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Literature Review

Key considerations for developing patient management tools for small and nutritionally at-risk infants: A scoping review

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Background

To improve global child health, efficacious interventions are important but real-world effectiveness is crucial; this requires translating technical guidance into frontline clinical and patient care practices. Patient management 'tools' are frequently used for this purpose, guiding healthcare workers to deliver quality care. Ahead of an update to a patient management tool for small and nutritionally at-risk infants under six months of age (C-MAMI Tool, V2), we reviewed how others have done this in the past. Our aim was to ensure an evidence-based development process to optimise future success and impact.

Methods

We investigated five patient management tools: Integrated Care Pathways (ICPs), Integrated Management of Childhood Illness (IMCI), Paediatric Early Warning Systems (PEWS), Growth Monitoring (GM), and Emergency Triage Assessment and Treatment (ETAT). Searches were run in PubMed and examined evidence on the development, uptake, and effectiveness of these tools.

Results

The tools were developed between approximately 1960-2005, with ongoing development of electronic patient management tools (e-tools). IMCI and ETAT were the most widely used in low- and middle-income countries (LMICs), but low coverage remains a major barrier to effectiveness. Growth monitoring is also widely used in LMICs but lacks strong evidence of effectiveness. Evidence on the use of e-tools for patient management in LMICs is growing. Whilst overall evidence for all these approaches was limited, the strongest evidence of effectiveness was for ICPs. Though evidence was sparse, formative work developing the tools prior to implementation seems important to their future success.

Conclusions

Informed by this review, the C-MAMI Tool was updated to the MAMI Care Pathway Package, using an ICP approach and modelled on IMCI. This living resource continues to evolve: aligning with and accounting for existing pathways and systems; baseline formative user-experience research; formal effectiveness research to actively plan for future scale up; collecting information on variance from and adaptations to the care pathway; possible future e-tools. An ICP approach is relevant to other child health and nutrition topics.

BACKGROUND

Globally, an estimated 8.5 million infants aged under six months (infants u6m) are wasted and many more are small and nutritionally at-risk as defined by other measures including low birth weight (LBW) and underweight (low weight-for-age; "MAMI Project Summary (Management of Small & Nutritionally At-Risk Infants Aged U6months and Their Mothers" 2022; Kerac et al. 2011). Despite associated short-term mortality risks as well as long term non-com-

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municable disease risks of such early life malnutrition, infants u6m are often neglected in nutrition and health programming (Grijalva-Eternod et al. 2017; Grey et al. 2021; Kerac, Mwangome, McGrath, et al. 2015). Reasons for this include: assumptions that they are fully protected from severe malnutrition by exclusive breastfeeding (this ignores suboptimal rates of breastfeeding globally; Kerac, Mwangome, McGrath, et al. 2015; Victora et al. 2016); a lack of global guidance in the use of a simple, rapid, user-friendly assessment tools such as mid-upper arm circumference (MUAC), which is widely used to identify malnutrition in children older than six months of age (Bliss et al. 2018); and the fact that their clinical management is more complex than that of older children with malnutrition (Kerac, Mwangome, McGrath, et al. 2015).

Since 2008, the management of small and nutritionally at-risk infants under six months and their mothers (MAMI) Global Network , an international collaboration of researchers, practitioners, and experts, has worked to build evidence, inform policies, and catalyse programming support for this vulnerable patient group (Kerac et al. 2011). In 2013, updated World Health Organization (WHO) guidelines on the management of severe malnutrition included, for the first time, a stand-alone chapter on infants u6m (WHO 2013a). However, whilst several strong recommendations were made, the underlying evidence-base was of low quality and country-level uptake has been poor (Kerac, Angood, McGrath, et al. 2017; Guyatt et al. 2008; Engl, Kerac, and London School of Hygiene & Tropical Medicine 2021). Reasons include a gap between high-level technical guidelines and frontline patient care, especially in resource-poor settings where nutrition and healthcare staff often work in difficult conditions and do not always have access to the materials and support that they need.

To help translate WHO guidance into effective frontline clinical and public health practice, the MAMI Global Network developed the 'Community Management of At-risk Mothers and Infants' patient assessment and management tool in 2015 (Version 1). Drawing on existing resources, most notably the format and approach of the Integrated Management of Childhood Illness (IMCI), this checklist-based guide provided directions for frontline healthcare staff on how to assess, classify, and manage at-risk infants u6m and their mothers in community settings (Read 2017a; WHO 2018). Evaluations of programmes implementing MAMI Tool Version 1 in Bangladesh and Ethiopia, as well as collated practitioner experiences and peer review, provided valuable operational evidence and informed Version 2 of the MAMI Tool (2018; Butler, Connell, and Barthorp 2018; ENN 2018).

With growing interest in MAMI and in preparation for a randomised control trial (RCT) on MAMI in Ethiopia, a significant revision was undertaken in 2021 to produce Version 3. Ahead of this update, this scoping review was conducted to strengthen the evidence-base for the approach.

Learning from similar child health/nutrition programmes and patient management tools, our objectives were to:

- Identify key steps and procedures in their development
- Understand factors underpinning successful uptake and implementation
- Understand possible facilitators and barriers underlying their effectiveness

As well as ensuring that our own work is effective, well-adapted to end users' needs, and has maximum potential for widespread scale-up and integration into existing health systems, we hope that this review will also inform those working on other patient management tools or care packages.

METHODS

To inform our approach to updating the MAMI Tool, we investigated existing case management tools across child nutrition and health including: Integrated Care Pathways (ICPs), Integrated Management of Childhood Illness (IMCI), Paediatric Early Warning Systems (PEWS), Growth Monitoring (GM), and Emergency Triage Assessment and Treatment (ETAT). All are examples of high-profile tools with global reach and were identified a priori by a senior author (MK) who has experience using some of them in clinical practice.

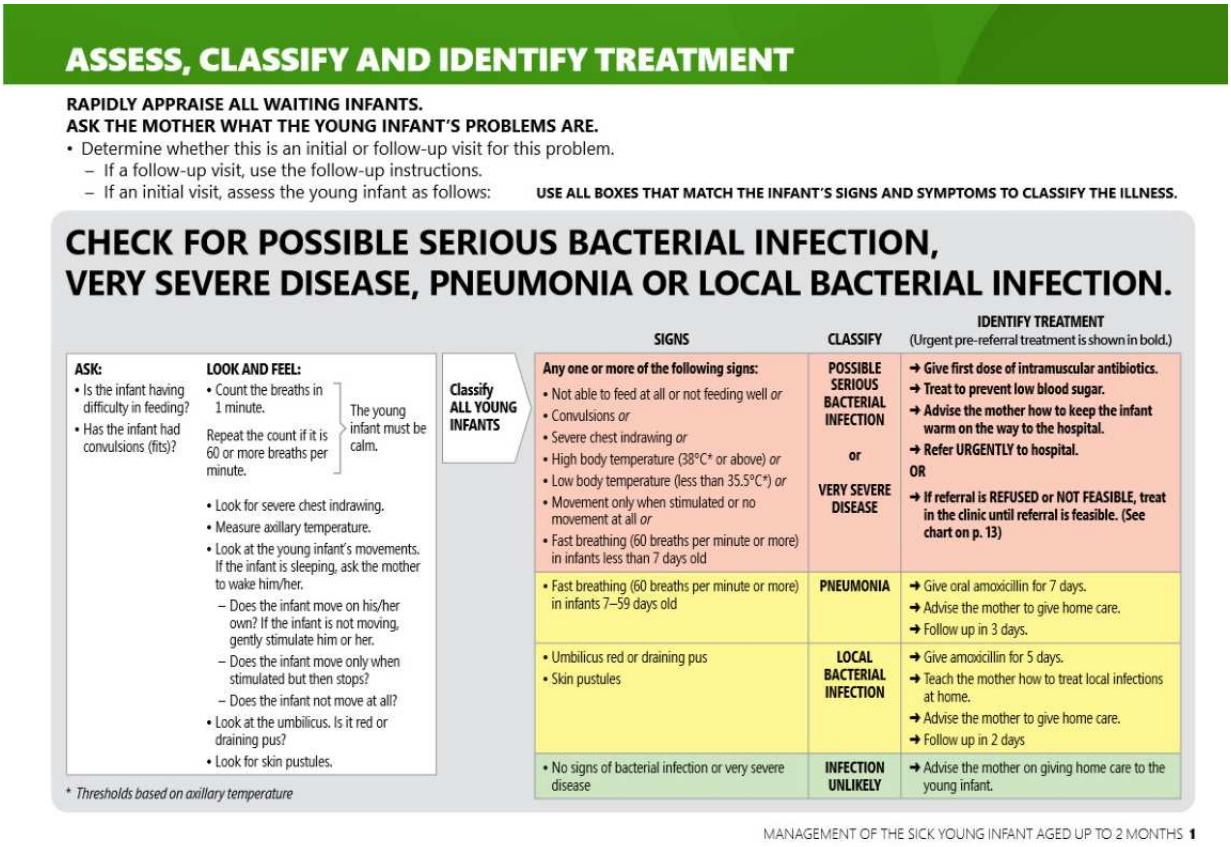
We first conducted Google searches for each tool to identify key records (guidelines, reports, research articles) from which relevant search terms were compiled. Using these terms, we built separate search strategies for each tool to examine evidence on their development, uptake, and effectiveness. All searches were run in PubMed (Jan 2020). The results were synthesized narratively and presented under three themes: 1) development, 2) uptake, and 3) effectiveness. The search strategy used is presented in Annex 1.

