REVIEWS AND DISCUSSION PAPERS

Implementation of nasal high flow therapy for infants with bronchiolitis: An integrative review

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ABSTRACT

Objective: Identify factors relevant to the implementation of nasal high flow for infants with bronchiolitis in rural and remote contexts.

Background: Healthcare services in rural and remote Australia must be resilient in responding to paediatric respiratory illness and provide equitable access of care to the tertiary contexts. Retrievals cannot be the only option to provide equitable care, particularly in examples of cyclones reducing aeromedical retrieval services. Nasal high flow (NHF) therapy is available for use in tertiary contexts for treating infants with respiratory illness. However, its use in rural and remote services is inconsistent and implementations to support routine implementation into this context are unknown.

Study design and methods: An integrative review was completed using an adapted implementation science framework. The COM-B (Capability, Opportunity, Motivation – Behaviour) framework was used to structure and analyse the results in alignment with translatable clinical care setting implementations. Seven databases were searched using specified search terms such as nasal high flow therapy, bronchiolitis, and implementation.

Results: The original search terms 'rural' and/or 'remote' yielded zero results and were therefore removed from the search criteria. Sixteen publications were included in the final analysis that yielded 73 implementation factors. Eight related to capability, 61 were opportunity factors and four were motivation factors. Many of the factors were relating to the local context level, such as using observation regimes. One study (two publications) explicitly reported using an implementation framework where context was considered as an important component in identifying implementation strategies.

Discussion: Implementation strategies included staff training (capability). The opportunity for staff to use NHF was the most common factor with using guidelines. The least represented motivation strategies focused on the clinician's confidence to use NHF therapy.

Conclusion: The lack of reported NHF studies in rural and remote hospitals highlights a knowledge gap. Implementation science is recommended for use in contexts such as the rural/remote setting where the context is unique and requires targeted implementation strategies.

Implications for research, policy, and practice: Research exploring the use of NHF therapy should consider the unique rural and remote context using appropriate implementation strategies.

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Implementation science has shown that factors such as local champions, guidelines, use of observational data, and having locally tailored training and supportive approaches does improve the implementation of NHF therapy. The authors recommend these strategies be applied in rural and remote contexts to inform future research, policies, procedures, and practices that will promote and support clinicians' confidence and ability to implement NHF therapy.

What is already known on the subject:
- NHF therapy is used for infants with bronchiolitis within the tertiary environment.
- NHF is used outside of paediatric intensive care units.
- Implementation science frameworks hasten evidence-based clinical practice routine uptake.

What this paper adds:
- Identifies a gap in the literature reporting implementation factors relevant for NHF therapy.
- Identifies no published literature reporting NHF use in rural and remote contexts.
- Describes, using an implementation framework, relevant factors for the use of NHF therapy in rural and remote hospitals.

Keywords: Implementation science, oxygen therapy, paediatric, remote, respiratory illness, rural.

INTRODUCTION

RATIONALE

Paediatric respiratory disease is a significant problem that incurs great emotional distress, life disruption and financial costs,[1] particularly in Australian rural and remote communities where respiratory disease disproportionately affects Aboriginal and Torres Strait Islander populations.[2,3] Aboriginal and Torres Strait Islander infants are more likely to be hospitalised, have more severe illness, and be susceptible to comparatively poorer outcomes than their non-Indigenous counterparts.[2-4] In a retrospective case review conducted in the Northern Territory, nearly one third (248 out of 789) of the paediatric aeromedical retrievals were due to bronchiolitis and pneumonia.[3] Of the children retrieved, 14 were ventilated, 10 required continuous positive airway pressure (CPAP) and one required bilevel positive airway pressure (BIPAP).[5] The review did not comment on any other oxygen delivery devices, such as nasal high flow (NHF) therapy.

NHF therapy is an oxygen delivery device that uses nasal cannulas to deliver higher concentrations of heated and humidified oxygen in the inspiratory breathing phase.[6] The efficacy of NHF therapy has been established in reducing escalations of care for use when standard oxygen delivery devices are insufficient in the tertiary and regional hospital settings.[5,7] NHF therapy is available to children in tertiary facilities, if needed.[7-9] However, children in rural and remote hospitals do not have equitable access to NHF therapy, with the current use of NHF therapy ranging from inconsistent to absent.[10] Current practice in most rural and remote hospitals includes children receiving oxygen therapy through standard low flow devices, such as simple nasal prongs. Any deterioration in the child's condition would normally result in escalation to retrieval to a tertiary facility and/or intubation/ventilation.[10] The unavailability and underutilisation of NHF therapy is largely due to there being no guideline for its use within the rural and remote context.[10] This has resulted in inequitable access to care for rural and remote children, who require NHF therapy, as they must rely on retrievals to tertiary hospitals to access this treatment option.

The escalation to retrieval of a child from a rural and remote site comes with many costs, both financial and psychosocial. A Retrieval Services Queensland representative quoted that an average cost for a child to be retrieved from Weipa to Cairns by a fixed-wing aeroplane as $8000.00; a retrieval of a child from Thursday Island to Cairns by a fixed wing aeroplane and helicopter averaged $23,000.00 (both locations are in Far North Queensland, Australia) (telephone conversation, 2 September 2019). Estimated retrieval costs are only based on the transportation component and not the cost of living away from home, loss of income, care of other family members, and the psychosocial impact of having to leave your home for possibly long periods of time.

NHF therapy is not a panacea for managing all children with respiratory illness and the benefits of its use are still being determined through ongoing research.[7,8,11] However, current evidence does demonstrate the effectiveness of NHF therapy, in children with respiratory illnesses, when low flow oxygen devices are insufficient.[7-9,12] Therefore, it is vital to better understand the reasons that impede the implementation of NHF therapy in the rural and remote context. Implementation Science (IS) can help clinicians understand barriers and enablers to the implementation of evidence-based interventions.[13] An IS behaviour change framework, The COM-B wheel,[13] will be used to help analyse the findings of this study.

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RESEARCH QUESTION AND OBJECTIVES

This literature review aims to answer the following research question: What strategies have been used to implement NHF therapy for infants (0-24 months) with bronchiolitis in rural and remote settings?

