u>Post intervention 2</u> n = 446				<u>Post Phase 2</u> n = 165 37.1%		
	<u>Total</u> N = 1261						
Di Martino, P (2011)	<u>Total</u> N = 420	Using alcohol-based hand rub or either soap and water prior to patient contact	Seminars and educational sessions	<u>HH Compliance</u>	<u>HH Compliance</u>	<u>HH Improvement</u>	The baseline HH compliance rate was 19.2%
Prospective Before and After Study in 3 Phases	<u>Nurses</u> n = 239			<u>Post Intervention</u> All HCW - 44.9% Nurses - 40.7%	<u>1-year Post</u> All HCW - 45.2% Nurses - 49.8%	<u>All HCWS</u> 0.3%	
Italy						<u>Nurses</u> 9.1%	
Galal, Y (2014)	N = 125	Types of handwashing, Conditions, use of disinfectants, & effectiveness of hand gel	Education on infection-control measures	<u>Knowledge Score Mean(SD)</u>	<u>Knowledge Score Mean (SD)</u>	<u>Difference</u>	<ul style="list-style-type: none">Nurses in the post-intervention phase had significantly more knowledge on avoiding recapping syringes.Many nurses believed that IPC measures could protect them completely from acquiring infection
Prospective before and after Study				<u>Pre Intervention</u> 28.67 (4.499)	<u>Post Intervention</u> 37.18 (3.494)	<u>Knowledge Score Mean</u> +8.50	
Egypt				<u>Knowledge of Types of Hand Washing (%)</u>	<u>Knowledge of Types of Hand Washing (%)</u>	<u>Knowledge of Types of Hand Washing (%)</u> 9.0% improvement	
				<u>Pre Intervention</u> 91.2%	<u>Post Intervention</u> 99.2%		
McCaskey, M (2013)	N = 187	Self-reported central line care compliance	Multi-component educational intervention with audit and feedback	<u>Mean Knowledge Score (SD) Pre-intervention</u>	<u>Mean Knowledge Score (SD) Post Intervention</u>	<u>Mean Knowledge Score (SD) Difference</u>	Nurses' self-reported compliance slightly increased between pre- and post-interventions
Prospective before and after Study				<u>HH before changing caps</u> 4.90 (.365)	<u>HH before changing caps</u> 4.98 (.143)	<u>HH before changing caps</u> 0.08	
United States				<u>HH before accessing central line</u> 4.84 (.463)	<u>HH before accessing central line</u> 4.94 (.282)	<u>HH before accessing central line</u> 0.10	

				HH before dressing change 4.93 (.251)	HH before dressing change 4.99 (.102)	HH before dressing change 0.06
				Scrubbing access port using alcohol 4.89 (.348)	Scrubbing access port using alcohol 4.90 (.306)	Scrubbing access port using alcohol 0.01
				Allowing alcohol to dry before accessing 4.62 (.685)	Allowing alcohol to dry before accessing 4.89 (.319)	Allowing alcohol to dry before accessing 0.17*
Song, X (2013)	<u>Pre Intervention</u> n = 1,433	HH compliance of 3 moments: sanitising hands before and after patient contact and after environmental contact.	<ul style="list-style-type: none"> Hand hygiene initiative Address barriers inhibiting effective HH 	<u>HH Compliance</u>	<u>HH Compliance</u>	<u>HH Improvement</u>
Retrospective before and after study	<u>Post Intervention</u> n = 9,580			<u>Pre Intervention</u> All HCWs - 50.3% Nurses - 46.5%	<u>Post intervention</u> All HCWs - 84% Nurses - 77.9%	<u>HCWs</u> 33.7%
United States						<u>Nurses</u> 31.4%
Hatler, C (2009)	N = 62	Evidence-based practices of CVC site care currently being used, including hand hygiene, glove use, and site vs infection risk	Verbal, written, poster based information during a 3-week period.	<u>Mean Knowledge Score</u>	<u>Mean Knowledge Score</u>	Unclear as to what specific knowledge was assessed and only lists the knowledge as catheter-related infection control practices and where nurses lacked knowledge.
Cross-sectional survey				<u>1st Administration</u> 86.67%	<u>2nd Administration</u> 84.65%	
United States						

Consumers and Infection Prevention and Control

There were 15 studies, (2 qualitative, and 13 quantitative), that investigated consumers' (family members, parents, or children) involvement in IPC. The key outcomes evaluated in each study are summarised in Table 3.

[Table 3 here]

Eight studies evaluated consumer knowledge, attitudes and compliance with infection prevention and control IPC with survey studies^{24, 44-50}, and two used semi-structured interviews to explore this topic.^{25, 51} Five educational intervention studies related to this topic were included and summarised in Table (3b).⁵²⁻⁵⁶ Two themes identified were: Consumer knowledge and attitudes to IPC and transmission-based precautions, and Parents' willingness to take an active role in infection prevention.

Consumer knowledge and attitudes to IPC and transmission-based precautions

Over half of the parents felt strongly about glove and mask use by health care workers when caring for patients⁴⁹, identifying that appropriate use could help or inhibit the spread of infectious diseases. However, Macqueen reported that consumers lacked education on infection risks and accepted that infections were likely to occur while children were in the hospital.²⁵ Lehnbecher et al. reported that paediatric oncology patients' IPC compliance rates were lowest for using face masks, and social contact restrictions.⁴⁶ However, Woolner et al. discussed how less than half of oncology consumers felt isolation was important, some had stricter opinions on isolation precautions than staff.⁵⁰ Parents and patients with Cystic Fibrosis (CF) were also noted to have positive views about the segregation measures to prevent cross infection.⁴⁵ Additionally, Oliver et al. reported that hand hygiene compliance rates were higher among mothers than nurses and doctors.²⁴ Some consumers believed that it was unlikely that their child would get an infection if CVC care was not perfectly executed on every occasion and had not received teaching on CVC care before their first discharge with a central line.⁴⁸ During the SARS-CoV outbreak in Canada, children admitted to a large paediatric hospital identified that IPC was a shared responsibility, and should be undertaken by everyone.⁵¹