RESULTS

We investigated five individual patient management tools and their respective electronic versions (e-tools) where available. These were developed between approximately 1960 – 2005, with ongoing development of new e-tools. Some are in widespread use globally (ICPs and GM), others are used primarily in low- and middle-income countries (LMICs) (IMCI and ETAT); others mostly in high-income countries (HICs) (PEWS and e-tools). Overall, evidence on their development and effectiveness was sparse. The subsequent section briefly describes the development, uptake, and effectiveness of each tool.

TOOL 1: INTEGRATED MANAGEMENT OF CHILDHOOD ILLNESS (IMCI)

IMCI is an integrated approach to child health that aims to improve the accurate identification of common childhood illnesses in outpatient care, facilitate the referral of severely ill children, ensure appropriate treatment, and strengthen healthcare workers' skills for counselling caregivers in health facilities (WHO 2018).



ASSESS, CLASSIFY AND IDENTIFY TREATMENT

RAPIDLY APPRAISE ALL WAITING INFANTS.
ASK THE MOTHER WHAT THE YOUNG INFANT'S PROBLEMS ARE.

- Determine whether this is an initial or follow-up visit for this problem.
  - If a follow-up visit, use the follow-up instructions.
  - If an initial visit, assess the young infant as follows:

USE ALL BOXES THAT MATCH THE INFANT'S SIGNS AND SYMPTOMS TO CLASSIFY THE ILLNESS.

CHECK FOR POSSIBLE SERIOUS BACTERIAL INFECTION, VERY SEVERE DISEASE, PNEUMONIA OR LOCAL BACTERIAL INFECTION.

ASK:
- Is the infant having difficulty in feeding?
- Has the infant had convulsions (fits)?

LOOK AND FEEL:
- Count the breaths in 1 minute. Repeat the count if it is 60 or more breaths per minute. (The young infant must be calm.)
- Look for severe chest indrawing.
- Measure axillary temperature.
- Look at the young infant's movements. If the infant is sleeping, ask the mother to wake him/her.
  - Does the infant move on his/her own? If the infant is not moving, gently stimulate him or her.
  - Does the infant move only when stimulated but then stops?
  - Does the infant not move at all?
- Look at the umbilicus. Is it red or draining pus?
- Look for skin pustules.

Classify ALL YOUNG INFANTS

SIGNS	CLASSIFY	IDENTIFY TREATMENT (Urgent pre-referral treatment is shown in bold.)
Any one or more of the following signs: • Not able to feed at all or not feeding well *or* • Convulsions *or* • Severe chest indrawing *or* • High body temperature (38°C* or above) *or* • Low body temperature (less than 35.5°C*) *or* • Movement only when stimulated or no movement at all *or* • Fast breathing (60 breaths per minute or more) in infants less than 7 days old	POSSIBLE SERIOUS BACTERIAL INFECTION or VERY SEVERE DISEASE	**→ Give first dose of intramuscular antibiotics. → Treat to prevent low blood sugar. → Advise the mother how to keep the infant warm on the way to the hospital. → Refer URGENTLY to hospital. OR → If referral is REFUSED or NOT FEASIBLE, treat in the clinic until referral is feasible. (See chart on p. 13)**
• Fast breathing (60 breaths per minute or more) in infants 7–59 days old	PNEUMONIA	→ Give oral amoxicillin for 7 days. → Advise the mother to give home care. → Follow up in 3 days.
• Umbilicus red or draining pus • Skin pustules	LOCAL BACTERIAL INFECTION	→ Give amoxicillin for 5 days. → Teach the mother how to treat local infections at home. → Advise the mother to give home care. → Follow up in 2 days
• No signs of bacterial infection or very severe disease	INFECTION UNLIKELY	→ Advise the mother on giving home care to the young infant.

* *Thresholds based on axillary temperature*

MANAGEMENT OF THE SICK YOUNG INFANT AGED UP TO 2 MONTHS 1

Figure 1. Example of the Integrated Management of Childhood Illness (IMCI) Chart Booklet for the management of the sick young infant aged up to 2 months.

Source: WHO IMCI Chart Booklet, 2019

Patient management guidelines are just one part of a wide set of IMCI materials. Through highlighting some of the commonest causes of childhood mortality (pneumonia, diarrhoea, malaria, measles, and undernutrition), these clinical guidelines recogise that children often present with multiple problems. The approach thus presents a simple step-by-step guide to interpreting key symptoms to make a diagnosis and offer appropriate treatment. It involves classification of signs and symptoms using a traffic light system, with pink, yellow, and green used to indicate high, moderate, and low risk, respectively (Figure 1). Separate charts are provided for infants under two months and over two months due to differences in common health problems between these age groups (WHO 2014).

DEVELOPMENT

IMCI was developed by the WHO and the United Nations Children's Fund (UNICEF) in the mid-1990s. The development process began with a technical review of existing programme guidelines to inform a draft IMCI guideline/treatment algorithm. The treatment algorithm was then pilot tested and evaluated in six countries. The validity of the algorithm was assessed by comparing sensitivities and specificities for classification of illness by a trained health worker using the IMCI algorithm compared to diagnosis by a physician with laboratory and radiological support (Weber, Mulholland, Jaffar, et al. 1997; Perkins, Zucker, Otieno, et al. 1997).

UPTAKE

IMCI has been adopted by more than 100 countries but coverage remains a major barrier to achieving reduced mortality through IMCI (Chopra et al. 2012). Inadequate local adaptation of guidelines, insufficient trained staff, weak supervision and referral systems, and poor health service utilisation have limited the impact and uptake of IMCI (Chopra et al. 2012).

EFFECTIVENESS

The Multi-Country Evaluation (MCE) of IMCI was carried out between 1997-2005 to review IMCI performance in reducing mortality in at least one country in every WHO region to understand the intervention's efficacy, delivery quality, service utilisation, and achieved coverage (Chopra et al. 2012). The MCE showed that IMCI improved health worker performance and their quality of care, but also indicated that large-scale intervention coverage is vital for achieving a significant reduction in under five mortality (Bryce et al. 2005). More recent evidence from a 2016 Cochrane review of IMCI identified two cluster RCTs and two controlled before-after studies (Gera et al. 2016).

Whilst estimating that IMCI could reduce mortality (RR 0.85, 95% CI 0.78 - 0.93; two trials, 65,570 participants; low-certainty evidence), the review also showed mixed effects on other key outcomes. For example, there was "little or no effect on wasting (RR 1.04, 95% CI 0.87 to 1.25; two trials, 4288 participants; moderate-certainty evidence)". Impact on exclusive breastfeeding and health-seeking behaviours was also mixed, and reviewers could not conclude about whether IMCI does or does not affect these.

TOOL 2: INTEGRATED CARE PATHWAYS (ICPS)

According to Campbell et al. (1998), "integrated care pathways —also known as coordinated care pathways, care maps, or anticipated recovery pathways—are task-oriented care plans which detail essential steps in the care of patients with a specific clinical problem and describe the patient's expected clinical course" (Figure 2; Campbell et al. 1998). ICPs offer a structured mechanism to translate national guidelines into local protocols that can be applied in clinical practice. The main features of ICPs are that they act as a multidisciplinary plan for and record of care; detail tasks, sequence, timescale, and contain a checklist of all necessary actions; provide an indication of the patient's expected condition over time; require minimal free text to complete; and are freely available to the patient.

