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Narrative review

Implementation of infection prevention and control for hospitalized neonates: A narrative review

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ABSTRACT

Background: The most prevalent infections encountered in neonatal care are healthcare-associated infections. The majority of healthcare-associated infections are considered preventable with evidence-based infection prevention and control (IPC) practices. However, substantial knowledge gaps exist in IPC implementation in neonatal care. Furthermore, the knowledge of factors which facilitate or challenge the uptake and sustainment of IPC programmes in neonatal units is limited. The integration of implementation science approaches in IPC programmes in neonatal care aims to address these problems.
Objectives: The aim of this narrative review was to identify determinants which have been reported to influence the implementation of IPC programmes and best practices in inpatient neonatal care settings.
Sources: A literature search was conducted in PubMed, MEDLINE (Medical Literature Analysis and Retrieval System Online) and CINAHL (Cumulative Index to Nursing and Allied Health Literature) in May 2022. Primary study reports published in English, French, German, Spanish, Portuguese, Italian, Danish, Swedish or Norwegian since 2000 were eligible for inclusion. Included studies focused on IPC practices in inpatient neonatal care settings and reported determinants which influenced implementation processes.
Content: The Consolidated Framework for Implementation Research was used to identify and cluster reported determinants to the implementation of IPC practices and programmes in neonatal care. Most studies reported challenges and facilitators at the organizational level as particularly relevant to implementation processes. The commonly reported determinants included staffing levels, work- and caseloads, as well as aspects of organizational culture such as communication and leadership.
Implications: The presented knowledge about factors influencing neonatal IPC can support the design, implementation, and evaluation of IPC practices. **Emanuela Nyantakyi, Clin Microbiol Infect 2022;▪:1**

Background

Globally, approximately 2.8 million neonates per year contract bacterial infections [1], with an estimated 600 000–680 000 associated deaths [1,2]. Healthcare-associated infections (HAIs) are amongst the most common infection type encountered in hospitalized neonates [3,4]. They are associated with excess mortality and morbidity [5–7] as well as substantial healthcare and societal costs, mainly due to increased length of hospital stay [5,8]. Very-low-birth-weight and preterm infants are at a particularly high risk of developing HAIs [9]. The reasons include a general susceptibility of neonates because of an underdeveloped immune system and skin barrier [7] as well as environmental factors, such as a frequent use of invasive medical devices [9,10]. The occurrence of HAIs in

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hospitalized neonates is a complex issue because the transmission of microorganisms can occur amongst patients through healthcare workers (HCWs) and caregivers (e.g. parents and family members) or contamination of the hospital environment and equipment (Fig. 1). Furthermore, certain neonatal-specific practices, such as administration of breast milk or delivery of care through incubators, and the central role of caregivers pose unique demands on infection prevention and control (IPC). Notably, however, not only infection but also colonization of neonates with antibiotic-resistant pathogens presents a major challenge in clinical practice [11–13].

A significant proportion of HAIs is considered preventable through the application of evidence-based IPC practices. However, a profound understanding of how to maximize the effectiveness of IPC programmes in neonatal settings is lacking [14,15]. Factors which influence the implementation of neonatal IPC practices remain unclear and underreported [14,16]. Moreover, the implementation of interventions to prevent neonatal infections in care bundles or multimodal strategies limits the ability to measure or ascribe their effects to single actions [17]. Most importantly, research on factors influencing the implementation of neonatal IPC practices at macro (e.g. policies), meso (e.g. hospitals) and micro (e.g. HCW) levels remains limited [18,19]. To our knowledge, no literature review has been conducted on this topic. Therefore, this narrative review aims to provide an insight into factors influencing the implementation of IPC practices in neonatal settings.

The field of implementation science, which promotes 'the systematic uptake of research findings and other evidence-based practices into routine practice' [22], is well suited to address the aforementioned divergence in research and IPC practice in neonatal care. Implementation frameworks are commonly used to categorize factors relevant to implementation and to structure implementation processes. The Consolidated Framework for Implementation Research (CFIR) is a determinant framework which describes factors related to the implementation of evidence-based practices or programmes [21]. It defines five inter-related domains of implementation determinants: intervention characteristics (e.g. evidence strength and quality), inner (e.g. organizational culture at hospital and unit levels) and outer (e.g. national IPC policies) settings, characteristics of individuals involved in implementation (e.g. knowledge about the intervention) and implementation process (e.g. caregiver involvement) [23]. In this narrative review, the CFIR [23] was used to identify and cluster determinants relevant to the implementation of neonatal IPC practices. Implementation determinants describe factors believed or empirically shown to positively (i.e. facilitators) or negatively (i.e. barriers) influence implementation [20,21].

