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ORIGINAL RESEARCH

Paediatric resuscitation in regional Queensland: A simulation informed biopsy of current system challenges

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Abstract

Objectives: An outreach education service, Simulation Training Optimising Resuscitation for Kids (STORK) identified opportunities to use their course (Optimus PRIME) to understand and help optimise regional paediatric resuscitation. Our objective was to document challenges faced by healthcare providers in rural, remote, and regional (RRR) health centres in Queensland during a paediatric resuscitation course and ensure information reached stakeholders.

Methods: Using *in situ* simulation, participants were prompted to identify real-life challenges during paediatric resuscitation. Participants co-generated solutions to these specific challenges and identified local advocates. Summaries for stakeholders included service strengths and improvement opportunities. Site follow-up identified actions taken and supported ongoing challenges.

Results: Between March and December 2023, 40 Optimus PRIME courses were delivered. Thirty-nine course summaries were sent. Using the safety software in infusion pumps, 60% and 81% of sites were unable to correctly administer adrenaline or phenytoin, respectively. One or more pieces of paediatric oxygenation or ventilation equipment were lacking at 65% of sites. Participants working at 81% of sites were unfamiliar with the Queensland Health paediatric guidelines.

Conclusion: We highlight challenges for healthcare providers across Queensland and demonstrate educational teams can contribute to their resolution. Many problems perceived as local were occurring statewide. Our findings inform further advocacy. Our report informs opportunities for system optimisation and highlights inconsistencies in three key areas: infusion pump safety software, access to paediatric resuscitation equipment, and access to information technology. Statewide consistency synergising with local expertise is needed to ensure every child in Queensland has access to optimal resuscitation.

Key findings

- Throughout Queensland, safety software in infusion pumps frequently impedes administration of adrenaline and phenytoin at rates and doses recommend by paediatric statewide guidelines.
- One or more pieces of paediatric oxygenation or ventilation equipment were absent in 65% of hospital resuscitation trolleys when visited during this study.
- Staff throughout Queensland frequently identified barriers to computer or internet connection in resuscitation areas, and 81% of sites visited documented staff unfamiliarity with statewide resources.

Key words: *outreach, paediatric, resuscitation, rural health services, simulation.*

Introduction

Rural Australians have disproportionately lower access to healthcare and poorer health outcomes than those in metropolitan areas.[1] Children are specifically vulnerable, because of unfamiliarity with paediatric guidelines, equipment, and decreased resources.[2–6]

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6 Improving paediatric resuscitation in regional Australia is crucial and dependent on understanding barriers to optimal care.

In Queensland, paediatric resuscitations are infrequent, limiting data collection from clinical events and identification of barriers. This is further complicated by Queensland's size, a state with 106 hospitals distributed over 1 700 000 km^2. While data have been published on regional healthcare in New South Wales (NSW),[5] little is published regarding barriers in rural, remote and regional (RRR) Queensland. Understanding these barriers potentiates targeted efforts to improve paediatric resuscitation in RRR settings.

Simulation provides opportunities to diagnose barriers to optimal care in clinical settings. The Simulation Training Optimising Resuscitation for Kids (STORK) simulation service from Children's Health Queensland, founded in 2014, delivers paediatric education with a mission to 'ensure every child in Queensland has access to optimal resuscitative care'. Over the years, our role in statewide education provided unique insights into the realities and resuscitation challenges faced by clinicians in RRR Queensland.

One of the courses that STORK delivers is called 'Optimus PRIME', which focuses on 'Preparing for Retrieval in Medical Emergencies'. In 2023, translational simulation principles were formally integrated into the course. 'Translational simulation' describes '*how simulation may be connected directly with health service priorities and patient outcomes, through interventional and diagnostic functions*'.[7] Using simulation to explore the real-world challenges that clinicians face,[8] we sought to understand barriers to optimal paediatric resuscitation in Queensland.

This article describes our findings, synthesises challenges in Queensland, and advocates for targeted innovation.