The objectives of this review are: a) to identify strategies important for the implementation of NHF therapy for infants with bronchiolitis, in rural and remote hospitals; and b) map each strategy to the COM-B wheel, an implementation framework. The findings will be used to inform the feasibility of implementing NHF therapy in rural and remote hospitals in North Queensland.

METHODS

An integrated review method, based on the framework by Cooper[14] and adapted by de Souza, da Silva and de Carvalho[15] was chosen as the best method to conduct this review. This is because an integrative review allowed for the inclusion of a diverse range of peer-reviewed sources, regardless of whether the methodology was qualitative, quantitative, or mixed methods. The authors also determined that the research question was not appropriate for a systematic review and meta-analysis.[16,17] As per the de Souza et al [15] framework, this review included six phases; formulating the research question; searching the literature; data collection; critical analysis of the studies; discussion of the results; and presentation of the integrative review. All phases were heavily influenced by IS as the overall framework that this review was guided by. The review was conducted by a remote area nurse with 20 years' experience (SW), and was supported by two nurse researchers (NH, SC) in regional and rural Queensland and a rural health clinician researcher (AC).

SEARCH STRATEGY (INFORMATION SOURCES)

A systematic search was conducted by one reviewer (SW) using CINAHL, PUBMED, MEDLINE, SCOPUS, INFORMIT, Cochrane Database, Joanna Briggs Institute and Google Scholar using the main keywords "Bronchiolitis" and "Nasal High Flow" and "Rural and Remote" on the date: 27.07.2021 (search strategy listed in Appendix B). When all three keywords were combined using Boolean terms "OR" and "AND" no results were produced. Therefore, the search was re-run removing the keywords "Rural and Remote", which then yielded 885 results. Google Scholar was searched using the keywords "bronchiolitis" and "nasal high flow" and the first five pages reviewed for missing studies. Manual searching of reference lists for all included studies was conducted. Results were exported into Endnote (version X9, Clarivate Analytics, PA, USA)[18] and duplicates were removed. Due to the keywords "Rural and Remote" not yielding any results and the search having to be rerun without these terms the research question was amended to: "What strategies have been used to implement NHF therapy for infants (0-24 months) who have bronchiolitis". The objectives were also revised to remove the words 'rural and remote'.

STUDY SELECTION AND ELIGIBILITY CRITERIA

Two reviewers (SW & AC) independently conducted the title, abstract, and full text screening against the eligibility criteria (Table 1). Any discrepancies between the two reviewers were resolved through discussion. Infants were defined as children aged 0-24 months, excluding neonates. Bronchiolitis was defined by the diagnosis described within the publications. Implementation strategies were defined as processes or policies that were used to support the delivery of NHF therapy and were able to be transferable to the rural and remote context.

TABLE 1: ELIGIBILITY CRITERIA

Inclusion criteria	Exclusion criteria
Rural and remote context	Non-English language
English language	Non-bronchiolitis presentations
Infants with bronchiolitis	Pre-term infants
Peer-reviewed	Not peer reviewed
Implementation strategies evident for example: • Clinical procedures • Training/education • Staffing ratios • Environment of care • Frequency of observations	Grey literature
	Publications that made no reference to implementation factors
	Studies focused on invasive procedures
	Home oxygen

There were six categories identified from the preliminary review of the literature, These categories included clinical procedures: any procedure required to perform alongside the use of NHF therapy; staff ratio: what the ratio of patient to nursing/respiratory therapy staff was required; observations: regime of observations including frequency and type of observations included, for example recordings of oxygen saturations, pulse, respirations; medications: what medications were recommended; consultation: what timeframe and who was recommended/mandated to consult on the patient being placed on NHF therapy for example, paediatrician within two hours of being placed on the therapy; staff training: what was the minimum amount of training required, how it was delivered and for who and whether a competency in NHF therapy's use was required. All implementation factors were then coded against the six categories. Studies were excluded where NHF therapy was being used for invasive procedures such as intubation for anesthetic as this is not a routine indication for NHF use in the emergency rural and remote setting.

DATA CHARTING AND ANALYSIS

Study characteristics were charted collaboratively by two reviewers (SW & AC). Data extracted included lead author, publication year, purpose/aim, study design, setting (where provided), Mixed Methods Appraisal Tool (MMAT) score,

key findings, and implementation factors. Using a reflective and iterative approach, implementation factors were only included if they could be applied to rural and remote settings. The implementation information was then grouped inductively into themes.

The COM-B wheel (Figure 1), an implementation science, behaviour change framework,[13] was used to help structure and analyse the publications that were identified during the study selection and eligibility criteria. Each implementation factor identified in the included studies was mapped onto the COM-B wheel and categorised into the three levels (1: system, 2: local context, 3: Individual); and also the three domains of behaviour change – capability, opportunity and motivation (Figure 3).[13] Level 1 represents an organisational/systemic/cultural influence, level 2 refers to the local setting where NHF is being implemented, and level 3 is at the individual level and refers to the frontline staff using NHF therapy.

CRITICAL APPRAISAL

Methodological quality was assessed independently using the MMAT[19] by two reviewers (SW & AC). Overall, four studies were categorised as being mixed methods, seven studies as being quantitative, three studies as being quantitative non-randomised, one study as being quantitative randomised controlled trial, and one paper was not able to be categorised due to the absence of a research question.[19] With respect to the quality appraisal of the 16 papers, six papers were graded as high, seven as moderate, two as low and the paper with no research question was unable to be graded. Despite this paper not having a research question, it did meet the eligibility criteria for inclusion and contained valuable information that helped address the research question. Any disagreements were resolved by discussion until consensus was achieved.

RESULTS

A total of 885 publications were identified. After removal of duplicates, the combined database searches yielded 750 peer-reviewed publications. After title, abstract and full text screening was undertaken, 734 publications were excluded, yielding a final sample of 16 eligible publications from 15 studies (Figure 2).[20-35] One study resulted in two publications.[25,30] As the search yielded no studies that were conducted in a rural and remote context, the research team recognised that metropolitan-based studies potentially held valuable knowledge on implementation that could be applied to the rural context.