The majority of parents were reported to be aware of the problem of HAI and were willing to be involved in infection prevention initiatives.⁴⁴ Despite this, both Buser et al. and Pan et al. reported that a third of parents and children were unwilling to prompt health care workers such as nurses to perform hand hygiene.^{44, 47} Engaging parents to assist nurses with their activities helped reduce HAI, as it allowed nurses to focus on high infection risk procedures.⁵⁵ Two studies reported hand hygiene compliance and IPC practices improved following consumer education.^{52, 53} Additionally, parental knowledge of IPC, and ability to recognise non-adherence to best practices by health care workers increased post home central-line care education.⁵⁴ Their study showed the greatest overall improvement in IPC practices, through the use of high-fidelity simulation with parents.

Table 3

Consumer and Infection Prevention and Control

	HH Opportunities	Sample Size	Measured Outcomes	Knowledge	Comments
Buser, G (2013)					
Cross-sectional survey study		N = 115	Willingness to prompt HCW to do HH	67% of parents would prompt HCW to perform HH	Almost all participants said that an invitation in the future would make them more likely to prompt a HCW to perform HH
United States					
Griffiths, A (2004)					
Cross-sectional survey study		N = 190	Reactions to the segregation measures	85% of parents and 63% of patients felt positive about segregation measures for IPC	There were apprehensions about the emotional impact from the lack of socialising
Australia					
Koller, D (2010)					
Qualitative Study		N = 21	Perspectives and recommendations during a SARS outbreak	Some participants stated that individuals should redirect their own needs to safeguard the whole community	Participants identified IPC as a collective obligation that should be undertaken by everyone, including children.
Canada					
				Compliance Rates	
Lehrnbecher, T (2008)				<u>Food Restriction</u> 89.3%	
				<u>Face Masks</u> 68.8%	
				<u>Antiseptic Mouth Rinses</u> 67.1%	
				<u>Social Contact Restrictions</u> 65.5%	
Germany and Austria					
				Beliefs of how infections are spread	
Macqueen, S (1995)				<ul style="list-style-type: none"> Through the air On your fingertips If you do not clean it properly inside the body as well as outside 	Some parents believed that an infection was likely to happen whilst their child was hospitalised.
Qualitative with observations and interviews		N = 7	Cultural influences that affect the implementation of IPC		'Germ theory' may be connected to the culture of biomedicine, not nursing practice, thus affecting IPC knowledge
United Kingdom					

				Ward HH compliance rates	Individual HH compliance rates	
Olivier, C (2018)	Total N = 493				Mothers 43.0%	
Point prevalence survey	Nurses n = 265	<ul style="list-style-type: none">HAI ratesHH provisionsHH compliance rates		Neonatal wards 51.4%	Nurses 27.8%	
South Africa				Paediatric wards 10.0%	Doctors 27.4%	
Pan, S (2013)			<ul style="list-style-type: none">Modified WHO Patient Safety Hand Hygiene SurveyAttitude of consumers and HCWs toward patient empowerment	95.4% of consumers felt positive about patient empowerment	67.2% of consumers had positive intentions to prompt HCWs about HH	
Cross-sectional survey	N = 345					Female HCWs and parents were less likely to have positive views around patient empowerment.
Taiwan						
				Care of Central Lines		
				<ul style="list-style-type: none">29% of consumers cared for the central lines48% of consumers would change central line dressingsEight patients reported that they "always" or "most of the time" undertake their own line care.		
Rinke, M (2015)			<ul style="list-style-type: none">Beliefs and practices about central line care and CLABSI riskBarriers and education in central line care		13% of respondents believed that an infection was unlikely if line care was not performed perfectly every time	Some respondents desired more education online care, of had received contradictory teaching
Cross-sectional survey	N = 105					
United States						
Siegel, L (1989)						
Cross-sectional survey	N = 316	Parental attitudes on IPC procedures used during examinations of their children		56% of parents felt strongly towards glove and mask use by HCWs during patient care	70% of parents believed that masks and gloves will help inhibit infectious diseases spread.	
United States						
Woolner, A	N = 56	IPC advice given to		Isolation was deemed	82% of consumers	27% of consumers
						Some consumers had stricter attitudes on