Abbreviations and terminology

- RRR: Rural, Regional and Remote.
- STORK: An acronym for 'Simulation Training Optimising Resuscitation for Kids', the statewide simulation outreach service funded by Children's Health Queensland.
- Optimus Courses: A suite of paediatric resuscitation courses provided by the STORK service.
- Optimus PRIME: One of the paediatric resuscitation courses provided by the STORK service. An acronym for 'Preparing for Retrieval in Medical Emergencies'.

Methods

This was a qualitative study using document analysis of course questionnaires, summaries, follow-up forms, and course-related emails generated from 40 Optimus PRIME courses delivered by the STORK team members from March to December 2023 across 37 healthcare facilities in Queensland. Below we provide details about our service (STORK), the course 'Optimus PRIME' and the hospitals included in the present study.

About the STORK service

STORK is an outreach simulation-based education service involving a multidisciplinary team of simulation educators travelling across Queensland delivering paediatric resuscitation courses. STORK provides training through a spiral curriculum named Optimising Paediatric Training in Emergencies Using Simulation (OPTIMUS). Our curriculum consists of four major constituent courses for first or second tier responders. STORK collaborates with RRR sites interested in the curriculum. During its first decade, STORK delivered 100–140 courses per year to over 60 hospitals. This work has provided insight into challenges faced by clinicians working in RRR Queensland, and the present study aimed at capturing these.

About Optimus PRIME

STORK's most frequently delivered course, 'Preparing for Retrieval in Medical Emergencies (Optimus PRIME)', focuses on resuscitation and retrieval of critically unwell children. In this course, faculty support participants to build on current knowledge, understand 'how to do' and 'what to do' during skills stations and promote knowledge application during simulations, delivered *in situ* whenever possible. In our traditional Optimus PRIME course (Fig. 1: educational arm), participants listened to specific lectures (e.g.: paediatric airway management), before rehearsing a specific skill (e.g.: preparing intubation as a team) and finally putting it together in a simulation activity (e.g.: severe bronchiolitis requiring intubation).

For the present study, methodologies from translational simulation were added to the traditional Optimus PRIME course (Fig. 1: translational arm) to explore and capture the challenges faced by clinicians across RRR Queensland. Early in the course, the Human Factor framework of 'self, team, environment and system'[9] is introduced, to help participants identify factors shaping their performance during the course. Each issue flagged by participants (e.g.: environment problem; no access to computer to help document resuscitation) was documented on a sticky note and displayed on a wall. During course closure, each issue was reviewed, discussed and actionable solutions were co-generated, with local advocates identified for implementation. Examples of collected data from our translational intervention, as it relates to our course's educational objectives and activities are presented in Table 1.

Within 14 days after each course, faculty wrote site summaries for stakeholders outlining service strengths and opportunities identified during training, categorised as: issues with (a) drug safety, (b) equipment or departmental layout, (c) resources, and (d) team relationships (Fig. 2). Sites were contacted by phone after 3 months to explore progress and troubleshoot challenges.

About the hospitals

The healthcare facilities visited varied from very small regional sites to large tertiary hospitals. To contextualise the generalisability of our data, an overview of their annual admission rates is provided in Table 2.

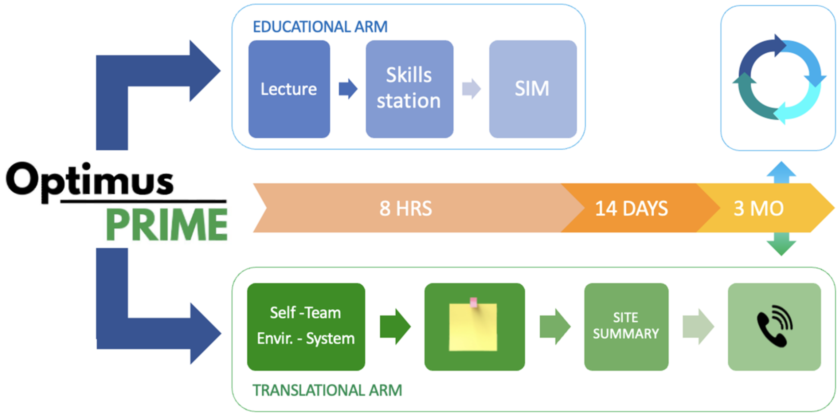


Figure 1. *Flow diagram of our intervention and associated time frame of each component. envir., environment; hrs, hours; mo, months; SIM, simulation.*