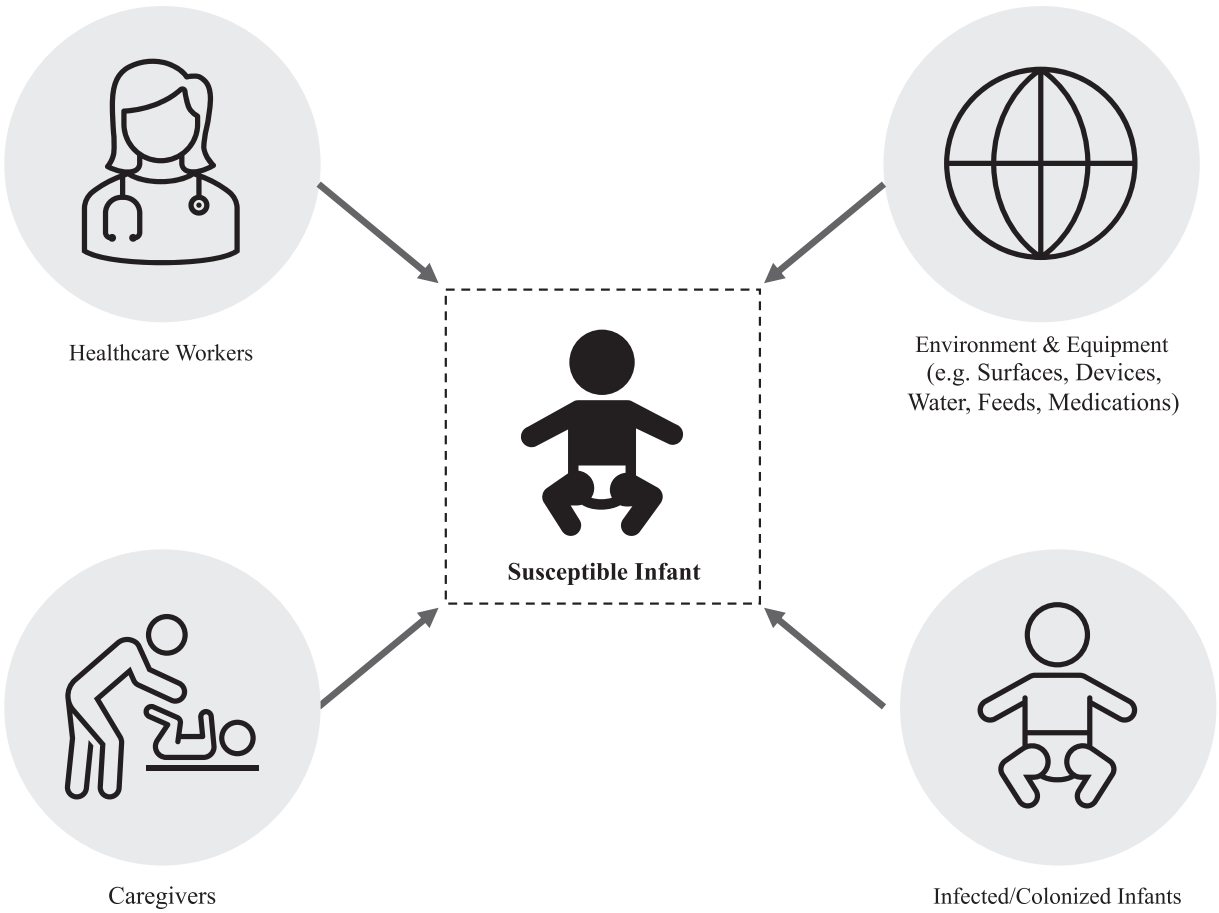

Fig. 1. Basic transmission dynamics of healthcare-associated infections (HAIs) in neonatal care settings. The transmission can occur among patients, through healthcare workers and caregivers or environmental contamination. Though arrows show a unilateral direction, real-world transmission dynamics are more complex.