(2012)			oncology patients	important by over 40% of consumers	avoided seeing potentially sick visitors	believed that patients should avoid sharing items with other children on the ward	isolation precautions than staff.	
A prospective, observational, and cross-sectional survey								
South Africa and United Kingdom								
Educational Interventions								
	HH Opportunities	Sample Size	Measured Outcomes	Intervention	Baseline HH Compliance	Follow-up HH Compliance	Difference HH Improvement	Comments
Chandonnet, C (2017)	<u>Pre Intervention</u> n = 1143		WHO '5 Moments for Hand Hygiene'	Education materials	<u>Pre intervention</u> 71%	<u>Post intervention</u> 89%	18%	The intervention had empowered parents on ensuring correct HH from HCWs
Pre-postintervention observational study	<u>Post Intervention</u> n = 939							
United States								
Chen, Y (2007)		N = 123	<ul style="list-style-type: none"> Author designed 10-item hand-washing checklist Compliance and accuracy of HH 	Video teaching and illustration poster teaching	Compliance score (Out of Maximum 10) <u>Experimental Group Score</u> 7.0 to 8.6 <u>Comparison Group Score</u> 4.7 to 5.9	Accuracy Score (Out of Maximum 10) <u>Experimental Group Score</u> 3.8 to 5.7 <u>Comparison Group Score</u> 2.7 to 3.7		The video-based teaching increased HH compliance and accuracy more than illustration-based teaching.
Quasi-experimental time series								
Taiwan								
Heiser Rosenberg, C (2017)		N = 17	<ul style="list-style-type: none"> Knowledge of IPC Psychomotor skill competence Capacity to recognise HCW non-adherence to best practices. 	High-fidelity simulation sessions	Pre-Intervention <u>Knowledge Score</u> 10 out of 16 <u>Skill Score</u> 8 out of 12 <u>Recognition Score</u> 3 out of 6	Post Intervention <u>Knowledge Score</u> 15 out of 16 <u>Skill Score</u> 12 out of 12 <u>Recognition Score</u> 6 out of 6		High-fidelity simulation and parental education on home central line care increased in parental knowledge
Feasibility study using a pre test/post test design								
United States								
De Gentile, A (2001)		N = 1,081	Nosocomial Rates	Parental education on IPC and recruitment of parents to relieve nurses can reduce nosocomial infections.	Nosocomial Rates <u>Ward A (Experimental Group)</u> 14/470 (2.98%) <u>Ward B (Control Group)</u> 63/611 (10.3%)			Parents were educated on hygiene, housekeeping, visitation, isolation precautions.
Prospective study								
Argentina								
Engaging parents as nursing assistants helped reduce HAI.								
Wong, M.W.H. (2020)	Pre intervention n=404; post intervention n=361	N= 765	Changes in Hand Hygiene adherence following 2 different interventions	Patient and visitor hand hygiene compliance rates increased by 4.7%, 9.2% at the baseline	The standard intervention wards increased from 7.3% to 10.9%, 2.6% increase (P = .46)		Front Line Ownership (FLO) intervention wards increased significantly from	FLO intervention was codesigned with staff on randomly elected units.
Step wedge cluster randomised controlled								

trial	to 13.9% in the post-intervention period.	14.3% to 25%, 10.7% increase ($P = .03$)
Canada		

Note. CLABSI = Central Line Associated Blood Stream Infection; HAI = Hospital Acquired Infection; HCW = Health Care Worker; HH = Hand Hygiene; IPC = Infection Prevention and Control

Antimicrobial Stewardship

Nurses and Antimicrobial Stewardship

Seven studies were identified that focused on paediatric nurses' role in AMS.^{9, 11, 57-61} Themes explored in these studies were: (1) nurses' understanding and beliefs of AMS Roles, and (2) barriers to nurses taking a greater role in AMS.

Nurses understanding and beliefs about their role in AMS

Nurses' understanding of AMS was explored in four studies.^{9, 11, 57, 59} These studies identified that nurses believed that their core role in relation to antimicrobial use was in medication safety. Mostaghim et al. stated that over half of the nurses were familiar with the term AMS and knew that they were expected to participate in the implementation of AMS initiatives in the clinical practice setting.⁹ Similarly, Monsees et al. highlighted that 69.4% of nurses self-reported that they knew what AMS meant, and 71.7% believed that they should be involved.⁵⁷ Kilpatrick et al. however identified that nurses had low awareness of the term AMS but that they were implementing some AMS components in their practice, such as providing education to families and monitoring patient safety to ensure optimal antibiotic use.¹¹

Nurses' knowledge of barriers in AMS

Toska et al. identified that nurses believed there was more antibiotic administration and prescribing in the paediatric setting, with 51.8% of nurses reporting an increase in parental demand for antibiotics, and 87% of nurses identified irrational prescribing as the main risk factors associated with AMR.⁵⁸ Additionally, Monsees et al. reported some barriers that nurses had identified affecting their implementation into AMS programs, such as failure to be included in medical rounds, and power differences between disciplines with similar barriers reported by Hamdy et al.^{57, 59}

Consumers and Antimicrobial Stewardship

Ten studies were identified that explored the role of consumers in AMS in acute paediatric care settings. Three studies examined the influences on parental decision making and understanding of appropriate antibiotic use⁶²⁻⁷⁰

Two themes were identified: (1) Misconceptions about the benefits, (2) Overestimating the benefits and downplaying concerns regarding antibiotic use.

Misconceptions about the benefits of antibiotics

There were many misconceptions about antibiotics in relation to their ability to cause resistance and harm. Bagshaw et al. reported that 50% of parents believed that antibiotics caused resistance or harmed the child's immunity while 27% had no concerns.⁶³ They also identified that over 50% of parents believed that recovery would be quicker if antibiotics were administered. In the study by Diorio et al., all participants expressed that the fear of death and infection were key drivers for the use of prophylactic antibiotic.⁶⁴ Gaps in parents' knowledge of appropriate indications for antibiotic prescription were identified in four studies. Bagshaw et al also reported that 88% of parents thought that antibiotics should be used for 'strep throat', and 56% for bronchitis.⁶³ Additionally, Farha et al. reported that 68% of parents believed that the main cause of acute upper respiratory tract infections were changes in the weather.⁶⁹ In all, 82.8 % of parents were also aware of bacterial antibiotic resistance. A cross sectional study by Bert et al. reported that around a third of the parents believed that antibiotics were effective against viral infections, and that 14% stop giving their child antibiotics if the child started feeling better.⁷⁰ While 94% of parents were able to recognise penicillin as an antibiotic, some parents identified incorrectly that aspirin and paracetamol were antibiotics. Abu Hammour et al. identified that a parent's age, the number of children, and parental income affects parental knowledge of antibiotic use.⁶²

Overestimating the benefits and downplaying concerns

Despite the majority of parents (65%) sourcing information about antibiotics from their physician misinformation remained a key issue.⁶² Abu Hammour et al. highlighted that 10% of parents believed that antibiotics have no adverse effects, 33.6% believe antibiotics should be given for fever and 48.6% unaware that viruses cause most URTIs.⁶⁵ Furthermore, 18% received their information from relatives or from the television.⁶² Schnellinger et al. conducted the only identified RCT in this review which demonstrated that education can improve parents' and guardians' knowledge about appropriate antibiotic use.⁷¹ The

reported number of parents asking paediatricians for antibiotics decreased greatly when parents had had received education.