Ethics

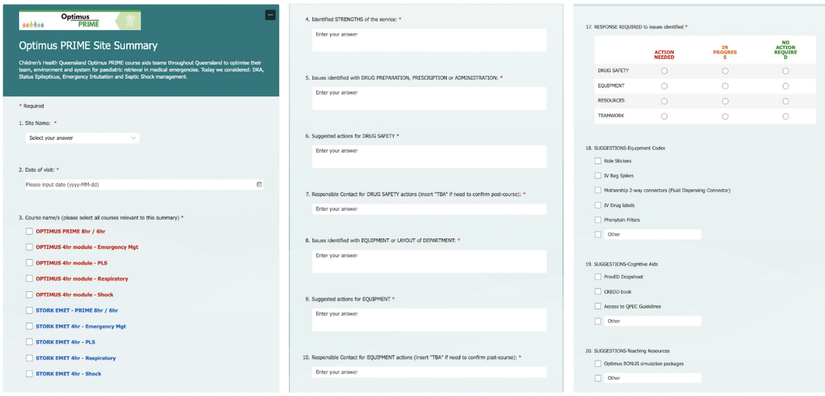
This project was granted an ethics review exemption from the Children's Health Queensland Human Research Ethics Committee as a Quality & Safety Project. No data on individual performance was collected. Course data collection occurred as a component of our standard quality processes. Optimus PRIME participants are oriented to our data collection process during the first phase of the course and contribute to consensus building at the end of the course about what issues should be communicated *via* report. All course coordinators involved in the present study were informed of our intent to publish the aggregated data within this text.

Document analysis

The present study used a convenience sample of all RRR sites where Optimus PRIME was delivered by STORK during our study period. Data was collected from multiple documents, including the initial site summaries, follow-up forms, participant questionnaires,

TABLE 1. *Examples of the educational and translational simulation goals for the Optimus PRIME course*

Optimus PRIME course structure	Educational arm	Translational arm	
	Educational objectives	Quality & safety data collected	Data collection source
Module 2: Paediatric status epilepticus	• Review the structured approach to status epilepticus • Review the status epilepticus clinical algorithm • Prescribe, prepare and administer second line anti-epileptic agents	• Access to statewide or local protocol on paediatric status epilepticus • Testing of smart pump safety software for phenytoin & levetiracetam • Presence of 0.22 μm filters for phenytoin infusions • Issues flagged by participants & facilitators	• Site summaries • Follow-up forms • Course-related emails
Module 3: Paediatric respiratory distress	• Discuss patient optimisation prior to intubation • Discuss a team-based approach to intubation • Integration of a paediatric intubation checklist • Introduction to paediatric ventilation physiology	• Availability and location of paediatric specific airway and ventilation equipment in resuscitation areas • Presence and integration of airway checklist • Presence and use of local escalation pathways for emergent intubation • Issues flagged by participants & facilitators	• Site summaries • Follow-up forms • Course-related emails
Course closure	• Take home learnings • Collaborative wrap up conversation between participants and faculty	• Synthesis of observations on post it notes and agreement on items for escalation • Email addresses for local change agents relevant to concerns	• Participants questionnaires • Site summaries • Follow-up forms • Course-related emails



Optimus PRIME

Optimus PRIME Site Summary

Children's Health Queensland Optimus PRIME course aids teams throughout Queensland to optimise their team, environment and system for paediatric retrieval in medical emergencies. Today we considered: DKA, Status Epilepticus, Emergency Intubation and Septic Shock management.

* Required

1. Site Name: *
Select your answer

2. Date of visit: *
Please input date (yyyy-MM-dd)

3. Course name/s (please select all courses relevant to this summary) *
- OPTIMUS PRIME 8hr / 6hr
- OPTIMUS 4hr module - Emergency Mgt
- OPTIMUS 4hr module - PLS
- OPTIMUS 4hr module - Respiratory
- OPTIMUS 4hr module - Shock
- STORK EMET - PRIME 8hr / 6hr
- STORK EMET 4hr - Emergency Mgt
- STORK EMET 4hr - PLS
- STORK EMET 4hr - Respiratory
- STORK EMET 4hr - Shock