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Methods

Search strategy and selection

We performed literature searches in the electronic databases PubMed, MEDLINE (Medical Literature Analysis and Retrieval System Online) and CINAHL (Cumulative Index to Nursing and Allied Health Literature) in May 2022. Primary study reports published in English, French, German, Spanish, Portuguese, Italian, Danish, Swedish, or Norwegian since the year 2000 were eligible for inclusion. The search strategy is documented in the supplementary material (Appendix A). Abstracts were screened by a single reviewer (EN, LC, MC, CS, AC, BA, JW, MTS), and thereafter, full texts were independently screened by two reviewers. Included studies had to be set in inpatient neonatal care contexts, focus on IPC practices and report related implementation determinants. The first author performed data extraction for the included studies.

Data analysis

A deductive qualitative analysis was performed. Barriers and facilitators were extracted verbatim and thematically clustered. The clustered items and defined themes were subsequently reviewed by two authors (EN and MTS), and disagreements were discussed until consensus was reached. The identified themes were mapped according to the CFIR domains [23]. During coding, it became apparent that the CFIR domains were not sufficient to capture all patient-related information; thus, similar to the approach by Safaeinili et al. [24], another domain, 'characteristics of patients', was added.

Results

Study characteristics

Upon removal of duplicates, 812 abstracts were screened. Of 153 full-text articles which were subsequently screened, 25 were included in the narrative review (Fig. 2, Table 1).

The included studies were conducted in Asia ($n = 7$) [25–31], North America ($n = 6$) [32–37], Europe ($n = 6$) [38–43], Africa ($n = 5$) [44–48] and South America ($n = 1$) [49]. The common IPC practices examined in the included studies were related to outbreak containment ($n = 6$) [26,27,35,38,40,41], prevention of device-associated infections ($n = 5$) [32–34,36,44] and hand hygiene ($n = 4$) [28–30,42]. All included studies, except four [29,39,46,49], focused exclusively on the neonatal intensive care unit (NICU) setting (Table 1).

Implementation determinants of IPC practices in neonatal care

All identified implementation determinants are depicted in Fig. 3. At the macro level, conceptualized as 'outer setting' in the CFIR, socio-cultural beliefs were reported to shape the