Journal Pre-proof

Antimicrobial Stewardship						
Author Design Country Date	Population	Sample Size	Measured Outcomes	Key Findings		Comments
Abu Hammour, K (2018) Cross-sectional prospective survey study Jordan	Parents	N=1301	Parental knowledge and attitudes concerning antibiotic use for their children	Parents' Knowledge Score on antibiotic use in URTI 7.02/14 (SD = 1.52)	Sources of information about antibiotic use: <ul style="list-style-type: none"> • 65.2% physicians • 18.5% TV • 17.6% relatives 	There was a relationship between the number of children, the age and income of parents on their knowledge and attitude towards the use of antibiotics.
Abu Hammour, K. (2019) Cross-sectional prospective survey Dubai	Parents	N = 467	Knowledge, attitudes and practices of parents towards antibiotic use for children with upper respiratory tract infections	Knowledge gaps regarding antibiotics., 10% of parents believed that antibiotics have no adverse effects, 33.6% believe antibiotics should be given for fever and 48.6% unaware that viruses cause most URTIs.	Lack of time or money (83.9%), pharmacist, recommendation (68.3%), and use of a previously prescribed antibiotic for a similar illness (66.2%) were cited as reasons to give antibiotics without prescriptions.	Overall low awareness among parents about reasons for antibiotics use.
Al-Saleh, S. (2020) Cross sectional survey Jordan	Parents	N = 467	Parental knowledge, attitude, and practice on antibiotic use in Dubai and the associated factors	Parents knowledge, attitudes and perceptions an antibiotic use in children with URTIs were affected by age, education, number of children and income.	Parents sourced antibiotics information from Physicians (84.8%), family (12.6%) and friends (9.9%).	This study is a different analysis of the sample reported in Abu Hammour (2020)
Bagshaw, S (2001) Cross-sectional survey study Canada	Adult caregivers of children	N=114	Parental beliefs and behaviours about antibiotic use for their children in an ambulatory setting	Parents Attitudes on Antibiotics <ul style="list-style-type: none"> • 58% believed taking antibiotics will cause resistance • 45% may harm child immunity • 27% had no concerns 	Parental indications for antibiotics <ul style="list-style-type: none"> • Ear infection 98% • Sinusitis 23% • Bronchitis 56% • Strep throat 88% 	Parents largely had good knowledge and understanding of the indications for antibiotic use and their adverse effects.
Bert, F (2017) Multicentre cross-sectional survey study Italy	Parents of children aged 0–14	N=1247	Parental knowledge of antibiotic use and their attitudes towards antibiotic administration to children	<ul style="list-style-type: none"> • 33% of the parents believed that antibiotics are useful for viral infections. • 20.6% thought they were useful for all types of pain and inflammation 	14% would stop giving their child antibiotics if they start feeling better.	Parents showed a lack of understanding and knowledge regarding the safe use of antibiotics.

Diorio, C (2012)	Parents, children and healthcare professionals	Parents n = 35 Children n = 22	Attitudes of parents, children and healthcare professionals on the use of antibiotic prophylaxis in a paediatric oncology setting	All groups discussed that the chance of death influenced their decision on using prophylactic antibiotics.	Attitudes towards prophylactic antibiotics <ul style="list-style-type: none"> antimicrobial resistance side effects of medication financial impact
Qualitative study with interviews					
Canada					
Farha, R. A (2016)	Parents	N=1329	Parental knowledge, attitudes and practices concerning antibiotics use for URTIs	68% of parents believed that changes in the weather were the main cause of acute URTIs in their children.	<ul style="list-style-type: none"> 82.8 % of parents were aware of bacterial antibiotic resistance 64.6 % reported that they would give antibiotics without prescription.
A cross-sectional survey study					
Jordan					
Hamdy, R.F. (2019)	Paediatric nurses	N = 90	Nurses perceptions of their role in antimicrobial stewardship.	Specific nursing roles in antibiotic stewardship identified: - advocating for the patient - communicating with the team - Safe administration of medications - Caregivers education - Self education	Barriers to role in AMS were also identified: - lack of inclusion in medical rounds - lack of protocols surrounding the use of antibiotics
Qualitative study with interviews					
USA					
Haskell, L. (2020)	Registered nurses in paediatric settings	N = 20 Nurses n = 8	Exploration of current practices and factors that could influence current evidence based practice of bronchiolitis.	Nurses reported pressure from parents who wanted an antibiotic prescription, or an antibiotic course continued. Nurses perceived that a knowledge deficit and lack of experience of medical treating team lead to antibiotics being prescribed rather than for a clinical indication.	Nurses found that there often was low competence and confidence in caring for infants with bronchiolitis.
Qualitative exploratory descriptive					
Australia and New Zealand					
Hernández-Díaz, I. (2019)	Parents and legal guardians who visited an emergency department	N = 101	Knowledge and beliefs, behaviours and adherence of antibiotics when used for URTIs	Mean Knowledge score 2.99/5, (SD 0.82) Mean Adherence score 2.12/5, SD 0.90 Mean Behaviour score 1.47/5, SD 0.56	The chronbach's alpha for the behaviour subscale was only 0.569, showing that the subscale lacked internal reliability
Cross sectional survey study					
USA					