DEVELOPMENT

The concept of ICPs in health services is rooted in management theories used in industry. Among these theories is the critical path method that became popular in the defence industry in the 1950s and provided a tool for planning, scheduling, and coordinating complex engineering-type projects. Other theories that contributed to the concept of ICPs include Lean Six Sigma, Business Process Redesign, and the Theory of Constraints (Schrijvers, Hoorn, and Huiskes 2012). These theories offer several general theoretical advantages to optimizing systems including: shortening the duration of processes; increasing coherence by analysing relationships and interactions between departments; reducing the likelihood of errors; standardizing processes; and avoiding duplication (Schrijvers, Hoorn, and Huiskes 2012).

According to Campbell et al. (1998), the development of ICPs in health services should involve thirteen steps: 1) selecting an important area of practice; 2) gathering support for the project; 3) forming a multidisciplinary group; 4) identifying existing guidelines; 5) reviewing past and present practice; 6) involving local staff; 7) identifying key areas for service development; 8) developing the ICP; 9) preparing documentation; 10) educating staff; 11) pilot testing; 12) regularly analyzing variances from the ICP and updating accordingly; 13) discussing variations and highlighting avoidable (vs. unavoidable) reasons for those (Campbell et al. 1998).

UPTAKE

ICPs were first introduced in the healthcare context in the 1980s in the United States and they are now used worldwide in different settings (Allen, Gillen, and Rixson 2009).

EFFECTIVENESS

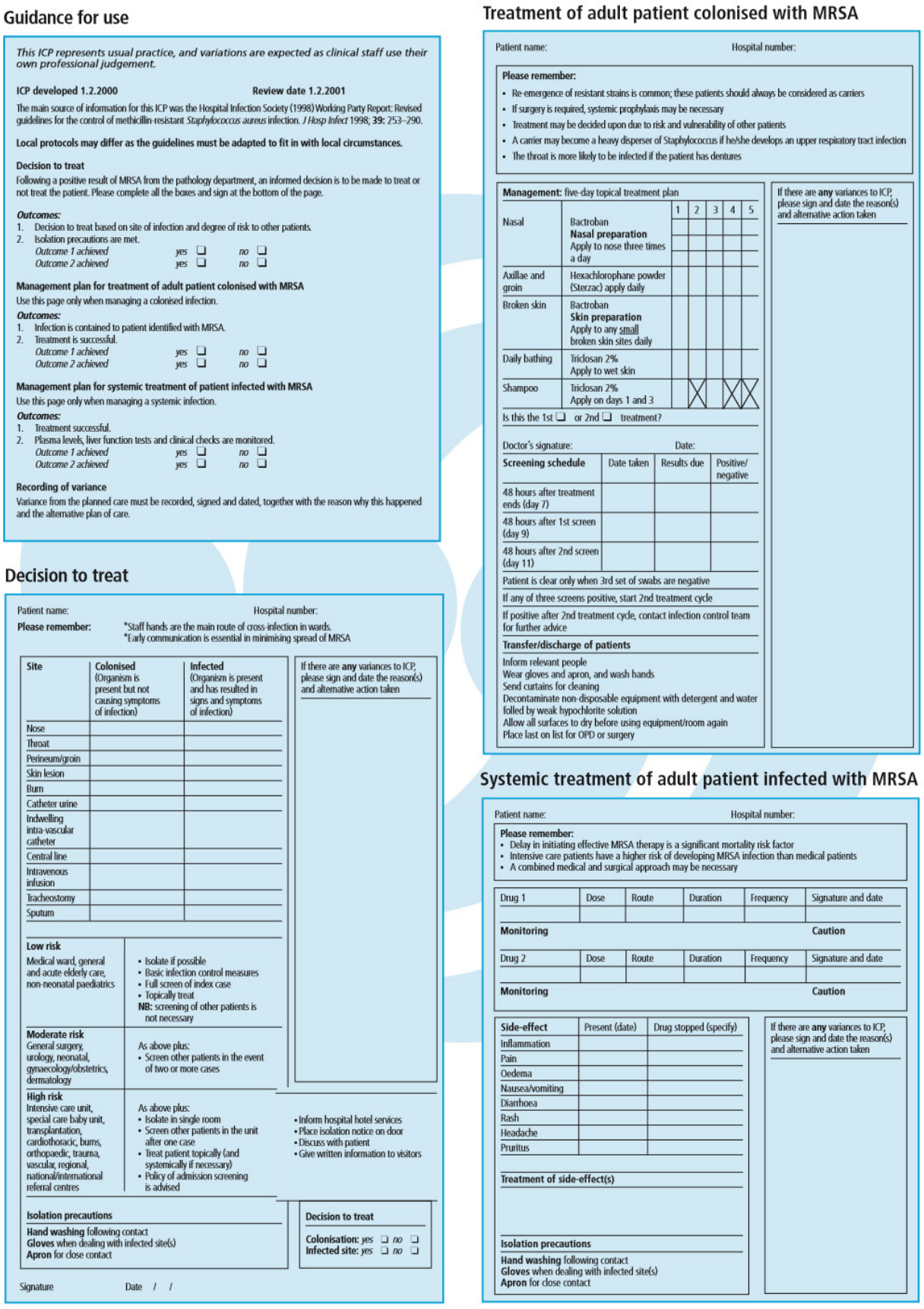
A 2009 review reported ICPs could be effective in supporting proactive care management and ensuring timely assessments and relevant clinical interventions for patients (included 7 RCTs, HICs; Allen, Gillen, and Rixson 2009). A 2018 review reported similar findings: ICPs may reduce the average length of stay, increase cost effectiveness, and improve the quality of services (included 4 studies, HICs; Asmirajanti, Syuhaimie Hamid, and Hariyati 2018). We could not identify evidence on the use or effectiveness of ICPs in LMICs.

TOOL 3: GROWTH MONITORING (GM)

GM is a common practice in paediatric care around the world (de Onis, Wijnhoven, and Onyango 2004). The general concept is as follows: 1) health workers regularly measure children's height and weight; 2) these are plotted on a growth chart (Figure 3); 3) when growth is abnormal, potential underlying issues are investigated in consultation with the family; 4) thus, illness or growth faltering due to malnutrition can be identified early; and 5) the prognosis can be improved by early diagnosis (Garner 2000). GM charts are line graphs depicting growth data from a reference group that is selected to represent healthy child growth patterns over time based on various indices (e.g., weight-for-age or weight-for-height). The data are plotted as centiles or z-scores around a median to facilitate the comparison of a child's growth with that of healthy children (WHO Multicentre Growth Reference Study Group 2006).

DEVELOPMENT

The development of GM has a long record. In the 1850s, regular weighing of infants was advocated by Guillot. By the mid-1920s, a nation-wide network of welfare centres for child weighing was organised in England, and in 1961, growth charts were recommended by a joint committee of FAO and WHO. Due to the pioneering work and advocacy of Dr. David Morley, by the 1970s, GM was being implemented in numerous LMICs. In the 1980s, UNICEF also started advocating for GM, and by 1996 growth charts were included in the WHO/UNICEF strategy for IMCI (Ashworth, Shrimpton, and Jamil 2008). In 2006, WHO published revised child growth standards, developed based on data from the WHO Multicentre Growth Reference Study (MGRS) conducted from 1993 to 2003 to provide updated curves for assessing child growth and development. The MGRS included a longitudinal follow-up from birth to 24 months and a cross-sectional survey of children aged 18 to 71 months among 8440 healthy breastfed children from Brazil, Ghana, India, Norway, Oman, and the USA living in good socioeconomic conditions. Worldwide consultation was held to de-



Guidance for use

This ICP represents usual practice, and variations are expected as clinical staff use their own professional judgement.

ICP developed 1.2.2000 **Review date 1.2.2001**

The main source of information for this ICP was the Hospital Infection Society (1998) Working Party Report: Revised guidelines for the control of methicillin-resistant *Staphylococcus aureus* infection. *J Hosp Infect* 1998; **39:** 253–290.

Local protocols may differ as the guidelines must be adapted to fit in with local circumstances.