SUMMARY OF OVERALL RESULTS

Table 2 presents characteristics of the 16 included publications (15 studies).[20-35] Most studies were based in America ($n=7$),[20,22,24,28,32-34] three were from Australia,[21,26,27] three from South America (Brazil and Peru),[25,29,30] and one each from Egypt, Turkey, and Italy.[23,31,35] Implementation characteristics from the included studies were mapped onto an adapted COM-B behaviour change wheel (Figure 3). Six publications identified implementation factors associated with capability,[20,23-25,27,30] all 16 publications reported opportunity implementation factors,[20-35] and two identified factors associated with motivation.[25,28,30] The COM-B factors were stratified by categorising each implementation factor into three social levels and domains of behaviour change.

CAPABILITY

Staff training was identified in all three COM-B levels (Figure 3).[20,23-25,27,30,35] One study used a System level Knowledge to Action framework to provide a comprehensive approach in identifying barriers and enablers, for example, establishing regular interdisciplinary meetings.[25] Another system level

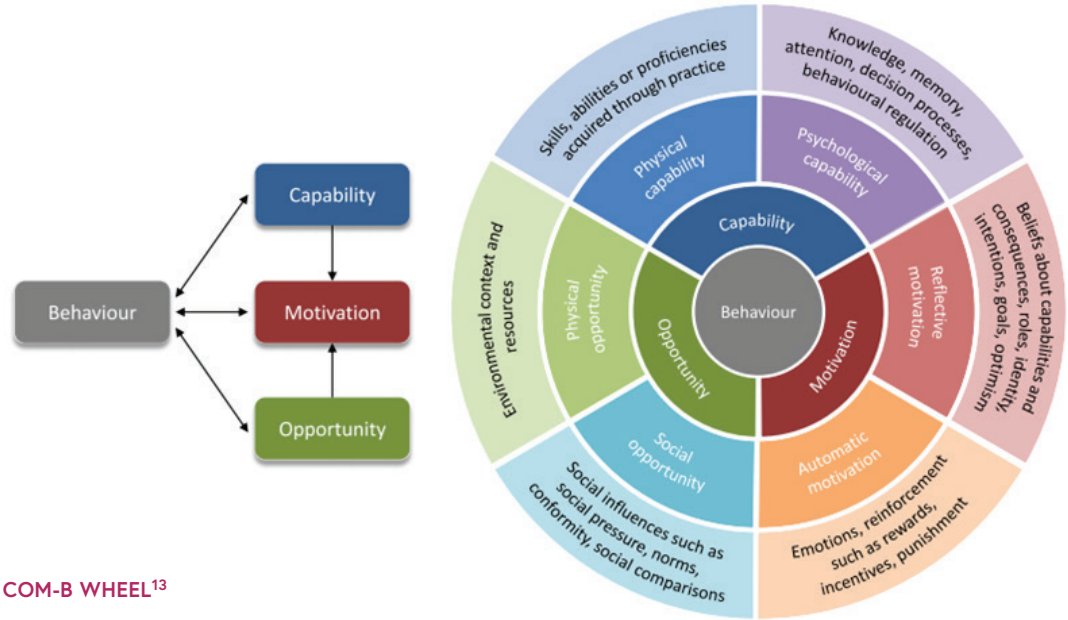

FIGURE 1: THE COM-B WHEEL[13]

TABLE 2: CHARACTERISTICS OF INCLUDED STUDIES USING NHF THERAPY WITH INFANTS DIAGNOSED WITH BRONCHIOLITIS

Author, year, country	COM-B level	Purpose/aim	Study design, setting (where provided)	MMAT Score (25)	Key findings	Implementation factor
Babl et al., 2020[21], Australia	1,2	Safety of enteral feeding in children <12 months on NHF therapy.	RCT	4	No adverse events when using enteral feeding while receiving NHF therapy. One child sustained a pneumothorax unrelated to the feeding.	Clinical procedures: feeding
Abboud et al., 2012[20], USA	1,2,3	Identify variables predicting NHF failure.	Retrospective chart audit	–	81.4% of children responded positively to NHF therapy., High pre NHF therapy partial pressure of carbon dioxide levels, lower respiratory rates and lower weight were predictors of NHF failure.	Clinical procedures: diagnostics management; medications; observation consultation; staff ratio
Yurtseven et al., 2019[35], Turkey	1,2	Comparison of 1L/kg/min and 2L/kg/min NHF rates in children < 24 months	RCT, Emergency Department	–	There was no significant difference between the two flow rates in reducing the risk of treatment failure. The 1L/kg/min flow rate provided reduced wean time.	Clinical procedures: feeding; diagnostics management; medication; observation; consultation; staff training
Sochet et al., 2017[34], USA	1,2	Determine incidence of aspiration and nutrition interruptions when enteral feeding on NHF.	Prospective, observational cohort stud	4	0.75% of children experienced respiratory aspiration and 9% of children experienced nutritional interruption due to tachypnoea. Oral nutrition was tolerated.	Clinical procedures: feeding
Slain et al., 2017[33], USA	2	Explore adverse feeding events and associations between enteral feeding patterns and clinical outcomes for children on NHF	Retrospective chart review. PICU		No association found between NHF therapy and adverse events with feeding.	Clinical procedures: feeding; diagnostics management; observations
Seliem & Sultan, 2017[31], Egypt	1,2	Evaluate if heliox improved gas exchange when delivered through high-flow nasal cannula (NHF therapy) in infants.	RCT	3	Provided recommendations of how to use NHF therapy and heliox, with imaging and a strict observation regime.	Clinical procedures: diagnostics; medication; observations
Nielsen et al., 2018[30], Peru	1,2,3	Implementation process evaluation of NHF therapy .	Implementation science: knowledge to action	–	Safely implemented NHF therapy in a PICU unit using implementation science knowledge to action framework.	Observations; consultation; staff ratios; training
Miller et al., 2018[28], USA	2,3	Explore NHF practice variation across five American clinical settings.	Quantitative survey	3	Minimal consensus of definitions around NHF.	Observations
Mayfield et al., 2014[27], Australia	1,2	Feasibility for an RCT assessing the safety and clinical impact of NHF therapy	Prospective pilot study Paediatric ward	5	Informed on guidelines for a larger RCT to be conducted including further assessment of financial implications of NHF therapy.	Observations; consultation; staff ratios; staff training
Betters et al., 2017[22], USA	1,2	Identify patient characteristics associated with NHF failure.	Retrospective chart review. Non-ICU setting	4	Predictors of a child's NHF treatment failure: having a cardiac comorbidity; unable to wean oxygen prior to intubation.	Clinical procedures: diagnostics; observations
Bressan et al., 2013[23], Italy	1,2	Feasibility of NHF therapy use in a paediatric ward.	Prospective cohort observational pilot study. Paediatric ward	2	Can safely use NHF therapy for infants with moderate to severe bronchiolitis in the ward setting. No cases of therapy interruptions or adverse events.	Clinical procedures: diagnostics; medications; observations; staff training
Ellington et al., 2019[25], Peru	1,2,3	Describe social institutional factors relevant to implementing NHF therapy	Qualitative study (focus groups, one-on-one semi-structured interviews). ICU	5	Knowledge to action framework identified an implementation strategy in a resource-limited setting. Recommended hands-on training for nurses with a requirement of more regular training intervals.	Staff ratio; staff training
Franklin et al., 2015[26], Australia and New Zealand	1,2	Comparing standard oxygen therapy to NHF therapy.	Non-blinded, multi-centre RCT. ED, Ward	4	Escalation criteria determined with observation regime.	Clinical procedures: feeding; diagnostics management; medications; observations; staff ratio
Nascimento et al., 2020[29], So Paulo, Brazil	2	Explore if nasogastric tube insertion is a predictor for NHF treatment failure.	Retrospective chart audit	3	Nasogastric tube use is a predictor for treatment failure.	Clinical procedures: feeding; observations
Shadman et al., 2019[32], USA	2	Explore if feeding exposure is associated with time to discharge.	Retrospective chart audit	5	Feeding during NHF therapy was associated with shorter time to discharge. Adverse events involving feeding were not associated with a feeding method.	Clinical procedures: feeding; diagnostics management
Dadlez et al., 2019[24], USA	1,2	Evaluate feasibility and safety of high flow nasal cannula outside of the ICU	Retrospective chart audit	4	NHF therapy is safe to use outside of an ICU setting if the patient has no pre-existing comorbidities prior to receiving treatment.	Clinical procedures: feeding; staff ratio; observation; staff training