Kilpatrick, M (2019)	Registered Paediatric Nurses, and Nurse Practitioners	N=16	Dermatology nurses' perceptions of their role in antimicrobial stewardship when caring for children with AD	Nurses were implementing AMS principles in their practice, however there was low awareness of term AMS.	Some nurses questioned prescribers on antibiotics use, and used pathology results to review current treatments.		
Qualitative Explorative descriptive study							
Australia.							
Monsees, E. (2018)	Direct care (Bedside) Paediatric Registered Nurses	N=180	10 identified practices that are a part of an inpatient nurses' responsibility, and also contributes to antimicrobial stewardship	Nurses' confident AMS skills <ul style="list-style-type: none">Adverse drug reaction history takingobtaining cultures prior to antibioticsparticipating in patient education. Nurses' less confident AMS skills <ul style="list-style-type: none">reviewing microbiology results to determine antibiotic appropriateness.	Barriers to Nurse AMS stewarding <ul style="list-style-type: none">Nurses not included in roundsinterdisciplinary power differentialsnursing input not actively sought		
Single-centred, cross-sectional survey study							
United States							
Mostaghim, M (2017)	Registered Paediatric and Adult Nurses	N=180	Nurses' attitudes towards AMS programs and their perceptions of the nurse's role.	<ul style="list-style-type: none">65% of nurses were familiar with the term AMS75% recognised that they were expected to have a role.	Identified Nurses AMS Roles <ul style="list-style-type: none">Hand hygiene and infection control (86%)Patient advocacy (85%)Knowledge of antimicrobials (84%)		
Multicentre cross-sectional survey study							
Australia							
Schnellinger, M (2010)	Parents and guardians of children	N=246	Compare their knowledge of parents on the appropriate use of antibiotics based on two different educational interventions	Time Period 1 Median Knowledge Score <u>Control</u> 8/10 <u>Pamphlet</u> 8/10 <u>Video</u> 9/10	Time Period 2 Median Knowledge Score <u>Control</u> 8/10 <u>Pamphlet</u> 10/10 <u>Video</u> 10/10	Time Period 3 Median Knowledge Score <u>Control</u> 8/10 <u>Pamphlet</u> 9/10 <u>Video</u> 10/10	The video-group scores exceeded the control-group scores at all 3 time periods.
Prospective randomised, controlled trial							
United States							
Schmidt, P. (2020)	Nurses working on paediatric palliative unit	N = 14	Explore nurse's opinions and attitudes of hygiene concept for patients colonised with antimicrobial resistant microorganisms.	Nurses demonstrated ambivalence relating to safety, effort, quality of care, and participation although they encouraged patients and families to stay in their rooms to reduce the risk of pathogen transmission.	Nurses felt that investing time to participate in activities with patient with antimicrobial resistant microorganisms, might negatively affect the care of other patients due to a perceived lack of time and resources.	The introduction of a complex hygiene program was reported to be a challenge by participants.	
Qualitative Exploratory Descriptive							
Germany							

Toska, A (2015)	Paediatric Nurses	N=301	Paediatric nurses' perceptions and knowledge of antimicrobial resistance and irrational antibiotic prescribing	87% of participants reported irrational prescribing to be an important cause of antimicrobial resistance	51.8% of respondents believed there was an increase in parental demand for antibiotics.
Cross-sectional survey study					
Greece					
Warembourg, M. (2020)	Patients	N = 75	Determine adherence to antimicrobials post discharge and identify non adherence behaviour risk factors	65.1 % of patients were determined non adherent – Majority of parents unaware of side effects and discontinued treatment early if child symptom free 26.4% of the children required further medical consultation or ED visit.	27% of parents believed antibiotics were ineffective against flu virus. 39.5% of parents unintentionally modified doses and 13.2% intentionally modified medication dose.
Prospective observational study with surveys and interviews					
France					
Note. URTI = Upper Respiratory Tract Infections; AD =Atopic Dermatitis					

Discussion

The systematic review demonstrated that there are consistent gaps in both nurses' and consumers' knowledge and implementation of IPC in acute paediatric settings that could lead to significant problems in practice. Although education and quality improvement activities improved practice and consumers articulated a willingness to be actively involved in infection prevention, observed practice remained suboptimal. In relation to optimal use of antimicrobials, although paediatric nurses were involved in supporting AMS processes and educating parents and children, nurses identified that they had limited knowledge of AMS principles. Consistent with previous research, parents and children had misconceptions about the benefits of antibiotics and downplayed their concerns regarding antibiotic use. The findings of this systematic review highlight gaps in nurses' knowledge of infection transmission, inconsistent adherence to hand hygiene, variation in practice across clinical settings, a lack of clarity about their role in AMS and limited engagement of parents and children in IPC and AMS activities.

Infection prevention and control in acute paediatric settings

Frontline nurses provide care for vulnerable patient populations at high risk of developing HAI and have increased personal exposure to transmittable infections. It is therefore crucial that nurses have the highest levels of IPC knowledge and adherence to best practice guidelines.⁷² The identified literature, however, does not reflect this view.^{11, 25-27, 31} Studies evaluating quality improvement and educational interventions for nurses demonstrated modest improvements in nurses' knowledge and adherence demonstrating that when organisational leaders promote hand hygiene and IPC, that greater adherence to best practice guidelines is achievable. Evidence identified from the studies showed that educational interventions were effective in improving adherence and knowledge in the short-term however to ensure consistent practice change, a system change may be required with ongoing audit feedback. Across the reported studies the magnitude of improvements in nurses' knowledge scores was higher than the demonstrated improvement in adherence, highlighting a theory to practice gap. The identified gaps in nurses' knowledge and adherence accentuates the practice gaps that need to be addressed to systematically prevent transmission of infection in the context of a pandemic.