Decision to treat

Following a positive result of MRSA from the pathology department, an informed decision is to be made to treat or not treat the patient. Please complete all the boxes and sign at the bottom of the page.

Outcomes:

1. Decision to treat based on site of infection and degree of risk to other patients.
2. Isolation precautions are met.

Outcome 1 achieved *yes* ❑ *no* ❑
Outcome 2 achieved *yes* ❑ *no* ❑

Management plan for treatment of adult patient colonised with MRSA

Use this page only when managing a colonised infection.

Outcomes:

1. Infection is contained to patient identified with MRSA.
2. Treatment is successful.

Outcome 1 achieved *yes* ❑ *no* ❑
Outcome 2 achieved *yes* ❑ *no* ❑

Management plan for systemic treatment of patient infected with MRSA

Use this page only when managing a systemic infection.

Outcomes:

1. Treatment successful.
2. Plasma levels, liver function tests and clinical checks are monitored.

Outcome 1 achieved *yes* ❑ *no* ❑
Outcome 2 achieved *yes* ❑ *no* ❑

Recording of variance

Variance from the planned care must be recorded, signed and dated, together with the reason why this happened and the alternative plan of care.

Decision to treat

Patient name: Hospital number:

Please remember: *Staff hands are the main route of cross-infection in wards.
*Early communication is essential in minimising spread of MRSA

Site	Colonised (Organism is present but not causing symptoms of infection)	Infected (Organism is present and has resulted in signs and symptoms of infection)
Nose		
Throat		
Perineum/groin		
Skin lesion		
Burn		
Catheter urine		
Indwelling intra-vascular catheter		
Central line		
Intravenous infusion		
Tracheostomy		
Sputum		

If there are **any** variances to ICP, please sign and date the reason(s) and alternative action taken

Low risk Medical ward, general and acute elderly care, non-neonatal paediatrics	• Isolate if possible • Basic infection control measures • Full screen of index case • Topically treat **NB:** screening of other patients is not necessary	
Moderate risk General surgery, urology, neonatal, gynaecology/obstetrics, dermatology	As above plus: • Screen other patients in the event of two or more cases	
High risk Intensive care unit, special care baby unit, transplantation, cardiothoracic, burns, orthopaedic, trauma, vascular, regional, national/international referral centres	As above plus: • Isolate in single room • Screen other patients in the unit after one case • Treat patient topically (and systemically if necessary) • Policy of admission screening is advised	• Inform hospital hotel services • Place isolation notice on door • Discuss with patient • Give written information to visitors

Isolation precautions

Hand washing following contact
Gloves when dealing with infected site(s)
Apron for close contact

Decision to treat

Colonisation: *yes* ❑ *no* ❑
Infected site: *yes* ❑ *no* ❑

Signature Date / /

Treatment of adult patient colonised with MRSA

Patient name: Hospital number:

Please remember:

- Re-emergence of resistant strains is common; these patients should always be considered as carriers
- If surgery is required, systemic prophylaxis may be necessary
- Treatment may be decided upon due to risk and vulnerability of other patients
- A carrier may become a heavy disperser of Staphylococcus if he/she develops an upper respiratory tract infection
- The throat is more likely to be infected if the patient has dentures

Management: five-day topical treatment plan

		1	2	3	4	5
Nasal	Bactroban **Nasal preparation** Apply to nose three times a day					
Axillae and groin	Hexachlorophane powder (Sterzac) apply daily					
Broken skin	Bactroban **Skin preparation** Apply to any small broken skin sites daily					
Daily bathing	Triclosan 2% Apply to wet skin					
Shampoo	Triclosan 2% Apply on days 1 and 3		X		X	X

Is this the 1st ❑ or 2nd ❑ treatment?

If there are **any** variances to ICP, please sign and date the reason(s) and alternative action taken

Doctor's signature: Date:

Screening schedule	Date taken	Results due	Positive/ negative
48 hours after treatment ends (day 7)			
48 hours after 1st screen (day 9)			
48 hours after 2nd screen (day 11)			

Patient is clear only when 3rd set of swabs are negative

If any of three screens positive, start 2nd treatment cycle

If positive after 2nd treatment cycle, contact infection control team for further advice

Transfer/discharge of patients

Inform relevant people
Wear gloves and apron, and wash hands
Send curtains for cleaning
Decontaminate non-disposable equipment with detergent and water folled by weak hypochlorite solution
Allow all surfaces to dry before using equipment/room again
Place last on list for OPD or surgery

Systemic treatment of adult patient infected with MRSA

Patient name: Hospital number:

Please remember:

- Delay in initiating effective MRSA therapy is a significant mortality risk factor
- Intensive care patients have a higher risk of developing MRSA infection than medical patients
- A combined medical and surgical approach may be necessary

Drug 1	Dose	Route	Duration	Frequency	Signature and date

Monitoring **Caution**

Drug 2	Dose	Route	Duration	Frequency	Signature and date

Monitoring **Caution**

Side-effect	Present (date)	Drug stopped (specify)
Inflammation		
Pain		
Oedema		
Nausea/vomiting		
Diarrhoea		
Rash		
Headache		
Pruritus		

Treatment of side-effect(s)

Isolation precautions

Hand washing following contact
Gloves when dealing with infected site(s)
Apron for close contact

If there are **any** variances to ICP, please sign and date the reason(s) and alternative action taken

Figure 2. Example of an Integrated Care Pathway (ICP) for methicillin-resistant Staphylococcus aureus (MRSA).

Source: Middleton et al. 2001.

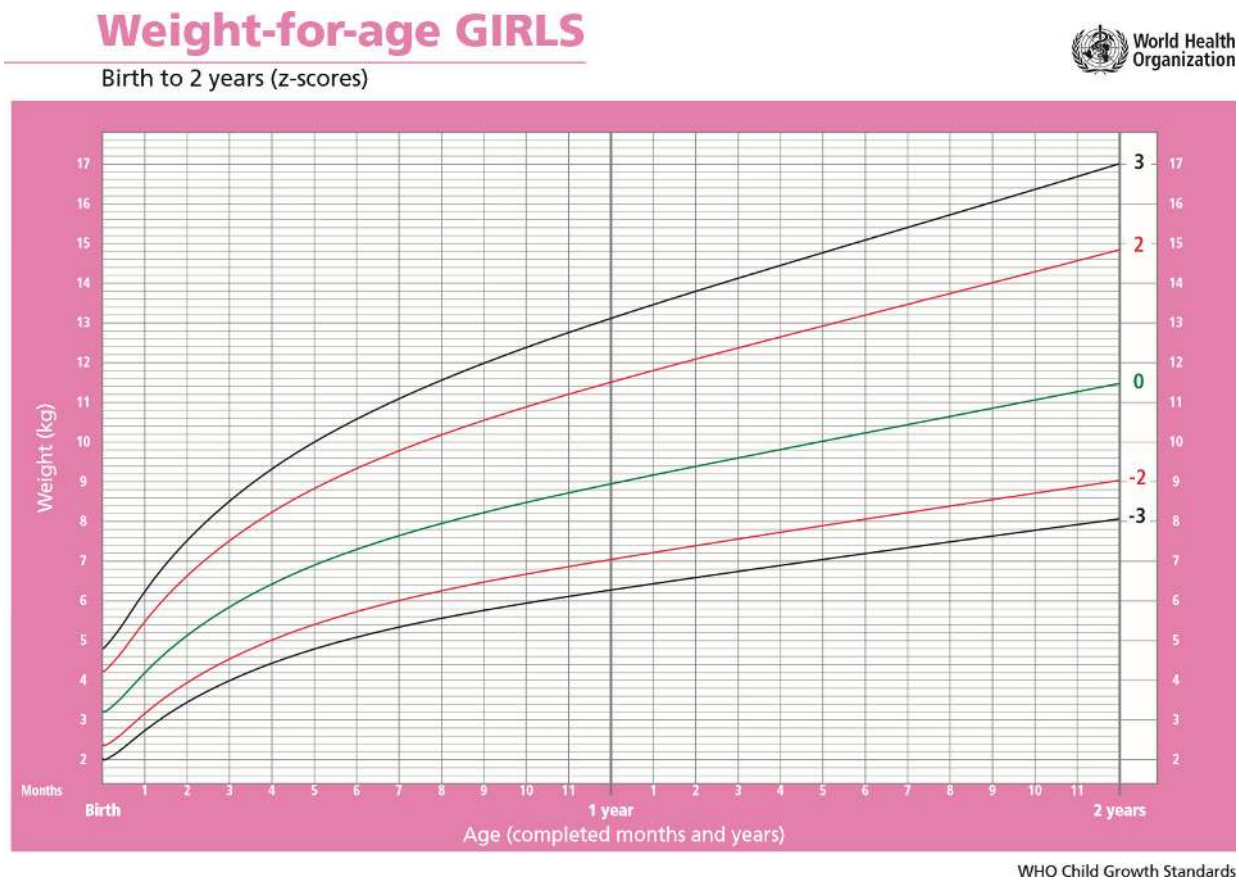


Figure 3. Example of a WHO Child Growth Standards chart depicting weight-for-age z-scores for girls from birth to two years.