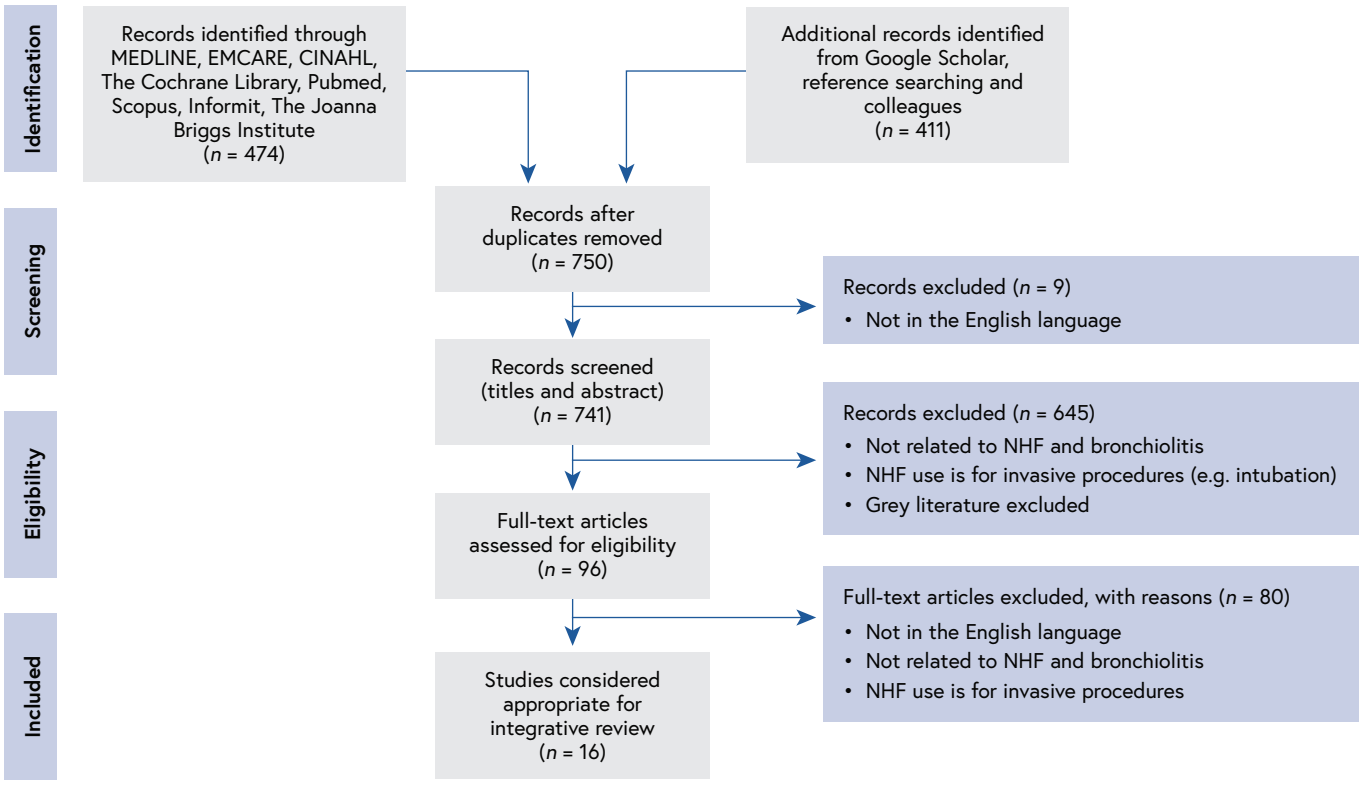

FIGURE 2: INTEGRATIVE REVIEW PRISMA FLOW CHART

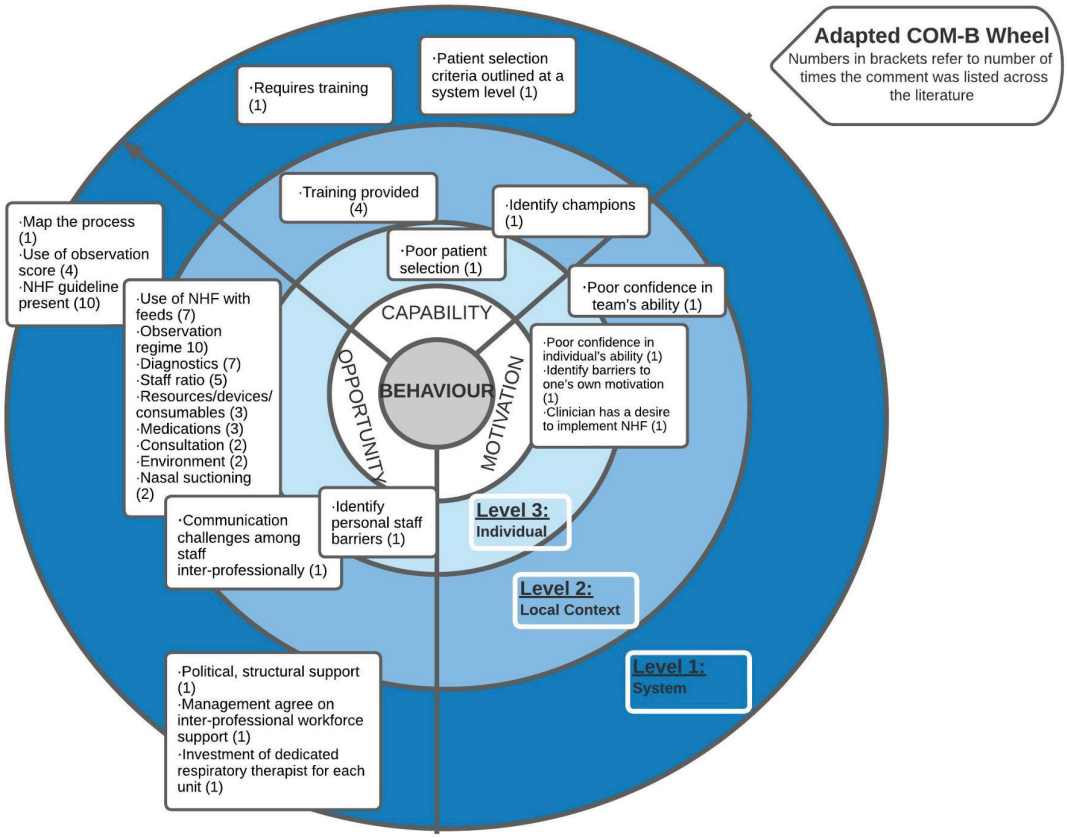

FIGURE 3: ADAPTED COM-B WHEEL WITH NHF THERAPY IMPLEMENTATION FACTORS MAPPED ON LEVELS AND INFLUENCING CAPABILITY, OPPORTUNITY, AND MOTIVATION DOMAINS

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example is a pre-established patient selection criteria.[24] Four publications identified local context factors relating to implementing NHF therapy, including local champions to support staff knowledge transfer and mixed-mode training, tailored to different professional's needs.[23,24,27,30] At the individual level, the clinician's capability to identify patients appropriate for NHF, and a lack of training and knowledge in the use of NHF impacted on successful implementation of NHF therapy.[20] The clinician's poor confidence in their capability was reducing their likeliness of using NHF therapy.[20]

OPPORTUNITY

All three levels (system, local context, and individual) were represented in the *opportunity* category with all 16 publications describing an implementation process or factor that could be mapped to opportunity (Figure 3). The presence of a NHF therapy guideline[20-27,30,34] and the use of patient observation/respiratory tool were the two most commonly reported mechanisms to support implementation of NHF therapy.[20-31,34,35] The type of patient observation tool varied between studies and included: Work of Breath Observation Score,[20] Wood's Clinical Asthma Score,[29,31] a modified Bronchiolitis Severity Score,[23] the Child Early Warning Tool (CEWT)[26] and a Clinical Respiratory Score (CRS).[24,35] Organisational and managerial support at the **system-level** for the implementation of NHF was discussed in one study (two publications) as a change management strategy at the **local context** (unit) level.[25,30]