Nurses' knowledge of IPC and educational interventions aimed to improve compliance was identified in six studies.³⁵⁻⁴⁰ There was a noted lack of knowledge of infection transmission routes, sources and prevention of HAI, and general IPC knowledge. Paediatric nurses were shown to have a lower level of understanding of strategies to decrease MRSA infection and transmission than adult nurses.²⁷ This finding is concordant with a recent study that found nurses lacked IPC knowledge in relation to MRSA; Daniel et al. identified that nurses had poor knowledge of predisposing factors of MRSA and transmission prevention in acute care.⁷³ This poor knowledge of predisposing factors and of transmission prevention could be an indication that over the past decade the focus on MRSA related IPC has diminished, or that paediatric nurses are less likely to be exposed to patients colonised with MRSA or other multi-drug resistant microorganisms in their clinical practice.²⁷ Gaps were also identified in the translation of knowledge into practice at the bedside. In the context of the SARS epidemic in Canada, health care workers understood the vital importance of IPC measures to protect their paediatric patients, however, many failed to comply with these measures.³⁰

Hand Hygiene compliance improved following educational and awareness raising interventions although no study reported a hundred per cent adherence to guidelines.^{35, 38, 39} Discordance between nurses hand hygiene practices and guideline recommendations for the type and duration of hand hygiene were also documented with nurses noted to over wash their hands (observed duration longer than recommended).²⁹ Over washing, or washing for longer than necessary can result in dermatitis,⁷⁴ which in turn increases the risk of nosocomial infection spread, and bacterial colonisation of nurses' hands.⁷⁵

There were higher rates of hand hygiene compliance in high acuity areas, specifically neonatal ICUs compared to general acute paediatric ICU settings.^{24, 42} This increased compliance could reflect a perception that infants are 'clean' and therefore HCWs have a stronger mandate to protect infants from HAIs. Bouchoucha et al. described similar findings that could reflect a biased risk perception.⁷⁶ According to Weinstein, such perception could reflect a potentially unrealistic optimism with nurses ignoring their own susceptibility to infection and underestimating the role of HCWs in facilitating cross infection and pathogen transmission between patients.⁷⁷ Observations of health care workers by Macqueen identified that handwashing after contact with patient 'dirtiness' varied depending on the type of bodily fluid, whether it came from the "top" or "bottom" half of the body, or the age

of the child.²⁵ Similarly, Bouchoucha et al. reported that nurses would regularly deviate from standard precautions based on their own assessments of the circumstances or the patient.⁷⁶ Jackson et al. and Kilpatrick et al. both found that standard precaution guidelines and PPE were used by nurses as a means of self-protection if the nurse judged the patient as “dirty”.^{32, 78} Macqueen showed that elements of disgust (described as degree of perceived ‘dirtiness’, such as considering some types of body fluids dirtier than others) can occur in the paediatric population, despite studies showing that children are considered to be cleaner than adults.²⁵ Again, this is similar to the study from Bouchoucha et al. who reported that children were seen as clean; however, older adults were seen as dirty by nurses.⁷⁶

There was wide variation observed between nurses’ practice and their knowledge of managing intravenous catheters and IPC.⁷⁹ Concordant with the identified studies, nurses’ knowledge of Central Venous line Care (CVC) was suboptimal but improved with educational interventions.³⁷ Ullman et al. discovered that the lack of implementing evidence-based guidelines for central lines was due to a lack of resources, considered to be ‘too hard’ or due to a lack of within hospital communication.³¹ Al Qadire determined that oncology nurses had a low knowledge of the CLABSI guidelines, which reflects a lack of formal training on CVC management.⁸⁰

Nurses perceived that isolation rooms and meticulous hand hygiene were effective ways to decrease cross-infection. Parker et al. reported that using isolation rooms, wearing a mask, and handwashing was considered most effective to prevent the spread of an outbreak infection.³⁰ However, Woolner et al. showed that nurses believed inpatient isolation was not necessary to prevent cross infection in oncology patients, highlighting that some nurses have inadequate knowledge of common transmission mechanisms and on the importance of environmental cleaning and air quality to prevent infection spread.⁵⁰ This finding is similar to studies in adult acute care where nurses were also noted to have inadequate knowledge on transmission precautions and inappropriate attitudes and practices on IPC practices.^{81, 82}

Although a range of gaps in nurses’ knowledge and implementation of IPC best practice was found, nurses identified that one of their key roles was in providing consumer education.³² The importance of consumer education is also emphasised by the Australian Commission on Safety and Quality in Health Care;⁸³ that recognises that it is part of the

nurse's role to educate consumers about IPC, including the importance of hand hygiene. However, there is a lack of research indicating that nurses are aware of their role as educators of IPC, outside of paediatric and infectious disease roles.⁸³ The findings of this review highlight the need to increase nurses' IPC knowledge and skills, so they have the foundational skills needed to provide effective, evidence-based consumer education.

The role of consumers in IPC

This systematic review is the first to explore the role of children in infection prevention in hospital studies. There were only five studies that investigated children's experience and attitudes to IPC.^{45, 46, 48, 50, 51} However, the majority of these studies had the parents as the main participant. Children with haematological and oncological conditions lacked knowledge about IPC precautions and they reported being more likely to adhere to food restrictions, than face masks and contact precautions.⁴⁶ There are multiple psychosocial factors that influence children's or adolescents' adherence with care such as: emotional well-being and peer and health care provider supports.⁸⁴ Consumers in CF clinics had positive attitudes towards IPC specifically the need for patient segregation, with the only concern expressed being feelings of alienation and concerns about social isolation.⁴⁵ During the SARS outbreak, children in a tertiary hospital reported finding the IPC measures were isolating for them but they recognised their importance to limit the spread of the outbreak.⁵¹