Source: WHO, 2006

termine what should be included in the charts in addition to growth curves (e.g., infant feeding information, demographic data, dietary supplementation, and immunization schedules; de Onis, Wijnhoven, and Onyango 2004).

UPTAKE

Charts for use in GM programmes are used worldwide in different contexts and formats. As part of a WHO study of worldwide practices in GM from 1998 to 2000, 154 countries provided hard copies of growth charts used in paediatric care (806 charts total; de Onis, Wijnhoven, and Onyango 2004). We could not identify direct evidence on the extent of uptake in practice.

EFFECTIVENESS

There is limited evidence on the effectiveness of GM for improving child growth and health. A 2000 Cochrane review assessing effectiveness of GM on anthropometric measures, referrals, maternal knowledge and satisfaction, and child morbidity and mortality, found only two studies (both were conducted in LMICs) and their evidence was inconclusive (Panpanich and Garner 2000). Limited qualitative and quantitative evidence suggests that poor comprehension and interpretation of growth charts among health workers and carers may limit the effectiveness of GM. A 2004 WHO study of worldwide practices in GM highlighted several important problems with the use and interpretation of growth charts including: accurately plotting the measurements, understanding the concept of a child "at-risk" and "reference curve", difficulties in interpreting the child's growth curve, and lack of accurate anthropometric equipment (de Onis, Wijnhoven, and Onyango 2004). A 2007 systematic review that included 20 studies from LMICs found that between 33% and 75% of carers do not understand growth charts. Literacy level had a strong effect on carers' ability to interpret growth charts, and training activities effectively increased carers' comprehension (Roberfroid, Pelto, and Kolsteren 2007; Liu et al. 2021; Ben-Joseph, Dowshen, and Izenberg 2007; Al Rahmad, Iskandar, Fadjri, et al. 2022; Ruel, Pelletier, Habicht, et al. 1990).

TOOL 4: PAEDIATRIC EARLY WARNING SCORES (PEWS)

PEWS are used to identify hospitalized children at-risk of physiological deterioration by assigning a score based on vital signs and clinical status, and then using that score to guide interventions using a response algorithm to improve outcomes. The system uses two components: 1) a scoring tool to calculate a PEWS at regular intervals during inpatient treatment, and 2) a response algorithm with appropriate treatment actions to be carried out based on the score (Figure 4; Brown, Martinez Garcia, and Agulnik 2018).

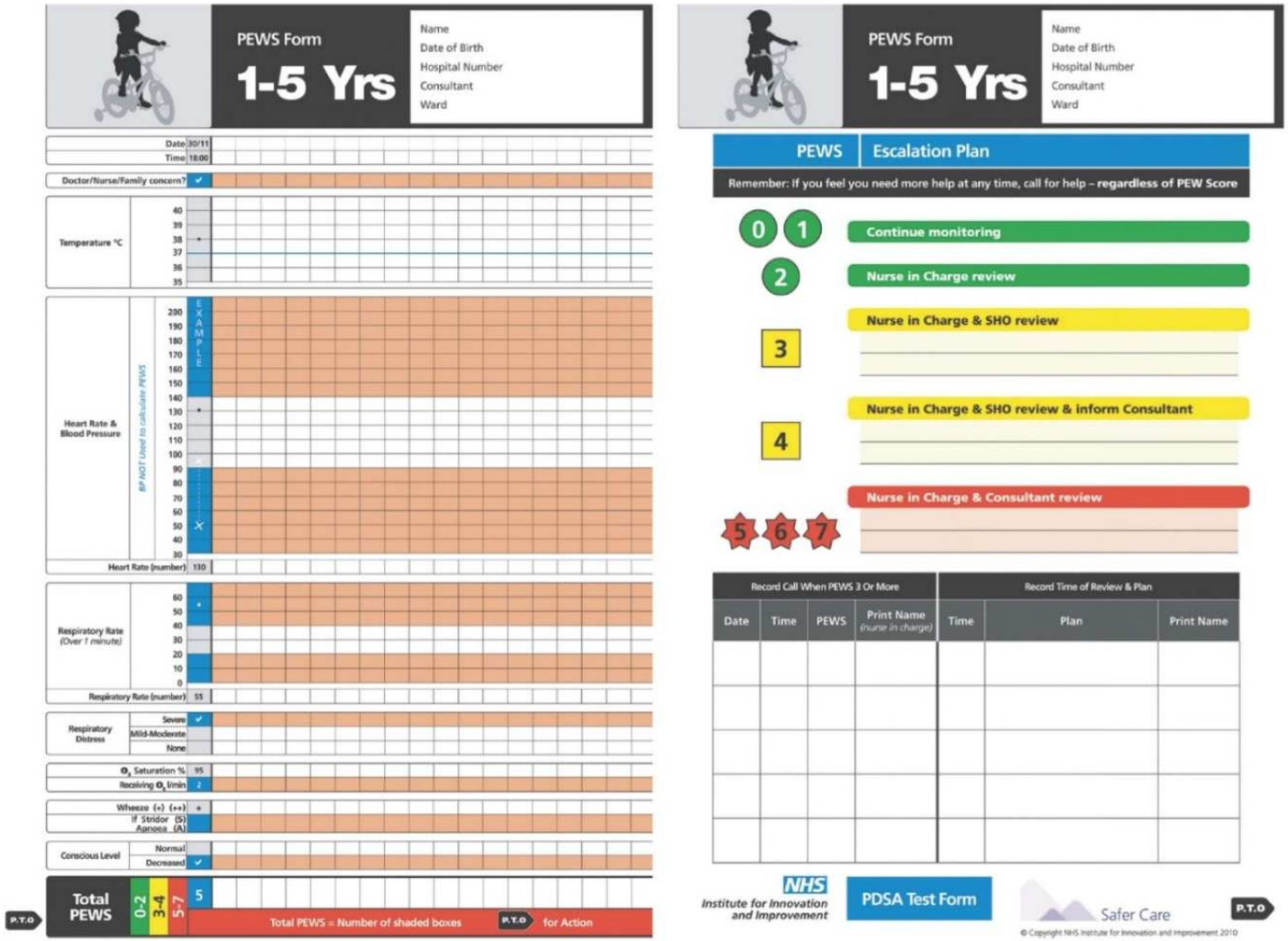


Figure 4. National Health Services Institute Paediatric Early Warning System, (PEWS) chart for children aged 1-5 years with scoring tool (left) and response algorithm (right).

Source: Roland et al. 2012

DEVELOPMENT

One of the first PEWS, known as the Brighton PEWS, was derived from early warning scores tools used in adults and published in 2005. According to Chapman et al. (2018), "no formal validation of the Brighton PEWS was undertaken. This unstructured method of development, based on expert opinion, sentinel events and 'knee jerk' response to individual cases of failed identification characterised the development of PEWS over the subsequent years and contributed to the proliferation of unvalidated PEWS, which are now in existence" (Chapman and Maconochie 2019).

UPTAKE

PEWS are increasingly used in paediatrics in Europe, North America, and Australia (Trubey et al. 2019). In the United Kingdom, most hospitals had implemented PEWS by 2013 (Chapman and Maconochie 2019). While PEWS are used in low-resource settings, we could not find information describing the extent of uptake (Brown, Martinez Garcia, and Agulnik 2018).