One study recognised individuals are key players in the implementation outcome and addressing any **individual level** barriers can reduce resistance to change.[30] Availability of resources and opportunities for staff to use NHF therapy was explicitly identified as a facilitator in two studies in relation to the treatment environment outside of the ICU setting.[20,22] The *opportunity* to use NHF was facilitated at a **local context** level by the existing clinical procedures around feeding, diagnostic processes, and medication use.[21,24,26,29,32-35] Eleven publications reported patient observation regimes.[20,22-24,26-29,31,33,35] These included: observing for treatment failure,[20,22,23,27,31,35] and a diversity of recommended observation regimes[24,26,28,29,31,33,35] including one study that implemented a specific respiratory therapist to observe NHF therapy patients for the unit.[28] These observation regimes are in addition to using the specific respiratory tools listed above.

Staff ratios provide an indication of workforce requirements and were reported in a third of the studies.[20,24-27,30] Ratios varied depending on the care environment and ranged from having a nurse:patient ratio of 1:2 (ICU)[30] to 1:4 (paediatric general ward).[20,26,27] Consulting with specialist doctors was reported in four publications, where the consultation was elicited in the emergency department.[20,27,30,35] Otherwise paediatric ICU consultants made the treatment decision to apply NHF therapy.[20,30]

MOTIVATION

Implementation factors that support the motivation of staff at both the individual and local context level were reported in two publications from the one study (Figure 3).[25,30] Key activities to support motivation included establishing local clinical champions, translation of the NHF therapy protocol onto large posters visible throughout the unit, and training that was tailored to the workplace needs. In this case the following model was considered to motivate the team to participate in the training: physician's training focused on the physiology of NHF therapy and nursing training focused on the practicalities of setting up and troubleshooting the NHF device.[30] There were no system level motivation factors identified.