4. Identified STRENGTHS of the service: *
Enter your answer

5. Issues identified with DRUG PREPARATION, PRESCRIPTION or ADMINISTRATION: *
Enter your answer

6. Suggested actions for DRUG SAFETY *
Enter your answer

7. Responsible Contact for DRUG SAFETY actions (insert "TBA" if need to confirm post-course): *
Enter your answer

8. Issues identified with EQUIPMENT or LAYOUT of DEPARTMENT: *
Enter your answer

9. Suggested actions for EQUIPMENT *
Enter your answer

10. Responsible Contact for EQUIPMENT actions (insert "TBA" if need to confirm post-course): *
Enter your answer

17. RESPONSE REQUIRED to issues identified *

	ACTION NEEDED	IN PROGRESS	NO ACTION REQUIRED
DRUG SAFETY	○	○	○
EQUIPMENT	○	○	○
RESOURCES	○	○	○
TEAMWORK	○	○	○

18. SUGGESTIONS-Equipment Codes
- Role Stickers
- IV Bag Spikes
- Mothership 2-way connectors (Fluid Dispensing Connector)
- IV Drug labels
- Phenytoin Filters
- Other

19. SUGGESTIONS-Cognitive Aids
- ProvED Dropsheet
- CREDD book
- Access to QPEC Guidelines
- Other

20. SUGGESTIONS-Teaching Resources
- Optimus BONUS simulation packages
- Other

Figure 2. *Captured images of the Optimus PRIME Site Summary.*

and course-related emails received from participants and local educators. An abstraction form created by the author [A.SOSH] with *Microsoft Excel* was used to extract and collect the data.

Demographic data included attendee numbers and clinical roles extracted from participants questionnaires. The number of issues within each category (drug safety, equipment or departmental layout, resources, team relationship) was extracted from all site summaries as well as a description of each issue identified specifically. Data from follow-ups included the status of each issue (resolved, in progress, not actioned) previously documented and narrative comments from site stakeholders about the new reporting process. Emails received from participants and local educators were included as an additional source of narrative data.

Categories for reporting were maintained for analysis, but themes within each category were extracted based on frequency from the data collection descriptives. For example, for drug safety, the most common issue revolved around the infusion pump profile. Once themes were identified, each was converted into categorical variables (e.g.: problem with infusion pump: yes/no). Descriptive statistics for categorical variables were calculated using proportions.

Three sites were visited twice during our study period. Each site had an initial PRIME summary with each visit. Data per site visited twice was aggregated. The two site summaries were compared for each site. If the same problem was listed in both documents, it was identified as a problem for the site in general. All issues identified during the second visit were extracted in the data collection as persistent problems. All successful improvement measures leading to the resolution of a previously identified issue were captured in the follow-up forms.

TABLE 2. *Number of hospitals enrolled in the present study, per range of annual admission rates*

Admissions/ Year	<1000	1000–5000	5000–20 000	20 000–100 000	>100 000
Number of hospitals visited	8	17	7	3	2

Information available through Census Data of the Australian Institute of Health and Welfare.[1]

Results

We identified 40 site summaries, 39 site summary follow-up forms including 26 narrative comments from local site educators and 4 course-related emails related to 40 Optimus PRIME courses delivered between March and December 2023 in 37 hospitals spread across 13 of the 15 Hospital and Health Service (HHS) regions. A total of 346 clinicians attended, and 72% were nurses, while 28% were medical practitioners. Results are presented below using the same categories used in the initial site summaries and follow-up. Through the analysis, the most frequent problems within each category have been identified and presented below. We also present some specific examples of local site initiatives, kickstarted with the aid of our reporting process but mainly a testament to the resilience, creativity, and dedication of local healthcare teams working in Queensland.

Drug safety issues

The most identified issue was the inability of infusion pump safety software to correctly administer drugs for septic shock and status epilepticus per the Children Resuscitation Emergency Drug Dosage (CREDD) reference book.[10] Irrespective of individual competence, participants were unable to correctly administer adrenaline, phenytoin, or levetiracetam at 60% ($n = 22$), 81% ($n = 30$) and 60% ($n = 22$) of sites, respectively (Fig. 3) because of the software installed on their hospital's pump. The drugs were either absent from the pump library or prompted participants to administer the drug using a concentration or duration inconsistent with guidelines.