EFFECTIVENESS

A 2019 review assessing the effectiveness of PEWS concluded that there was limited evidence that implementing PEWS leads to reductions in patient deterioration and that methodological issues in many studies precluded clear judgement of their utility (36 validation and 30 effectiveness studies, mostly from HICs; Trubey et al. 2019). Another review from 2019 focusing on the use of PEWS in LMICs and humanitarian settings found a paucity of studies on the topic (Brown, Martinez Garcia, and Agulnik 2018). Nonetheless, the available studies showed the potential to reduce mortality and resource utilisation in these settings. The authors identified several key limitations to using PEWS: 1) using a system that relies on frequent collection of vital signs and clinical assessments is impractical in settings where nurse to patient ratios are as low as 1:50, and 2) the response algorithm for many systems includes referral for assessment by a critical care physician or transfer to intensive care which may not exist in some low resource settings (Brown, Martinez Garcia, and Agulnik 2018).

TOOL 5: WHO EMERGENCY TRIAGE ASSESSMENT AND TREATMENT (ETAT)

The WHO ETAT guidelines are designed to identify children with urgent life-threatening conditions frequently seen in LMICs, including airway obstruction and breathing problems due to infections, shock, coma or convulsions, and severe dehydration (WHO 2005). The ETAT guidelines were created to complement IMCI but are intended to be accessible to non-clinical health workers who may be called upon to assist with triage (Robertson, Manson, and Fioratou 2018). Several charts are provided along with the guidelines to guide triage procedures; these charts are also found in the WHO Pocket Book of Hospital Care for Children (Figure 5; WHO 2013b).

DEVELOPMENT

First published in 2005, the ETAT guidelines were developed in Malawi and field tested in multiple countries including Angola, Brazil, Cambodia, Indonesia, Kenya, and Niger (WHO 2005). The ETAT guidelines and materials were adapted from the guidelines for Advanced Paediatric Life Support that are used in HICs (European Resuscitation Council 2005). Updated guidelines were published in 2016 to reflect new evidence on paediatric care identified by a WHO guideline development scoping group (WHO 2016a).

UPTAKE

We could not identify specific information on the uptake of ETAT; however, one study assessed the coverage and uptake of the WHO Pocket Book which includes the ETAT guidelines in the first section (Li et al. 2013). It found that 64 LMICs (44% of 145 LMICs globally) reported at least partial implementation of the Pocket Book, with 17% of LMICs reporting that implementation was well under way. However, the classification that implementation is 'well under way' does not imply national coverage, and even in countries using multiple implementation strategies, the proportion of hospitals estimated to be using the Pocket Book was low (Li et al. 2013).

EFFECTIVENESS

We could not find any reviews of the effectiveness of ETAT, but we did identify four individual studies that investigated the effectiveness of using ETAT including one qualitative study. The results suggest that the ETAT system performs well as a triage tool and may improve patient care even when used in resource-limited settings (Crouse et al. 2016; Buys et al. 2012; Tamburlini et al. 1999). Barriers include staff training needs, heavy workload, and a lack of resources in some settings (Robertson, Manson, and Fioratou 2018).

TOOL 6: ELECTRONIC PATIENT MANAGEMENT TOOLS (E-TOOLS)

The use of e-tools has the potential to improve quality of care by providing health workers with instant bedside decision support and improving adherence to treatment guidelines (Bessat, Zonon, and D'Acremont 2019). In HICs, the use of e-tools for clinical decision making has been well-investigated as health systems may be more amenable to technological innovation than those in resource-limited settings (Adepoju et al. 2017). Nonetheless, there is a substantial body of evidence on the use of e-tools in LMICs. We identified literature on e-tool versions of ICPs, IMCI (Figures 6) and PEWS but could not find similar literature for GM or ETAT.

DEVELOPMENT

Likely due to wide variation, at the time of our review we could not identify specific descriptions of key steps for the

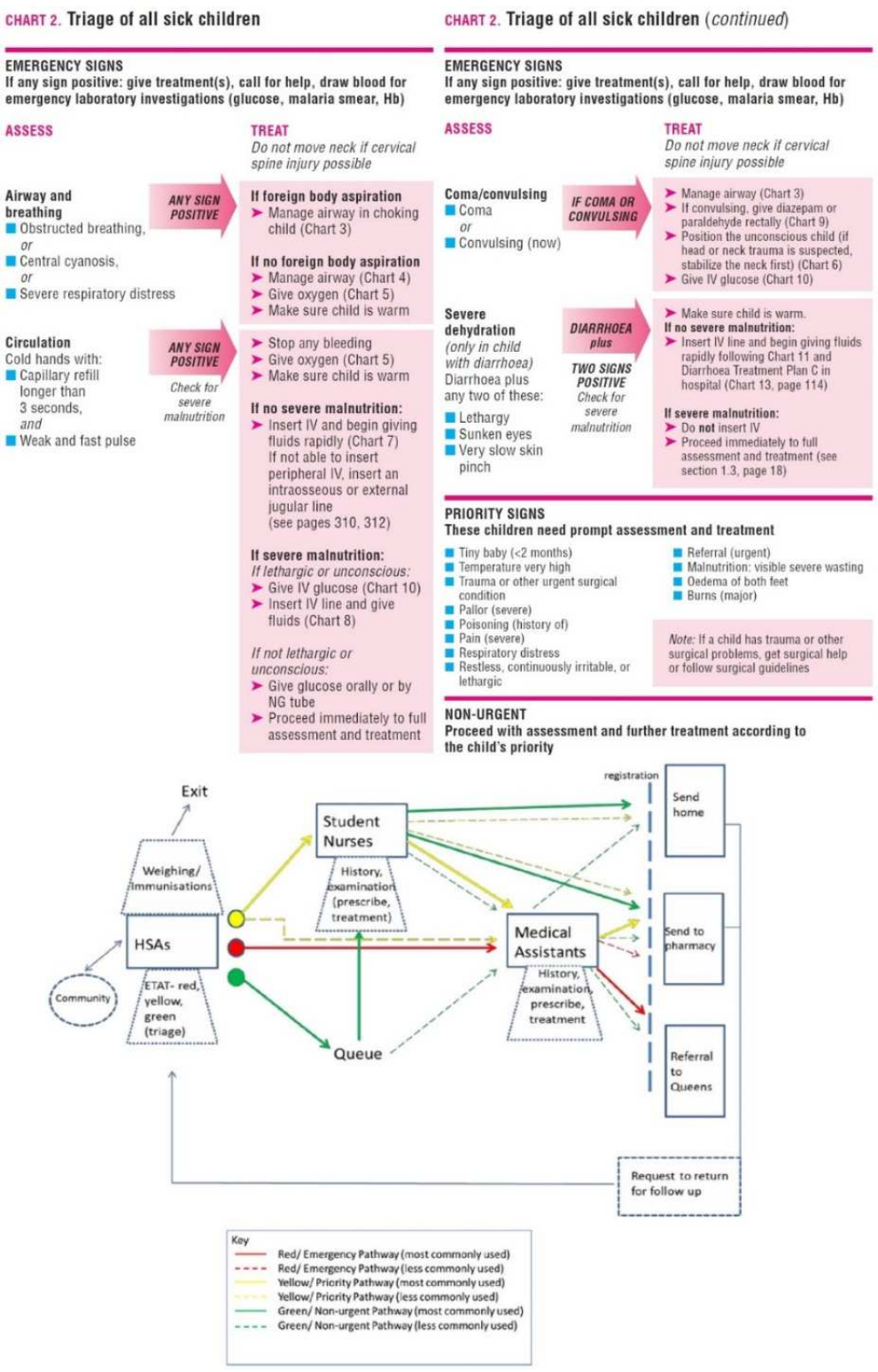


Figure 5. Emergency Triage Assessment and Treatment (ETAT) guidelines included in the first pages of the WHO Pocket Book of Hospital Care for Children (Top) and Process map of a primary healthcare clinic in Malawi using WHO ETAT model (Bottom).

Sources: WHO 2013b; Robertson, Manson, and Fioratou 2018

development of electronic patient management tools. With regards to ICPs, one study reported a lack of understanding on the requirements for designing user-friendly electronic care pathways (Balatsoukas et al. 2015).

UPTAKE

We could not find information on the scale of e-tool uptake; however, a 2010 review of medical decision support systems in Africa reported limited progress as most of these systems



Figure 6. An electronic decision-making tool to support the implementation of IMCI in primary healthcare facilities in KwaZulu Natal, South Africa.

Source: Jensen, McKerrow, and Wills 2019

were deployed by international organizations with limited ownership by local stakeholders (Bediang, Bagayoko, and Geissbuhler 2010).