DISCUSSION

The purpose of this integrative literature review was to identify factors relevant to the safe implementation of NHF therapy for the treatment of bronchiolitis in infants in rural and remote hospital settings in Australia. As most studies examined in this review did not include a description of implementation processes, limited information was gathered pertaining to the concept of interest. Importantly there were no studies that reported on the use of NHF therapy for bronchiolitis in rural or remote hospitals. Findings from this review will discuss implementation factors and strategies from metropolitan settings and consider how this can be applied in the rural and remote context.

NHF is a therapy used in emergency medicine and, like most treatments, is not without risk, including barotrauma.[36] Emerging evidence has refined the age-related recommendations for use of NHF therapy outlined by the Paediatric Research in Emergency Departments International Collaborative (PREDICT) guidelines and the Paediatric Acute Respiratory Interventions Studies (PARIS).[8,9,11,37] This integrative review does not consider efficacy of NHF against other treatments, acknowledging that in tertiary settings in Australia, NHF therapy is part of a standard complement of therapies available.

The two overarching predominant implementation factors identified by this review included staff capability and human resource support (i.e., staff knowledge and availability of specialist medical officers) and the physical resources to support the safe application of the therapy (e.g., NHF consumables and diagnostic equipment). While staff factors were represented across all three COM-B wheel domains and levels, staff training and staff ratios were reported most often. However, the compliance, duration, frequency, or mode of staff training was not reported. Educational enablers from both a system and local context level were reported including the adoption of local champions.[25,30] Rural and remote workforce challenges such as high staff turnover presents difficulties in maintaining a highly skilled but

generalist workforce and strategies such as a 'champion' role, that can be handed over when staff turnover, should be considered during the early stages of implementation.[38] This implementation was used during the PARIS I and PARIS II trials resulting in a saturation of the intended knowledge within the workforce.[8,9]

There was a range of other human resource strategies used to support NHF implementation in the reviewed studies that are not available in rural and remote settings such as respiratory therapists and proximity to paediatric ICUs. The lack of these supports in rural and remote hospitals often leads to high nurse:patient ratio, which typically increase as rurality increases.[39] The standard hospital protocol for nurse:patient ratios of 1:4 is used in Australian tertiary emergency departments and paediatric wards.[26] Applying a nurse:patient ratio, derived from a specialised paediatric or tertiary ward setting would not necessarily consider additional logistical implications that exist in rural and remote communities.[4,40,41] This ratio would likely be insufficient in rural and/or remote Australia. Insufficient nursing staff was identified as a potential risk to more intensive care admissions with more invasive treatment and in rural and remote areas this often means aeromedical retrieval.[26]

Medical consultation was rarely discussed within the literature reviewed, and this appears to be due to the implied nature that consultation is continually occurring within the context of large tertiary and intensive care settings. However, Australian rural and remote communities, separated by large geographical distances, rely greatly on patients transferring to the tertiary hospital to access specialised medical care. Safe rural and/or remote health care depends on the ability to escalate care and time to access senior medical practitioner consultation.[22,42] The use of telehealth to address disparities in access to specialist services for rural and remote communities is growing and should be a consideration in all future service implementation processes.[43]

Resource constraints in rural and remote hospitals may limit timely availability of diagnostics such as pathology results and medical imaging. A locally conducted needs assessment, prior to the adoption of NHF therapy into routine practice, would be paramount to ensure adequate resources were available and pragmatic decisions around resource procurement could be conducted[20,30] Also true to rural and remote Australian contexts, the acknowledgement of the local health context as well as political context within and external to the organisation were identified as paramount to success of an implementation study in the only NHF study reviewed that described an implementation strategy.[30] In this study, support from management for staff to practice in a more inter-disciplinary manner was considered an important enabler.[25] Rural and remote locations often have reduced staffing, which is multidisciplinary in nature. Therefore, there is a heavy reliance on inter-professional collaboration and training, which is a known supportive implementation strategy.[44]

Additional procedures such as enteral feeding while on NHF therapy may be a determining factor for inter-hospital transfers from a rural and/or remote context to a tertiary/specialist hospital. Severity of illness and early identification of treatment failure are essential considerations in managing emergencies in rural and remote hospitals, given the time considerations for accessing inter-hospital transfers, either by air or road. Some of the clinical findings reported in the reviewed studies provide salient information to detect early[22,42] treatment failure such as work of breath (including respiratory rate, oxygen saturations),[20,23,24,31] and timeframes for reassessment of the patients in facilitating early identification of deterioration.[20,31] Balancing the benefits of treating patients close to home versus the risk of patient deterioration is common place for rural and remote doctors and nurses and these staff make decisions based on a range of considerations, resources, patient presentation and confidence in the team's ability to safely implement care.[3,45,46]

The successful translation of new therapies such as NHF therapy into rural and remote contexts can be supported by the application of research translation theories and frameworks. Of note, only one study (2 publications) identified in this review explicitly described a structured implementation strategy.[25,30] The use of the COM-B wheel[13] in this review has highlighted where the gaps in current implementation processes (most notably in motivation) have been. The minimal motivation information still provided an understanding that an individual's confidence, across all contexts, can impact on whether an intervention will be taken up into everyday clinical practice.[30] The influence of an individual's opinion of their team's abilities also impacts and again is not context dependent.[30] The COM-B wheel has been used in previous health services research to identify strategies to promote the use of evidence-based clinical practice.[47] It is possible that an increased likelihood of positive practice change will occur when strategies supporting implementation are broadly spread across all the domains of the wheel.[13,47]

Rural and remote Australian hospitals are highly conducive to using implementation science theories and frameworks, given the importance of contextual barriers and enablers that are unique to this setting.[13] Poor uptake of interventions in rural and remote locations could be explained by a lack of consideration to the unique needs of these sites, evidenced by the absence of literature found by this review. Historically, NHF therapy has not been approved due to the unknown risks of applying this intervention in a rural and remote location.[10] However, implementation science has shown that factors such as local champions, guidelines, use of observational data, and having locally tailored training and supportive approaches does improve the implementation and uptake of NHF therapy.[24,25,26,27,30] The authors recommend

these strategies be applied in rural and remote contexts to inform policies and procedures that will promote and support clinicians' capability, opportunities, and motivation to implement NHF therapy.