The importance of parents in promoting IPC best practice in acute paediatric setting was described in three studies.^{44, 47, 55} Parents have a high level of awareness regarding the risk of nosocomial infections during their child's admission,^{85, 86} but may not perceive that they have an active role in infection prevention. Observations of parental involvement in IPC have demonstrated that parents have greater hand hygiene compliance than healthcare workers.²⁴ This is in line with parents of oncology patients having stricter views relating to IPC precautions than nurses, such as staying in an isolation room, or avoiding busy, crowded areas.⁵⁰ Parents were able to provide care in high infection risk tasks, however, they felt that further education should be provided, due to an increased difficulty in complying with procedures at home.⁴⁸ The use of videos and visual simulations have been shown to increase parental knowledge and skills in hand hygiene adherence,⁵³ and home management of CVC lines.⁴⁸

Previous studies have documented that when parents are recruited to provide assistance with low risk routine procedures within the ward environment, there is a decrease in nosocomial infections.⁵⁵ This provides an indication that parents and children being partners in care, can improve IPC and hand hygiene adherence.⁴⁴ Despite the advantages of greater consumer involvement, Pan et al. also reported that HCWs had negative thoughts concerning patient empowerment in regards to hand hygiene and another study found that HCWs did not perceive this as part of the patients' role.^{47, 87} A systematic review found heterogeneity in the proportion of children who actively promoted hand hygiene ranging between 5% and 80%, and that patients were more likely to speak up if they had clear indications of approval from healthcare workers.⁸⁸

Nurses' engagement with Antimicrobial Stewardship

Three studies identified that many nurses were unaware of the term AMS, however, they knew that they had a role in ensuring appropriate and safe antibiotic therapy for patients.^{9, 11, 57} Merrill et al. reported similar results in adult settings, where half of the nurses were not aware of AMS, however, almost all participants believed that nurses should be involved in AMS interventions.⁸⁹ A lack of education was further highlighted in Kilpatrick et al. which identified a practice to theory gap whereby nurses were implementing AMS principles in their practice but were unaware of the terminology.¹¹ This gap was also recognised by Dyar et al. who reported that nurses were undertaking many routine activities that were central to AMS such as, administering antibiotics, taking of cultures, and educating consumers.⁷ Monsees et al. and Toska et al. identified organisational and cultural barriers to greater nursing involvement such as: not being included in medical rounds, power differences between disciplines, parental demands and irrational prescribing.^{57, 58} In a review of the adult nursing population, they identified that the main reason for nurse's lack of participation in AMS programs were: time constraints, physician pushback, and a lack of knowledge of microbiology and antibiotics.⁹⁰ Due to their important role at the bedside, empowering nurses could result in increased awareness and adherence to AMS interventions.^{10, 14}

Consumers attitudes and beliefs about Antimicrobial Stewardship

The current review gives a unique perspective as it includes consumers and has a focus on acute paediatric settings. Parents and children had limited knowledge of antimicrobials, and thus were making poor decisions on antibiotic use, including administration and adherence to prescriptions. This is similar to findings of a systematic review by Gualano et al. who reported that around half of the study population was unaware that antibiotics do not treat viral infections, and did not know that antibiotic misuse could lead to AMR.⁹¹ This lack of knowledge may be a result of how consumers obtain their information primarily from relatives or the television⁶². This was also supported by Zucco et al. who reported that nearly three quarters of parents were using the internet to find information rather than accessing information and guidance from healthcare professionals.⁹² Furthermore, a lack of consumer information about appropriate antibiotics use was also a major reason for calls to an on-line medication help-line in Australia,⁹³ indicating that providing consumers with information about appropriate antimicrobial use is a substantial gap in current services. Consumers indicated that antimicrobials may result in harm to the patient, this concern of harm or 'fear of death' influenced parents' decision concerning the use of prophylactic antibiotics for their children. However, multiple consumers reported that they would rather administer antimicrobials, than risk death of the patient.

Conclusion

Consistent gaps were identified in nurses' and consumers' knowledge of and adherence to IPC. Inconsistent implementation of hand hygiene, transmission-based precautions and use of PPE highlights that both clinicians and consumers played down the potential risks of infection transmission. This finding highlights the substantial practice gap that needs to be addressed in the context of a pandemic to prevent both HCW and patient exposure and infection.

There is a lack of published research on consumer attitudes surrounding prophylactic antibiotics, and the risk of AMR. Further research needs to be undertaken to develop a greater understanding of the concerns of parents and children. There was also a distinct lack of consideration of the developmental aspects of children and their knowledge of and understanding of IPC and this should be included in future work.

Although the current evidence suggests that education provided to consumers and HCWs improves hand hygiene and IPC precautions adherence, there is a lack of studies evaluating their knowledge of appropriate antibiotic use in acute care settings. Greater education interventions are needed to strengthen the involvement of consumers in AMS and IPC roles; and to promote correct and improve adherence to IPC precautions in HCWS. Integrating AMS education on the nurses' role within AMS programs also needs to be investigated.

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Conflict of interests

Conflicts of interest: none

Quality Score Tables

Table 7				
Quantitative Studies Quality Assessment				
Author	Date	QUALITY SCORE		
		Weak	Moderate	High
Abu Hammour, K	2018	X		
Abu Hammour, K	2019	X		
Al-Saleh, S.	2019	X		
Bagshaw, S	2001	X		
Belela-Anacleto, Aline S.C	2019	X		
Bert, F.	2017		X	
Buser, G.	2013	X		
Chandonnet, C.	2017	X		
Chen, Y	2007		X	
De Gentile, A.	2001	X		
Di Martino, P	2011	X		
Donnellan, R. A	2011	X		
Farha, R. A	2016	X		
Galal, Y.	2014	X		
Galway, R	2003	X		
Gras-Valenti, P	2020		X	
Griffiths, A	2004	X		
Hatler, C	2009	X		
Heiser Rosenberg, C	2017	X		
Hernandez-Diaz	2019		X	
Lehrnbecher, T	2008	X		
McCaskey, M.	2013	X		
Monsees, E.	2018	X		
Morritt, M-J	2006	X		
Mostaghim, M.	2017	X		
Olivier, C	2018	X		
Pan, S-C	2013		X	
Parker, M J	2006		X	
Rinke, M	2015		X	
Scheithauer, S.	2011		X	
Schnellinger, M	2010	X		