EFFECTIVENESS

E-tools may improve quality of care by improving adherence to guidelines, increasing completeness of patient assessments and accuracy of classification of conditions, and aiding with referral decisions compared to paper forms. However, health system barriers present an important challenge to effectively implementing e-tools. These barriers include: increased workload and consultation time compared to routine practice, lack of staff, low computer literacy, and limited access to computers (Bessat, Zonon, and D'Acremont 2019; Schaeffer et al. 2019; Jensen, McKerrow, and Wills 2019; Shao et al. 2015; Mitchell et al. 2013). A 2017 review of mobile clinical decision support systems (mCDSS) in sub-Saharan Africa reported improvement in individual service delivery components; however, existing evidence does not support the ability of mCDSS to improve quality of care or clinical outcomes (Adepoju et al. 2017).

DISCUSSION

SUMMARY OF EVIDENCE

The results of this scoping review provided useful insights to inform not just the update of the MAMI Tool, which was reconfigured to apply an integrated care pathway approach and reframed as the 'MAMI Care Pathway Package,' but also for others working on other tools and patient care pathways for a broader range of conditions. Given their widespread use globally, the most striking finding of our review was the paucity of published evidence underpinning patient management tools throughout their life cycle – from initial development to roll-out and scale-up to evidence of impact and effectiveness at-scale. Although many are logical, intuitive, and contain individual elements/interventions that are underpinned by robust evidence, this does not automatically mean that they will work as expected at scale. The strongest evidence of effectiveness is for the use of ICPs. However, this evidence was generated in HICs and may not be as applicable in LMICs. Among the tools investigated in this review, IMCI and ETAT appear to be the most commonly used patient management tools in LMICs: both of these have some (albeit not extensive) research describing early stages of their development. Coverage remains the major barrier to effectiveness. GM is also widely used in LMICs despite a lack of evidence of its effectiveness. There is growing evidence on the use of e-tools for patient management, but evidence from low resource settings is limited and their use might not be practical or scalable at present; context-specific research on feasibility would provide better insights.

Of note since our review, WHO has initiated development of Em Care, an open-source digital platform (app) that delivers clinical decision-making support to frontline workers in emergency settings; it is currently being piloted in Iraq and Cameroon. They use SMART Guidelines (Standards-based, Machine-readable, Adaptive, Requirements-based, and Testable), a five-step pathway to advance the adoption of best clinical and data practices.

In summary, though patient management tools are widely used, there seems to be a major need to improve the evidence base underpinning currently used tools. New resources being developed – ours included – should investigate and better document every stage of their development and subsequent use.

LIMITATIONS AND STRENGTHS

We acknowledge the limitations of our review. Being a scoping review, we may not have found all directly relevant evidence. Even so, had we conducted a full systematic review on key steps in the development and rollout of each tool, we suspect that information may not have been published, especially for the older ones like GM and IMCI. That said, we did find some systematic reviews and it was striking that even these included few papers – we expected to find far more evidence underpinning such large-scale, long-established patient management tools. Future reviews might thus also explore if there are internal reports and other unpublished documents available. Addressing this limitation, we hope that scientists developing future tools (as well as agencies funding their development) will pay more attention to formal write-ups so that the process from start to finish is better documented and accessible in major clinical and public health databases. A related challenge in building the evidence base is that some tools are inherently difficult to research because control groups (e.g., where growth is not formally monitored) may be considered unethical or may be impractical and hence utilizing the 'pyramid of evidence-based medicine' may not be feasible or even fully relevant. Finally, we acknowledge that we only looked at a limited range of patient management tools – others may also be available and might have broadened our discussion and insights.

Despite these limitations there are also strengths to our review. Firstly, this scoping process highlights the importance of learning from the past to build on what others have done, both what has gone well and what could be improved on. Secondly, though we started this review to directly inform our own work on the MAMI Tool, many of our findings and insights may be generalizable lessons for others. Finally, and most importantly, we hope that our finding regarding the paucity of evidence will inspire future researchers from a wider range of settings to better document the process for all stages of patient management tool development and utilization.

IMPLICATIONS: FROM PATIENT MANAGEMENT 'TOOL' TO 'CARE PATHWAY' AND OTHER KEY STEPS

Based on this scoping review, we followed the key steps below to update our MAMI Tool to a MAMI Care Pathway Package, reconfigured using an ICP approach. These may also be key considerations for other teams working to improve patient care and translate technical guidelines to ef-

fective frontline clinical practices in other areas of child (and adult) health and nutrition.

1. FOCUS ON ICPS RATHER THAN TOOLS

We had previously focused our thinking and terminology on a patient management "tool" to support key steps in assessing and treating vulnerable infants. This approach risks being seen by some programme managers as all that is needed to start a new service or programme, vertically delivered or isolated from the local context. Reframing the tool as an ICP and following the steps outlined by Campbell et al. (1998) provide a much clearer, more comprehensive structure and reminder that an intervention is part of a wider system with staff being a key part of that system and that context is critical. Good 'tools' are necessary but not sufficient for success. Rather, the 'tool' is nested within the wider process of an ICP. The ICP framework is especially important in reminding managers that staff must be closely involved, and individual context adaptations made in order to implement change. It also serves as a reminder of *why* care pathways matter and *for whom* they matter. They are not an end in themselves but rather a means to continually improving and achieving quality patient care so that clinical and public health-relevant outcomes can be optimized.

Process maps are important to indicate what should happen at each step of patient care and what linkages and referrals should be made according to different enrollment and discharge criteria. Process maps may be used during communications with new stakeholders and trainings to help a broad range of stakeholders understand the overall approach.

The need for good documentation is also highlighted in ICP frameworks/guides. This helps both immediate patient care (e.g., reminding healthcare workers of what to do in certain situations) but also helps with auditing and learning from the programme overall when many sets of patient care notes are combined (e.g., is a particular step being done well or not and why; does it seem to be impacting final outcomes). In developing the materials, ICP thinking also emphasises the importance of considering "end user" experience. For example, this might entail involving a range of stakeholders across a wide range of disciplines, operational experiences, and contexts in the initial development, as well as considering usability and format, engaging with graphic designers and other specialists to optimize visuals and key documents.

2. ALIGN NEW CARE PATHWAYS WITH EXISTING PATHWAYS AND CLINICAL CARE SYSTEMS

To facilitate future integration at scale, it is important to align and be consistent with existing systems and frameworks. For example, IMCI is a well-established and long-standing framework and approach to infant and child health in LMICs. The MAMI Care Pathway is designed not as a new parallel system but as a resource to fit within the existing IMCI format and patterns of thinking. We add value by elaborating or adding new elements to IMCI (e.g., emphasis on the role of maternal mental health as a key determinant of infant health/growth/nutrition) and by directly testing these new components. The MAMI Care Pathway remains consistent with the IMCI approach and content and defers to local guidance and protocols for individual case management. Since it is already familiar, we hope that this will count positively towards healthcare worker user experience as well as patient experience (since links and referrals for other health problems can more easily be made). This also maximises the potential for inclusion into existing systems and IMCI updates.

3. BASELINE QUALITATIVE AND OTHER FORMATIVE RESEARCH

Before testing the MAMI Care Pathway in a RCT in Ethiopia in 2022/23, MM and MK have conducted qualitative research among health workers and end-users to inform context-specific adaptation to strengthen feasibility (Read 2017b; Jibat et al. 2022). This will also add to a wider body of qualitative research in other settings and is in line with the WHO recommendation 4a from 'A Strategic Review of Options for the Future Building on Lessons Learnt From IMNCI' conducted in 2016 which encouraged:

- *"User-centred design, a longstanding and proven conceptual framework for developing products, services or systems, can improve health workers' experience with guidelines and thereby increase effectiveness.*
- *[Bringing] together existing guidance packages on care for newborn and child health into one set of flexible, adaptable, user-friendly tools, incorporating input from end users and design specialists".* (WHO 2016b)

4. CONDUCT FORMAL EFFECTIVENESS RESEARCH

Following on from initial qualitative and formative research, larger-scale and more formal studies are important (e.g., the RCT on the MAMI Care Pathway, Version 3 in Ethiopia involving co-authors MK and MM; Kerac 2022). It is surprising that the interventions we reviewed in this piece were not underpinned by more formal initial studies, but this is perhaps explained by the fact that population-based and complex intervention designs were not as common at the time. Following frameworks such as the UK Medical Research Council guide on "developing complex interventions to improve health and healthcare" could add much value to long-term intervention use and impact (O'Cathain et al. 2019). This is because once an intervention is established as a 'standard of care' controlled trials become ethically difficult. Other evaluation methods are of course available but can be more difficult to interpret due to risks of bias and unknown confounding in observational study designs.