STRENGTHS AND LIMITATIONS

This review was limited to publications published in English. Relevant publications in other languages may have been missed; however, a broad range of databases were searched, and reference lists of included publications were searched. The search strategy followed an integrative review approach and did not include grey literature, excluding hospital guidelines and procedural documents. The lack of rural and remote specific studies limits our ability to translate the identified implementation factors into a rural context and arguably grey literature may have provided some insight into this. The quality appraisal of publications using the MMAT tool was found to be subjective and frequently required discussions between authors.[19]

This review informs on a peer-reviewed information gap around the use of NHF therapy in the rural and remote context. This review is translatable to inform clinicians on what information is available on how NHF therapy has been implemented in the past to inform on future guideline development.

CONCLUSION

This integrative literature review has shown the absence of peer-reviewed publications reporting on the implementation of NHF therapy for infants with bronchiolitis within rural or remote hospital settings. Implementation issues reported in the literature on the use of NHF with bronchiolitis in tertiary, metropolitan hospital settings is likely to have some applicability to the rural and remote context. Implementation of tertiary evidence to rural and remote settings requires a systematic understanding of implementation processes. Using the COM-B wheel to categorise the reported capability, opportunity and motivation of health systems, local departments, and individuals to implement a treatment such as NHF therapy in rural or remote settings highlighted the focus on the system level opportunity to deliver the therapy with minimal strategies to address motivation or capability.

Successful implementation of NHF therapy in rural and remote hospitals will require further research into associated risks and benefits for individuals and communities where emergency transfers for specialist care require considerable individual and health service resources. Careful consideration of the process for implementing NHF therapy will be important to ensure all behavioural change factors are addressed, potentially improving the safety and efficacy of the therapy. This is particularly important in the rural and remote context where the breadth of generalist skills required by staff in these settings and the lack of on-site respiratory or intensivist specialist skills creates challenges for maintaining important clinical skills.

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The primary author has accepted $5000.00 from Fisher & Paykell for the purposes of conducting NHF therapy clinical workshops with Torres & Cape Hospital and Health Service. Fisher & Paykell provided consumables to the value of $10 000 and Airvo2 devices to the value of $20 000 to Torres & Cape for facilitating research.

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REFERENCES

1. Hsu BS, Meyer BD, Lakhani S. Healthcare costs and outcomes for pediatric inpatients with bronchiolitis: comparison of urban versus rural hospitals. *Rural Remote Health.* 2015;15(2):3380.
2. Bailey EJ, Maclennan C, Morris PS, Kruske SG, Brown N, Chang AB. Risks of severity and readmission of Indigenous and non-Indigenous children hospitalised for bronchiolitis. *J Paediatr Child Health.* 2009;45(10):593-7.
3. Barker CL, Ross M. Paediatric aeromedical retrievals in the 'Top End' of the Northern Territory: Paediatric Aeromedical Retrievals. *Aust J Rural Health.* 2014;22(1):29-32.
4. Smith JG, Plover CM, McChesney MC, Lake ET. Isolated, small, and large hospitals have fewer nursing resources than urban hospitals: Implications for rural health policy. *Public Health Nurs.* 2019;36(4):469-77.
5. Moreel L, Proesmans M. High flow nasal cannula as respiratory support in treating infant bronchiolitis: a systematic review. *Eur J Paediatr.* 2020;179:711-8.
6. Schibler A, Franklin D. Respiratory support for children in the emergency department. *J Paediatr Child Health.* 2016;52(2): 192-6.
7. Franklin D, Babl FE, George S, Oakley E, Borland ML, Neutze J, et al. Effect of early high-flow nasal oxygen vs standard oxygen therapy on length of hospital stay in hospitalized children with acute hypoxemic respiratory failure: the PARIS-2 Randomized Clinical Trial. *JAMA.* 2023;329(3):224-34.