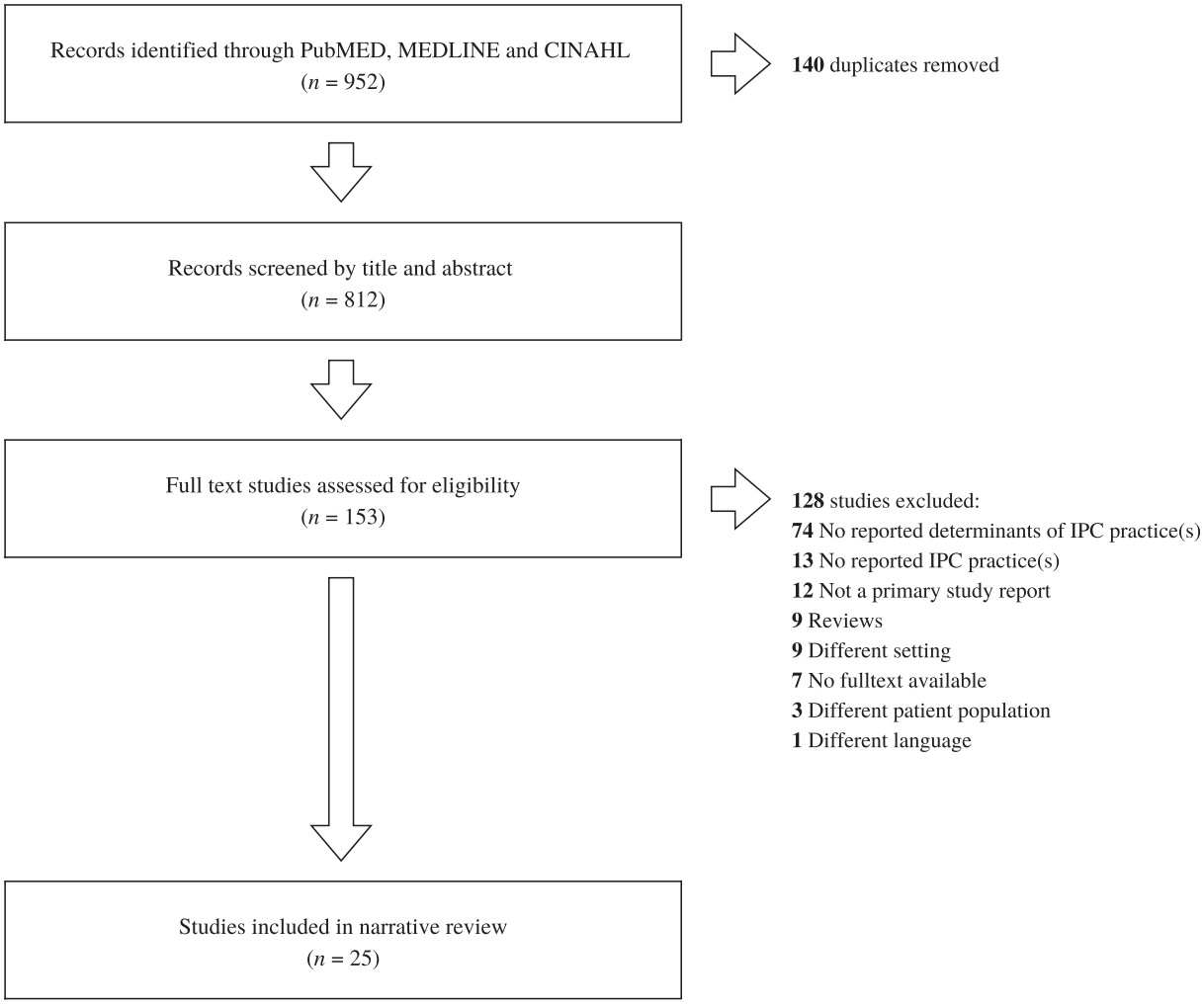

Fig. 2. PRISMA Flow diagram of narrative review.

Table 1
Included studies

Author, year	Country	Care level	IPC practice or intervention
Intervention studies			
Bharadwaj et al. [25], 2019	Singapore	NICU	MRSA prevention bundle
Buffet-Bataillon et al. [38], 2009	France	NICU	Outbreak containment (*Serratia marcescens*)
Caspari et al. [32], 2017	USA	NICU	Device-associated infection prevention
Ceballos et al. [33], 2013	USA	NICU	Device-associated infection prevention bundle
Chan et al. [26], 2007	Taiwan	NICU	Outbreak containment (*Acinetobacter baumanii*)
Gramatniece et al. [40], 2019	Latvia	NICU	Outbreak containment (*Staphylococcus aureus*)
Hosoglu et al. [27], 2012	Turkey	NICU	Outbreak containment (*A. baumanii*)
Iacobelli et al. [41], 2013	France	NICU	Outbreak containment (MRSA)
Joy-Joseph et al. [34], 2010	USA	NICU	Device-associated infection prevention
Khoury et al. [35], 2005	USA	NICU	Outbreak containment (MRSA)
Lam et al. [28], 2004	Hong Kong	NICU	Hand hygiene
Lauderbaugh et al. [36], 2019	USA	NICU	Device-associated infection prevention bundle
López et al. [49], 2013	Nicaragua	NNU	National policy
Phang et al. [29], 2012	Singapore	N/A	Hand hygiene
Picheansathian et al. [30], 2008	Thailand	NICU	Hand hygiene
Rogers et al. [42], 2010	Ireland	NICU	Hand hygiene
Sakamoto et al. [31], 2010	Japan	NICU	MRSA prevention bundle
Non-intervention studies			
Cowden et al. [44], 2020	Zambia	NICU	Device-associated infection prevention bundle
Dawczynski et al. [39], 2017	Germany	NNU	National policy
Gon et al. [45], 2017	Tanzania	NICU	Hygiene
Herbeć et al. [46], 2020	Zimbabwe	NNU	Neonatal IPC
Salem and Youssef [47], 2017	Egypt	NICU	Neonatal IPC
Sunkwa-Mills et al. [48], 2020	Ghana	NICU	HAI prevention
Triantafillou et al. [43], 2020	Greece	NICU	HAI prevention
Trudel et al. [37], 2018	Canada	NICU	Neonatal IPC

HAI, healthcare-associated infection; IPC, infection prevention and control; MRSA, multi-resistant *Staphylococcus aureus*; N/A, not applicable; NICU, neonatal intensive care unit; NNU, neonatal unit; USA, United States of America.