5. COLLECT INFORMATION ON ANY VARIANCE FROM, ADAPTATIONS TO, AND EXPERIENCES OF DELIVERING CARE PATHWAYS

Many emerging experiences of researching, piloting, and implementing the approach around the world will inform future updates of the MAMI Care Pathway Package. Con-

textual adaptations may be minor or major and may or may not apply to other settings (e.g., a minor change might involve including questions about family planning which is acceptable to discuss freely in some settings but not others; a major change might involve changes to the anthropometric admission criteria defining at-risk infants – whilst there may be local reasons for sticking to weight-for-length rather than weight-for-age, such a change might make neighbouring programmes difficult to compare and so should be considered very carefully). They might also involve whether or not healthcare workers and/or carers are following a particular recommendation or the cadre of staff delivering care. Documentation of the implementation process will allow programmers to describe and investigate reasons why practice is deviating from that recommended in the pathway and the implications both for outcomes and future updates (Campbell et al. 1998).

6. INVESTIGATE THE FEASIBILITY OF USING AN E-TOOL

Whilst not an immediate priority for our MAMI Care Pathway, e-tools are increasingly proving to be useful, so we should bear in mind that current paper-based tools might be adapted and used on electronic platforms in the near future. Advantages of this could include that changes to the patient information forms can be made more easily and quickly; data are more quickly captured; and data can be immediately validated at source (e.g., the system would ask that very large or very small infants be re-measured to ensure that they are indeed very large/small rather than that the anthropometric measure or age has been entered incorrectly).

CONCLUSION

Despite being widely used in many settings worldwide, there is relatively little evidence on patient management tools. Whilst many provide a logical and plausible way of translating individual interventions and guidelines into frontline clinical practice, overall evidence of effectiveness is poor. Among the tools we reviewed, ICPs showed the most consistent evidence of effectiveness. While this evidence was primarily from HICs, applicability to LMIC settings is likely, especially as they outline the entire process of development of a care pathway and emphasise the need to adapt and reflect different contexts, settings, and services available. Future work to improve frontline patient care should focus on ICPs (rather than isolated patient management 'tools' alone), align with and take into account existing pathways and systems, conduct baseline qualitative and formative research, conduct more formal effectiveness research prior to scale-up, collect information on variances from and adaptations to the care pathway, and consider future e-tools.

The results of this scoping review provided useful insights to inform the update of the MAMI Tool, which was reconfigured to apply an integrated care pathway approach and reframed as the 'MAMI Care Pathway Package.' Our findings also have relevance for those working on other tools and patient care pathways for a broader range of conditions. Based on the findings of this scoping review as well as other literature reviews, stakeholder consultation, and learnings from previous implementation experiences, the MAMI Care Pathway Package (Version 3, 2021) is published at https://www.ennonline.net/mamicarepathway.

ROLE OF AUTHORS

KG, MK and MM conceived the manuscript. KG performed electronic search and synthesized the findings. KG and RR drafted the manuscript. MM and MK reviewed and revised the manuscript. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None

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ANNEX 1. SEARCH STRATEGY

SEARCH STRATEGY 1: INTEGRATED MANAGEMENT OF CHILDHOOD ILLNESS

Search 1: Limited to titles and abstracts 85 results

- (Integrated management of childhood illness or IMCI) AND (tool* or chart* or checklist*)

Search 2: Limited to titles and abstracts 51 results

- (Integrated management of childhood illness or integrated management of newborn and child illness or IMCI or IMNCI)
- AND (tool* or chart* or checklist*)
- AND (design* or format* or develop* or effective* or uptake or graphic* or lay out)

Search 3: Limited to titles and abstracts 246 results (no results specifically related to design or visuals)

- (Integrated management of childhood illness or integrated management of newborn and child illness or IMCI or IMNCI)
- AND (design* or format* or develop* or effective* or uptake or graphic* or lay out or interface)

Search 4: Limited to titles and abstracts 29 results

- (Integrated management of childhood illness or integrated management of newborn and child illness or IMCI or IMNCI)
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or eIMCI or computer based or automat* or mobile-assisted or mobile* or mhealth or telehealth or digital)

SEARCH STRATEGY 2: INTEGRATED CARE PATHWAYS

Search 1: Started reviewing Campbell 1998 for search terms

Search 2: Limited to reviews, searched in titles only 3284 results (too many hits to review all)

- (Patient or integrated or coordinated) AND care pathway*
- (Care or clinical) AND pathway
- (Anticipated recovery or patient) AND pathway*
- (patient or integrated or coordinated) AND (pathway design or pathway redesign)
- Structured care method*

Search 3: Added another line to search 2 and re-ran: limited to reviews, searched in titles only 147 results

- AND design or redesign or development or format or layout or effective* or improve* or creat*

Search 4: Limited to reviews, searched in titles only 33 results

- (Patient or integrated or coordinated or clinical) AND care pathway*
- AND effective*

Search 5: Broke down search components: limited to reviews, searched in titles only 37 results

- (Patient or integrated or coordinated) AND care pathway*

Search 6: Limited to reviews, searched in titles only 11 results (all identified previously)

- (Patient or integrated or coordinated or clinical or care) AND pathway*
- AND effective*

Search 7: Limited to reviews, searched in titles only 43 results

- (Patient or integrated or coordinated or clinical or care) AND pathway*
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or computer based or mobile-assisted or mobile* or mhealth)

Search 8: Limited to titles and abstracts 50 results

- Integrated care pathway* or computer-based medical decision support system*
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or computer based or mobile-assisted or mobile* or mhealth)

SEARCH STRATEGY 3: GROWTH MONITORING

Search 1: Limited to reviews, searched titles and abstracts 21 results, 121 results w/o review filter

- Growth monitoring
- AND effective*

Search 2: Limited to titles and abstracts 122 results

- Growth monitoring
- AND (tool* or chart* or graph*)
- AND (design* or format* or develop* or effective* or uptake or graphic* or lay out)

Search 3: Limited to titles and abstracts 24 results (none relevant)

- (Child or childhood) AND growth monitoring
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or computer based or automat* or mobile-assisted or mobile* or mhealth or digital)

SEARCH STRATEGY 4: PEDIATRIC EARLY WARNING SCORES

Search 1: Google search for PEWS Roland hand searched reference list to identify Chapman and Pashuram

Search 2: Searched titles and abstracts, limited to reviews 11 results

- (Paediatric or pediatric) AND (early warning system or early warning scores)
- OR (paediatric or pediatric) AND alert criteria
- OR (paediatric or pediatric) and (track and trigger tool*)

- AND effective* or valid*

Search 3: Searched titles and abstracts 48 results

- (Paediatric or pediatric) AND (early warning system or early warning scores)
- OR (paediatric or pediatric) AND alert criteria
- OR (paediatric or pediatric) and (track and trigger tool*)
- AND (tool* or chart* or graph*)
- AND (design* or format* or develop* or uptake or graphic* or lay out)

Search 4: Limited to titles and abstracts 50 results

- (Paediatric or pediatric) AND (early warning system or early warning scores)
- OR (paediatric or pediatric) AND alert criteria
- OR (paediatric or pediatric) and (track and trigger tool*)
- OR PEWS
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or computer based or automat* or mobile-assisted or mobile* or mhealth or digital)

SEARCH STRATEGY 5: EMERGENCY TRIAGE ASSESSMENT AND TREATMENT

Search 1: Searched titles and abstracts 38 results

- (Emergency Triage Assessment and Treatment) or ETAT
- AND effective* or valid*

Search 2: Searched titles and abstracts 10 results

- (Emergency Triage Assessment and Treatment) or ETAT
- AND (tool* or chart* or graph*)
- AND (design* or format* or develop* or uptake or graphic* or lay out)

Search 3: Searched titles and abstracts 28 results (none relevant)

- (Emergency Triage Assessment and Treatment) or ETAT
- AND (e-tool or e-platform or mobile technolog* or web-based or application* or electronic or computer based or automat* or mobile-assisted or mobile* or mhealth or digital)