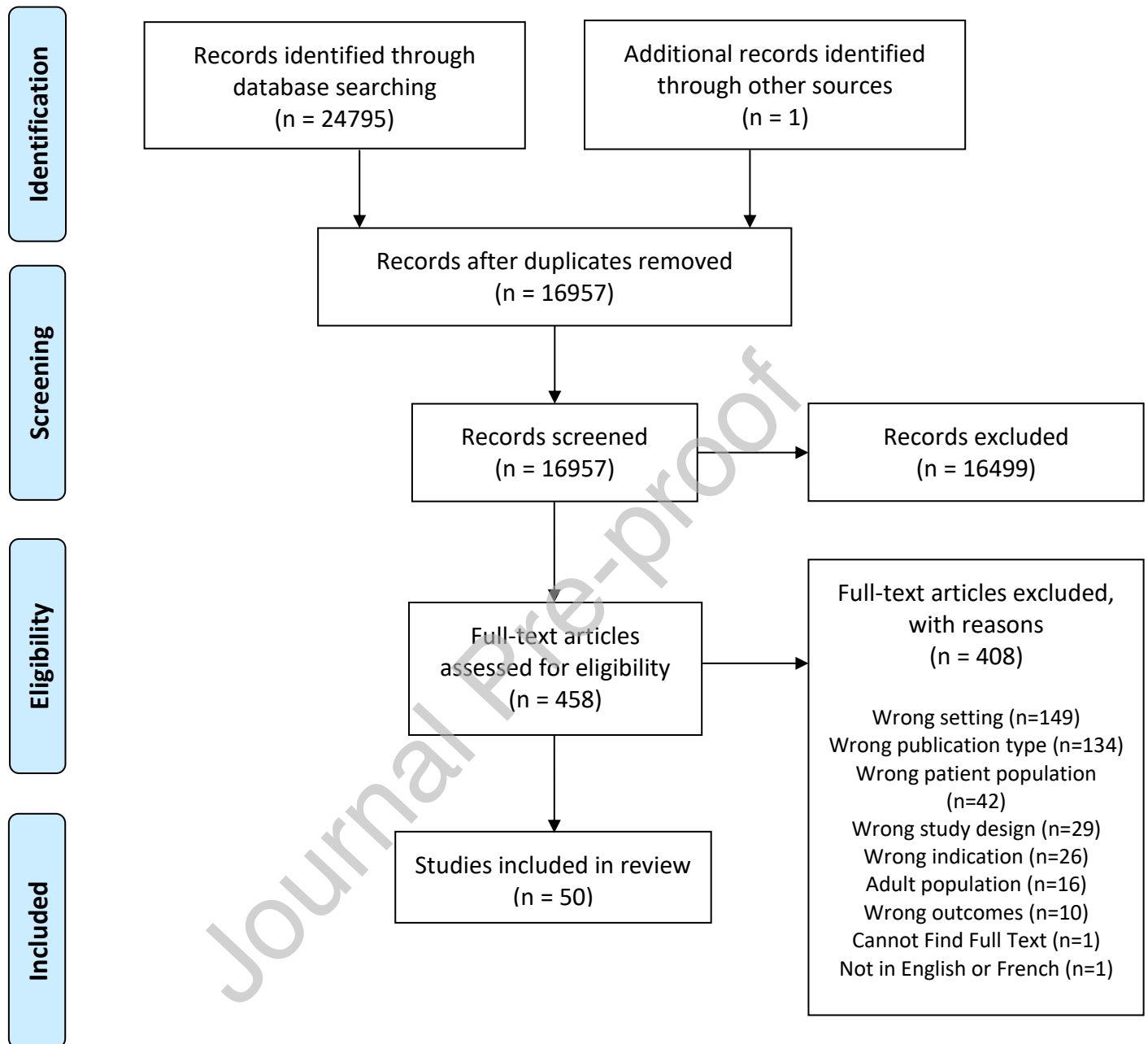
Siegel, L.	1989	X		
Song, X	2013		X	
Toska, A	2015		X	
Ullman, A.	2014	X		
Woolner, A	2012	X		

Table 8

QUALITATIVE Studies Quality Assessment

Who is the 1st author? (Last Name and Initial)	What year was the study published?	Was there a clear statement of the aims of the research?	Is a qualitative methodology appropriate?	Was the research design appropriate to address the aims of the research?	Was the recruitment strategy appropriate to the aims of the research?	Was the data collected in a way that addressed the research issue?	Has the relationship between researcher and participants been adequately considered?	Have ethical issues been taken into consideration?	Was the data analysis sufficiently rigorous?	Is there a clear statement of findings?	How valuable is the research?
Diorio, C.	2012	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Medium value
Hamdy,	2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High value
Haskell,	2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Medium value
Isaac, R	2019	Yes	Yes	Yes	Yes	Yes	Cannot tell	Yes	yes	Yes	Medium value
Kilpatrick, M.	2018	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Medium value
Kilpatrick, M.	2019	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Medium value
Koller, D.	2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High value
Macqueen, S.	1995	Yes	Yes	Yes	Can't Tell	Yes	No	Yes	Cannot Tell	No	Low value
Ray-Barruel, G	2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High value
Schmidt,	2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	High value
Warrembourg,	2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Medium value

Figure 1 - PRISMA Flow Diagram



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