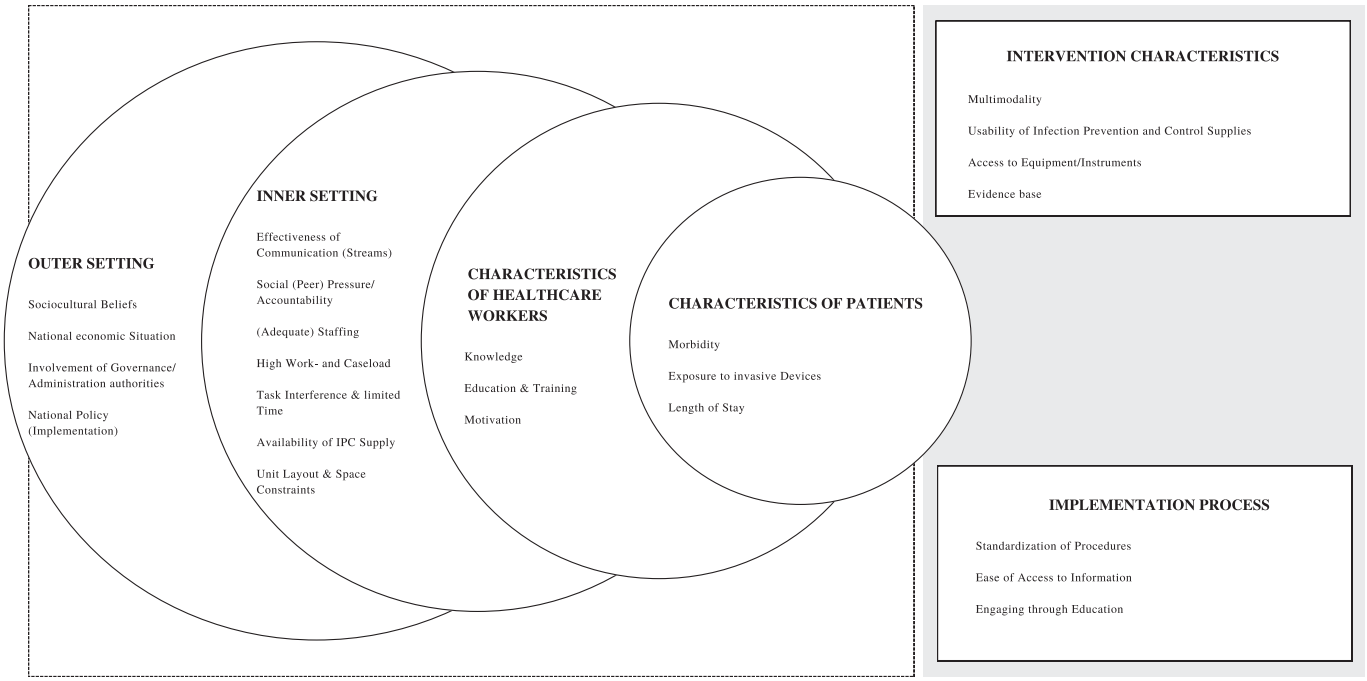

Fig. 3. Reported implementation determinants to neonatal infection prevention and control practices. Results clustered based on the Consolidated Framework for Implementation Research (CFIR). All reported determinants for the domains outer setting, characteristics of patients and intervention characteristics are illustrated. Due to the high number of reported determinants for the domains inner setting, characteristics of healthcare workers and implementation process, only the most frequently mentioned are represented ($n \geq 5$).

implementation of IPC practices in neonatal care [43,44,48,49]. These included work mentality [43] and culturally informed beliefs held by HCWs and caregivers towards neonates [44,48] to a collective understanding of the dynamics of infection transmission. For example, a study reported a widely held belief amongst HCWs of contact infections being transmissible through air [49]. The involvement of governmental authorities and the level of implementation of national IPC policies were also reported to be relevant to the implementation of IPC practices at the organizational level [27,43,48,49]. In one study conducted in Greece, the national

economic situation was explicitly reported to limit organizational resources and practices relevant to IPC, such as staff hiring levels or the provision of IPC consumables [43].