Additionally, clinicians noted software features that made administration more difficult. Multiple paediatric drug libraries often coexisted within the same pump. Some drugs are stored in one library, others in both, with different rates and doses. Participants delivering unfamiliar drugs instinctively searched the libraries based on their simulated patient's physical location rather than on the drug's

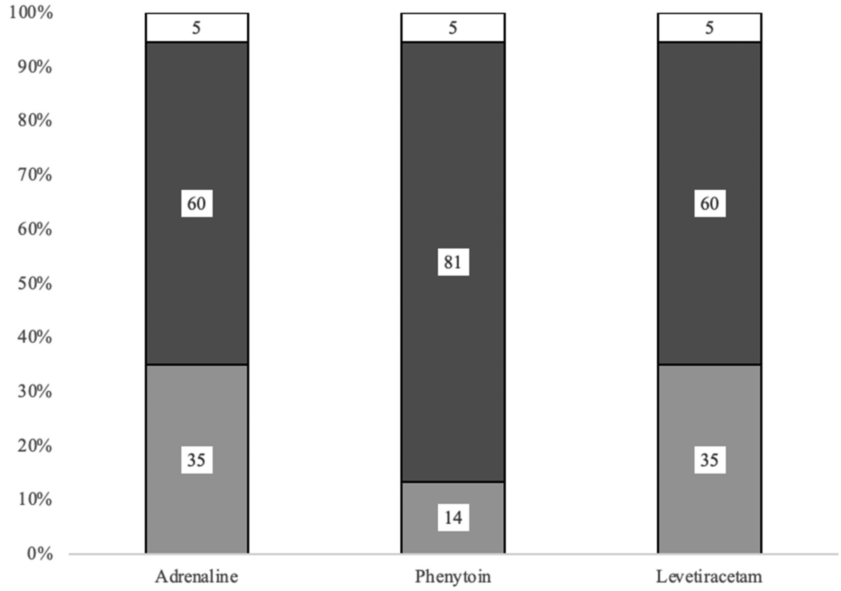


Figure 3. *Site ability (%) to administer recommended paediatric drugs through their infusion pump safety software. (■) Data not available. (■) Unable to administer per guideline. (□) Able to administer per guideline.*

location within the software. For example, if the simulated patient was on the paediatrics ward, staff frequently searched in the 'paediatric ward' library, rather than the 'paeds crit care' library where resuscitation drugs are more frequently stored. Several participants ceased looking after searching only one library, assuming the drug did not exist. Pump software updates were described by staff as expensive and infrequent, often with years between updates.

Equipment or departmental layout issues

Most sites (65%, $n = 24$) lacked access to the equipment necessary to optimise paediatric ventilation and/or oxygenation in accordance with the ANZCOR[11] and Queensland Health guidelines.[12,13] Small nasopharyngeal airways, cuffed endotracheal tubes (ETT), paediatric video laryngoscope blades, ETT cuff manometers, and humidified-moisturised-heated filters were most frequently absent.

Participants frequently identified issues with organisation of paediatric resuscitation trolleys. Through simulation, some centres found their whole resuscitation space did not meet their clinical needs. The Joyce Palmer Health Service in Palm Island created 'Project: Revamp Resus room', reorganising their resuscitation space and creating a photographic chart of 'what's where'. Coupled with staff orientation sessions, this centre used the course to launch their own quality improvement (QI) initiative.

Barriers to accessing resources

Challenges with ED structure were recognised in 57% ($n = 21$) of sites, commonly a lack of computer or internet connection to reliably access guidelines and clinical pathways. As a potential downstream effect, participants at 81% ($n = 30$) of sites were not familiar with statewide resources by Children's Health Queensland, including the paediatric emergency care website[14] and the CREDD book.[10]

Team relationship issues

Teams at 30% ($n = 11$) of sites shared ongoing challenges with teamwork and task allocation during resuscitation. Many sites spoke of pride in their hospital and colleagues, valuing close-knit relationships built in regional locations. Resuscitations involving the convergence of multiple teams were frequently described as vulnerable to confusion. Sites with a high turnover of medical locums identified challenges in establishing rapport and shared mental models.