8. Franklin D, Babl FE, Schlapbach LJ, Oakley E, Craig S, Neutze J, et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018;378(12):1121-31.
9. Franklin D, Shellshear D, Babl FE, Schlapbach LJ, Oakley E, Borland ML, et al. Multicentre, randomised trial to investigate early nasal high – Flow therapy in paediatric acute hypoxaemic respiratory failure: a protocol for a randomised controlled trial – A Paediatric Acute respiratory Intervention Study (Paris 2). *BMJ open*. 2019;9(12).
10. West S, Franklin D, Harvey N, Cairns A. Nasal high flow therapy in remote hospitals: guideline development using a modified Delphi technique. *Rural Remote Health*. 2024(8516).
11. O'Brien S, Haskell L, Schembri R, Gill FJ, Wilson S, Borland ML, et al. Prevalence of high flow nasal cannula therapy use for management of infants with bronchiolitis in Australia and New Zealand. *J Paediatr Child Health*. 2022;58(12):2230-5.
12. Moreel L, Proesmans M. High flow nasal cannula as respiratory support in treating infant bronchiolitis: a systematic review. *Eur J Pediatr*. 2020:1-8.
13. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011;6(1):42-.
14. Cooper HM. Scientific guidelines for conducting integrative research reviews. *Rev Educ Res*. 1982;52(2):291-302.
15. Souza MTd, Silva MDd, Carvalho Rd. Integrative review: what is it? How to do it? *Einstein* (São Paulo). 2010;8:102-6.
16. Christmals CD, Gross JJ. An integrative literature review framework for postgraduate nursing research reviews. *Eur J Res Med*. 2017;5(1).
17. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467-73.
18. The EndNote Team. *EndNote*. X9 ed. Philadelphia: PA: Clarivate.; 2013.
19. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for information*. 2018;34(4):285-91.
20. Abboud PA, Roth PJ, Skiles CL, Stolfi A, Rowin ME. Predictors of failure in infants with viral bronchiolitis treated with high-flow, high-humidity nasal cannula therapy*. *Pediatr Crit Care Med*. 2012;13(6):e343-9.
21. Babl FE, Franklin D, Schlapbach LJ, Oakley E, Dalziel S, Whitty JA, et al. Enteral hydration in high-flow therapy for infants with bronchiolitis: secondary analysis of a randomised trial. *Aust Paediatr. J*. 2020.
22. Betters KA, Gillespie SE, Miller J, Kotzbauer D, Hebbar KB. High flow nasal cannula use outside of the ICU; factors associated with failure. *Pediatr Pulmonol*. 2017;52(6):806-12.
23. Bressan S, Balzani M, Krauss B, Pettenazzo A, Zanconato S, Baraldi E. High-flow nasal cannula oxygen for bronchiolitis in a pediatric ward: a pilot study. *Eur J Pediatr*. 2013;172(12):1649-56.
24. Dadlez NM, Esteban-Cruciani N, Khan A, Shi Y, McKenna KJ, Azzarone G, Southern WN. Safety of high-flow nasal cannula outside the ICU for previously healthy children with bronchiolitis. *Respir Care*. 2019;64(11):1410-5.
25. Ellington LE, Jacob-Files E, Becerra R, Mallma G, Tantalean da Fieno J, Nielsen KR. Key considerations prior to nasal high flow deployment in a Peruvian PICU from providers' perspectives. *Acta Paediatr*. 2019;108(5):882-8.
26. Franklin D, Dalziel S, Schlapbach LJ, Babl FE, Oakley E, Craig SS, et al. Early high flow nasal cannula therapy in bronchiolitis, a prospective randomised control trial (protocol): A Paediatric Acute Respiratory Intervention Study (PARIS). *BMC Pediatr*. 2015;15(1):183.
27. Mayfield S, Bogossian F, O'Malley L, Schibler A. High-flow nasal cannula oxygen therapy for infants with bronchiolitis: Pilot study: High-flow nasal cannula in bronchiolitis. *Aust Paediatr J*. 2014;50(5):373-8.
28. Miller AG, Gentle MA, Tyler LM, Napolitano N. High-Flow Nasal Cannula in Pediatric Patients: A Survey of Clinical Practice. *Respir Care*. 2018;63(7):894-9.
29. Nascimento MS, Quinto DE, Oliveira GC, Rebello CM, do Prado C. Nasogastric tube, a warning sign for high-flow nasal cannula failure in infants with bronchiolitis. *Sci Rep*. 2020;10(1):15914.
30. Nielsen KR, Becerra R, Mallma G, Tantaleán da Fieno J. Successful Deployment of High Flow Nasal Cannula in a Peruvian Pediatric Intensive Care Unit Using Implementation Science-Lessons Learned. *Front Pediatr*. 2018;6:85.
31. Seliem W, Sultan AM. Heliox delivered by high flow nasal cannula improves oxygenation in infants with respiratory syncytial virus acute bronchiolitis. *Jornal de Pediatria*. 2018;94(1):56-61.
32. Shadman KA, Kelly MM, Bruce Edmonson M, Sklansky DJ, Nackers K, Allen A, et al. Feeding during high-flow nasal cannula for bronchiolitis: associations with time to discharge. *Br J Hosp Med*. 2019;14(9):E43-E8.
33. Slain KN, Martinez-Schlurmann N, Shein SL, Stormorken A. Nutrition and High-Flow Nasal Cannula Respiratory Support in Children With Bronchiolitis. *Hosp Pediatr*. 2017;7(5):256-62.
34. Sochet AA, McGee JA, October TW. Oral Nutrition in Children With Bronchiolitis on High-Flow Nasal Cannula Is Well Tolerated. *Hosp Pediatr*. 2017;7(5):249-55.
35. Yurtseven A, Turan C, Erseven E, Saz EU. Comparison of heated humidified high-flow nasal cannula flow rates (1-L.kg.min-1 vs 2-L.kg.min -1) in the management of acute bronchiolitis. *Pediatr Pulmonol*. 2019;54(6):894-900.
36. Piastra M, Morena TC, Antonelli M, Conti G. Uncommon barotrauma while on high-flow nasal cannula. *Intensive Care Med*. 2018;44(12):2288-9.
37. (PREDICT); PRIEDIC. Bronchiolitis Guideline: *Predict*; 2022 [updated 29.22.2022. Available from: https://www.predict.org.au/bronchiolitis-guideline/.
38. Chisholm M, Russell D, Humphreys J. Measuring rural allied health workforce turnover and retention: what are the patterns, determinants and costs? *Aust J Rural Health*. 2011;19(2):81-8.
39. Kirchner JE, Smith JL, Powell BJ, Waltz TJ, Proctor EK. Getting a clinical innovation into practice: An introduction to implementation strategies. *Psychiatry Res*. 2020;283:112467.
40. Smith S, Sim J, Halcomb E. Nurses' experiences of working in rural hospitals: an integrative review. *J Nurs Manag*. 2019;27(3):482-90.
41. Murray RB, Wronski I. When the tide goes out: health workforce in rural, remote and Indigenous communities. *Med J Aust*. 2006;185(1):37-8.
42. Milési C, Boubal M, Jacquot A, Baleine J, Durand S, Odena MP, Cambonie G. High-flow nasal cannula: recommendations for daily practice in pediatrics. *Ann Intensive Care*. 2014;4(1):1-7.
43. Marcin JP, Shaikh U, Steinhorn RH. Addressing health disparities in rural communities using telehealth. *Pediatr Res*. 2016;79(1):169-76.

44. Reed K, Reed B, Bailey J, Beattie K, Lynch E, Thompson J, et al. Interprofessional education in the rural environment to enhance multidisciplinary care in future practice: Breaking down silos in tertiary health education. *Aust J Rural Health*. 2021;29(2):127-36.
45. Schlapbach LJ, Schaefer J, Brady A-M, Mayfield S, Schibler A. High-flow nasal cannula (HFNC) support in interhospital transport of critically ill children. *Intensive Care Med*. 2014;40(4):592-9.
46. Fleming PF, Richards S, Waterman K, Davis PG, Kamlin COF, Stewart M, Sokol J. Medical retrieval and needs of infants with bronchiolitis: An analysis by gestational age. *Aust Paediatr J*. 2013;49(3):E227-E31.
47. McDonagh LK, Saunders JM, Cassell J, Curtis T, Bastaki H, Hartney T, Rait G. Application of the COM-B model to barriers and facilitators to chlamydia testing in general practice for young people and primary care practitioners: a systematic review. *Implement Sci*. 2018;13(1):130-19.