The reviewed studies suggested that effective implementation of IPC practices in neonatal care was highly dependent on determinants at the organizational level, i.e. the 'inner setting' of the CFIR. Ten studies highlighted the importance of human resources, e.g. staff shortage was commonly reported as a barrier to the implementation of best IPC practices [25,27,31,39,43–48]. Furthermore, multiple studies reported shortages in material resources necessary for effective IPC, such as personal protective equipment [27,29,36,43–46,48]. The reported staff limitations were often exacerbated by high work- and caseloads at the unit level [30,36,43–47], resulting in time constraints and interfering tasks [30,37,44,48]. For example, HCWs reported that the need for emergency procedures [30,44] or non-nursing tasks [37,48] compromised IPC practices in some instances. Moreover, aspects of organizational culture were mentioned multiple times as relevant to the implementation of IPC practices. The presence of effective communication structures, such as a forum for regular discussions about IPC practices at the unit level, were deemed vital to effective implementation of IPC practices [29,30,37,41,46,48]. Organizational culture also influenced the level of accountability and social peer pressure exercised to uphold IPC practices at the unit level [26,33,46–48]. Aspects of leadership culture, such as strong organizational emphasis on hierarchies, were reported as particularly relevant to this point because they impeded peer monitoring and feedback [43,47,48]. Unit layout and design also compromised the execution of IPC practices, such as cohorting or hand hygiene, e.g. through space constraints or impractical placement of soap and disinfection dispensers [25,27,29,36,39–41,43,44,47,48].

The 'characteristics of HCWs' relevant to the implementation of IPC practices included their general awareness of the importance of IPC in neonatal care [25,36,46,49] and their motivation to implement IPC practices [29,30,43,46,48]. Insufficient adherence of HCWs to IPC protocols and practices was often reported [26,32,33,38,45,46,48]. The reasons included lack of familiarity with IPC guidelines [25,48], scepticism towards the efficacy of the intervention [43] or forgetfulness [30,46]. Furthermore, the level of knowledge, education and training of HCWs [29,30,43,45–48] as well as their attitudes [25,30,37,48] were often reported to be relevant to IPC implementation.

Several studies mentioned the 'characteristics of patients' which potentially complicated the implementation of IPC practices because of their underlying risk of colonization and infection, such as low birth weight and gestational age [25,27,35], frequent exposure to invasive devices [27,33,35,38] and length of stay at the unit [27,35].

Regarding 'intervention characteristics', the perceived convenience of IPC practices and suitability with environmental surroundings were reported to influence their implementation. For example, studies reported discomfort experienced by HCWs using hand rubs because of skin irritation [30,44] or the lack of fit-for-purpose IPC tools, such as small size of alcohol wipes for skin antisepsis, as a hindrance to IPC practice [33]. The ease of access to necessary equipment and IPC instruments at the point of care, such as disinfection dispensers, reportedly promoted the implementation of IPC practices [27,29,30,36,48]. The use of multimodal strategies, commonly referred to as bundling, to implement IPC practices was further deemed an enabling factor in two studies [30,40]. Another study highlighted the importance of the perceptions of HCWs regarding the robustness of evidence for ensuring the uptake and penetration of IPC interventions or practices [44].

The beneficial characteristics of the 'implementation process' included standardization of procedures, e.g. through the use of checklists [25,32,34,41,43,44,49]. The presence of role models and (peer) supervision was also facilitative to the implementation process, particularly through reinforcement of IPC best practices [46–48]. Engagement of key parties, e.g. IPC teams [42] and caregivers [46,48], was further viewed as advantageous. The most utilized forms of engagement were educational activities [29,30,34,36,48].

Discussion

In our review of 25 studies, we found relevant factors across multiple levels suggested to influence the implementation of IPC practices in neonatal care. Most studies reported challenges and facilitators at hospital and unit levels, e.g. staff shortages, high work- and caseloads as well as aspects of organizational culture, such as communication and leadership style. Moreover, the characteristics of HCWs, such as their knowledge and education, attitudes and motivation, played a significant role in several studies. The frequent use of invasive devices and equipment, such as incubators, added to the perceived challenges of IPC in NICUs. It could be argued that these factors are highly relevant to IPC in any hospital setting, however, an important characteristic of the neonatal setting is the high vulnerability of its patient population. Therefore, we added the category 'characteristics of patients' during our data analysis using the CFIR, which did not include a corresponding patient dimension in its original version.