As a takeaway from the course, teams expressed appreciation for clear role allocation and communication, with some centres adopting teamwork-specific tools introduced in the course. Following our visit, nurse educators from Thursday Island Hospital started a QI project to strengthen teamwork within their ED through daily, 5-min mental simulation. With this routine, they established a process to think explicitly about role allocation, team members strengths, appropriate staff allocation, and learning needs of the team on each day.

Site summary follow-up

Thirty-nine follow-ups were conducted. For one site, visited twice during the study period, one summary was conducted. Clinical teams were overall appreciative of the follow-up process. In many instances, the site summary provided momentum for new QI processes, as described above. Informed by feedback, we modified our own approach, ensuring our summary process met site needs. We responded to requests for the direct involvement of hospital managers and HHS stakeholders. Local educators have been invaluable in understanding the root cause of problems and integrating solutions.

Discussion

Our simulation informed biopsy of statewide practice reveals improvement opportunities. Many issues thought local are widespread, and seemingly simple issues were complex on follow-up. We discovered financial, technological, and organisational barriers that would be eased by statewide approaches. We specify three barriers that would benefit from coordinated responses: infusion pump safety software, resuscitation equipment, and technology access.

Infusion pump safety software

We advocate for coordination and standardisation of updates to infusion pump safety software within Queensland. Inconsistencies across infusion pump safety software were frequent and are a high risk for patient impact.

Teams trust that safety software keeps them within the boundaries of safe practice. Having two paediatric drug libraries in the same pump, with similar names, containing different drugs and infusion rates, impedes timely and safe administration. Common workarounds to 'manually override' the software suggest current settings are less safe than believed. While intended as an asset to resuscitation, outdated and un-instinctive interfaces are a latent safety threat for patients and friction points for care.

Contributors include the fact that pump software updates are infrequent and challenging to coordinate. The speed at which drug recommendations change, based on new evidence, far outpaces pump updates. Responsibility for software updates resides in centralised HHS pharmacies without capabilities for remote updates, leaving regional centres with few options.

A statewide strategy for timely updates and avoidance of extraneous profile libraries would increase the likelihood of drugs being given fast and safely. Significant work is needed to optimise safety software to be human-centred and streamlined, increasing our collective competence.

Availability of paediatric resuscitation equipment

Availability of paediatric equipment can be improved in most sites. Our results are concordant with the findings of The National Paediatric Readiness Project, authors of the Paediatric Readiness Checklist.[15] This United States-based project discovered that hospitals with high paediatric readiness scores are associated with decreased mortality,[16] while lower paediatric readiness scores were associated with higher hospital transfers.[17] Difficulty in sourcing respiratory equipment was identified as a contributing factor for lower ED readiness.[18]

Discordant guidance on paediatric resuscitation trolleys creates additional challenges for local decision makers. Queensland Health published an emergency services standardisation form for resuscitation trolleys[13] in lower acuity EDs, combining basic equipment for both adult and paediatric patients in one trolley. A separate guideline recommends procedure boxes to store advanced paediatric equipment.[12] In our simulations, we noticed that storing resuscitation equipment in multiple locations hinders access, whereas stocking trolleys with paediatric and adult equipment creates clutter when functionality is needed. Importantly, the current Queensland Health guidelines only apply to level 1 & 2 ED services, leaving many slightly bigger regional EDs without guidance. Without a comprehensive statewide guideline on paediatric resuscitation trolleys, their layout will remain *ad hoc*.

When our team recommended ordering specific equipment, however, broader complexities revealed themselves. Equipment requests were often declined because of cost. Equipment is sold in bulk, meaning small hospitals face the financial burden of ordering many pieces despite only needing a handful. Commercial pathways involve wasteful purchases of large quantities that expire before use. This results in centres having incomplete, heterogeneous collections of paediatric equipment despite their best intentions.