Further idiosyncrasies regarding the implementation of IPC practices in the neonatal setting include the handling of breast milk and the involvement of caregivers. Particularly in neonatal intensive care, family-centered care is being increasingly recognized for its neurodevelopmental benefits in pre-term and very-low-birth-weight infants [50]. However, implementation determinants related to family-centered care were seldom described in the reviewed articles. Similarly, the implementation determinants of neonatal-specific interventions, such as kangaroo care, have been researched [51] but rarely in relation to their benefits as IPC practices. Additionally, most studies focused on generic IPC interventions such as the prevention of device-associated infections and hand hygiene.

In the terminology of the reviewed articles, there was often no clear distinction made amongst IPC interventions, strategies to support their implementation as well as barriers and facilitators to implementation. For example, 'training of NICU staff' was mentioned both as an enabling factor for implementation [36] and an IPC intervention [30,33]. However, from the perspective of implementation science, implementation strategies describe 'methods or techniques used to enhance the adoption, implementation and sustainability of a clinical program or practice' [52]. The act of delivering training would thus be considered an implementation 'strategy' to enhance the knowledge of HCWs about a particular IPC intervention. Clearly distinguishing between these concepts can facilitate implementation planning, execution and evaluation of IPC innovations.

Finally, most of the reviewed studies used discrete, as opposed to multidimensional, approaches to implement neonatal IPC practices. Discrete implementation strategies were employed to tackle specific identified needs, e.g. the use of education to fill the knowledge gaps for HCWs. Although such targeted efforts may seem logical and efficient, they often fall short of acknowledging the inter-connectedness of factors associated with existing challenges. It is well established that single measures, such as education or guideline dissemination, are necessary yet insufficient to sustainably change the behaviour of HCWs [53]. The simplification of the complexities of the neonatal care setting to ensure the application of IPC interventions is understandable and, in certain situations, appropriate. However, it may be beneficial to design

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strategies based on assessment of the interrelation and multifactorial nature of challenges.

The results of the present review highlight the complex, multifaceted determinants which influence the uptake of IPC implementation and reinforce the necessity to adapt interventions for specific practice contexts. This further suggests why interventions successfully applied in one setting may render different results in another. The vulnerability of the neonatal patient population raises important questions for the implementation of IPC practices: Which aspects of the said risk are inherent to the patient population (i.e. non-modifiable) [54]? Which aspects are environmentally related and mitigable through IPC (i.e. modifiable) [54]? A discussion of these questions may form a meaningful starting point for neonatal units working to enhance their IPC implementation because it guides attention towards implementation determinants which hospitals and their staff can modify, improve or eliminate. Moreover, neonatal units should consider the extent to which the risks of infection can be reduced using traditional IPC practices, such as environmental cleaning and hand hygiene, or by modulating patient vulnerability to infections, e.g. by choosing less-invasive therapeutic options, promoting kangaroo care and early enteral feeding (preferably breast feeding).

This narrative review provides the first overview and categorization of factors reported to influence the implementation of IPC practices in neonatal care. Awareness of these factors, many of which are specific to neonatal settings, should inform the development of implementation strategies tailored to the neonatal context. To increase the chances of implementation success, such implementation strategies should be co-designed by individuals with neonatal, IPC and implementation science expertise and be subsequently analyzed in process evaluations [55–57]. The use of determinant frameworks, such as the CFIR, can prove helpful in identifying relevant determinants at micro, meso and macro levels which may impact the uptake of interventions and the sustainment of IPC practices in neonatal care. Future research on neonatal IPC interventions should evaluate the extent to which contextual determinants influence implementation success, e.g. through hybrid effectiveness-implementation trials [58]. Such research holds the promise of improved translation of research findings into neonatal clinical practice and requires close collaboration amongst professionals of clinical practice, clinical research and implementation science.

Author contributions

MTS, EN and LCl conceptualized the article. TM, JB, LCa, AC, CS and MC gave feedback to the conceptualization and search strategy. EN, LCa, BA, MTS, AC, CS, MC and JW conducted the screening of publications. EN performed the data extraction, and EN and MTS analysed the included publications. EN and MTS wrote the first manuscript draft. All authors critically revised the manuscript.

Transparency declaration

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cmi.2022.11.007.

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