Some workarounds exist. 'Robin Hood' clinicians working in both paediatric and general hospitals redistribute small amounts of equipment from paediatric workplaces to their adult or mixed ED. A team in Darling Downs is leading a project to improve standardisation of emergency equipment across their HHS, which included creation of a 'Clinical Products and Equipment Committee'. They aim to acquire a central storage space, distributing consumables to smaller sites, providing a supply chain to small centres unable to justify the cost of bulk items.

A statewide guideline establishing the necessary equipment to stock a paediatric resuscitation trolley, combined with a centralised service that can distribute smaller quantities of equipment, could help regional sites access equipment.

Access to information technology

Clinical guidelines improve care by promoting standardised, evidence-based practice. Despite the availability of a statewide paediatric emergency care website[14] with open-access guidelines, many participants were unfamiliar with their use or could not access them. Access to information technology was hampered by slow or absent internet access, inconsistent Wi-Fi coverage, and absence of computers in the resuscitation area. This limits the ability for timely use and impedes training opportunities to ensure clinicians are familiar with the guidelines.

Though our study involves Queensland, our results are consistent with prior Australian publications, suggesting a national challenge with guideline integration and access to technology.[5,19] In 2015, Conh *et al.* published about barriers to the use of paediatric clinical guidelines in regional NSW.[5] Although clinicians surveyed found guidelines useful and believed in their utility, only 22% reported frequent use. Major barriers were lack of awareness, training, and poor access, with 52% reporting a lack of electronic access in their department.

Unfamiliarity and lack of awareness are commonly reported as barriers to clinician adherence with guidelines.[5,19–21] Our Optimus PRIME course was designed to improve awareness and familiarity with pre-existing resuscitation resources through their embedded use in simulations. Newly acquired knowledge and awareness of paediatric-specific resources are consistently highlighted as a highly valued component of the course. One particularly successful statewide intervention, independent from STORK, was the introduction of the CREDD book,[10] which provides weight-based drug dosages and preparation instructions in a laminated format. This affordable and well-designed cognitive aid for paediatric drug preparation has become a mainstay for paediatric resuscitation in Queensland.

It is suboptimal for RRR health centres to operate without consistent access to invaluable resources because of poor internet reliability. Guidelines and resources exist to lessen cognitive load on clinical teams, necessitating access and use in real time. While evidence regarding their actual impact on clinical practice varies,[22] we maintain that access to standardised paediatric resources is an essential component of safe paediatric care. Without improvement in internet connectivity throughout RRR Queensland, the use of resources will remain limited. We call for stakeholders to bridge this gap so that paediatric-specific and up-to-date recommendations for care can be accessible to all.

Limitations

There are limitations inherent to our study design. The sample size was dictated by our educational delivery model and only included sites enrolled in our annual courses. However, our data include sites from 13 out of 15 HHS across Queensland and encompass the state's most remote areas. Our results are specific to the RRR Queensland healthcare model, limiting the overall generalisability of our findings to metropolitan centres and more broadly to Australia and internationally.

During some courses, simulation activities were conducted in educational spaces where the recognition of issues was more difficult to tease out and potentially introduced information bias. However, real pumps and resources were sourced from clinical spaces on all courses. It is harder to ascertain if the same or different challenges would have been apparent if all courses were delivered *in situ*.

Consensus on what issues to include in each site report was built during course closure upon discussion with all participants. As such, the findings of each report are influenced by the collective opinion of faculty and participants present on each course. Only clinical staff were included as faculty or participants, and the perspective of non-clinical staff or patients was not collected.

Optimus PRIME remains an educational vehicle with QI benefits. As such, issues identified reflect the content of our teaching rather than a comprehensive assessment of a department's resuscitation capacity. Nevertheless, the course focuses on the commonest paediatric resuscitation presentations rather than high acuity, low occurrence events, representing valuable data for those seeking to improve regional resuscitation systems.

Conclusion

The present study highlights current challenges for healthcare providers across RRR Queensland and demonstrates educational teams can contribute to their resolution. Many challenges are occurring statewide. Our findings provide knowledge about regional initiatives and areas of need, informing further advocacy. Specific efforts should go into designing comprehensive approaches to infusion pump safety software, the availability of paediatric resuscitation equipment, and access to information technology. Statewide consistency synergising with local expertise is needed to ensure every child in Queensland has access to optimal resuscitation.

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Competing interests

None declared.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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