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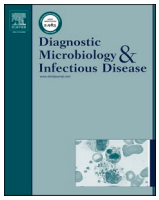

The adoption of point of care testing technologies for respiratory tract infections in primary care in Australia: Challenges and facilitators

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ABSTRACT

Despite technological advances and readily available point of care test (POCT) devices with rapid turn-around results for respiratory tract infection (RTI) management, their adoption in primary care remains low. This paper summarises the challenges and facilitators of POCT implementation for RTIs in primary care settings in high-income countries. The review of 28 studies identified by systematic searches of electronic databases improves our understanding of the current state and will help guide the design and implementation of strategies to improve widespread POCT adoption. To effectively implement respiratory POCT in primary care, it is crucial to address several key challenges. These include ensuring the availability of resources to alleviate time pressures and costs, enhancing training, increasing quality control, improving device feasibility, and managing patient expectations. In doing so, diagnostic POCTs can contribute to an accurate, rapid, and evidence-based diagnosis of RTIs to reduce antimicrobial use and improve antimicrobial stewardship and patient outcomes.

1. Introduction

The emergence and spread of antimicrobial resistance (AMR) across a wide spectrum of infectious microorganisms is an urgent and significant global health threat. AMR is the ability of microorganisms to develop mechanisms that render them resistant to the antimicrobials commonly used for treating infection. To date, antimicrobials, predominantly antibiotics, have been successful in the management of infectious diseases. However, their widespread and often inappropriate use has resulted in reduced effectiveness and a rise in drug-resistant infections leading to higher mortality rates and increased healthcare costs worldwide. AMR is exacerbated by inappropriate prescribing, which includes overuse, misuse and underuse of antimicrobials. Inappropriate prescribing is largely driven by primary healthcare settings, which account for up to 95 % of antibiotic prescribing in most high-income countries [1]. Although estimates vary between studies and settings, up to half of all antibiotics are inappropriately prescribed; with the majority for non-bacterial upper respiratory tract infections (URTIs), such as acute sinusitis, acute otitis media and pharyngitis [2,3]. Respiratory tract infections (RTIs) account for the majority of antibiotic prescribing in primary care across high-income countries (with GDP per capita >USD $48,220) (Table S1 shows comparisons by country) [2–8]. In Australia, antibiotic prescriptions for acute RTIs are up to nine times higher than recommended by therapeutic guidelines [9]. Though there has been a steady decline in the Australian antibiotic dispensing rate, non-compliance with national guidelines continues to rise for common RTIs, such as acute bronchitis and chronic obstructive pulmonary disease. Recent Australian hospital data shows that 25 % of antimicrobial prescriptions are inappropriately prescribed and antimicrobial prescriptions in Australian hospitals are substantially higher than in most comparable European countries, Scotland and Canada [10].

There have been numerous attempts in Australia (and internationally) to reduce inappropriate prescribing. Australia developed a National Antimicrobial Resistance Strategy to guide antimicrobial stewardship (AMS) programs in primary care and foster optimal antimicrobial prescribing practices, including restricting prescribing to align with national guidelines [11], and several pilot programs have tested introducing practice audits with feedback on prescribing, educational interventions for prescribers and near-patient testing [12-16]. The management of RTIs in Australian primary care is a priority area for sustaining improvements in the volume and appropriateness of antimicrobial prescribing and usage [10]. There is evidence of the benefits of

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AMS pilot programs in primary care, and a range of methods are used to evaluate these programs [17,18]. Several systematic reviews and meta-analyses of AMS interventions have reported reductions in AMR and inappropriate prescription rates, increased patient safety, and reduced healthcare costs for adult and children populations [19,20].

Rapid microbiological point of care testing (POCT) can detect a range of upper respiratory tract microorganisms and provide diagnostic certainty to improve antimicrobial prescribing. POCT is a powerful AMS tool that supports clinical decision-making since inappropriate prescribing is driven by diagnostic uncertainty and delayed diagnosis. In hospital settings, POCT has been shown to inform decisions that improve patient management and outcomes and improve prescribing [21]. In primary care, research has shown that both stakeholders–general practitioners (GPs) and patients–consider diagnostic POCTs for respiratory viruses to be a valuable contribution to primary care [22]. In Australia, the currently available POCT tools for RTIs in clinical practice include C-reactive protein testing (CRP-POCT), which is one of the most common cost-effective AMS interventions; lung point of care ultrasound (POCUS or LUS), a portable bedside diagnostic imaging device with comparable or superior sensitivity and accuracy to gold-standard imaging; and molecular-based point of care respiratory test panels, which have gained popularity due to their specificity and sensitivity in rapid and accurate diagnosis. The COVID-19 pandemic has highlighted the importance of POCT adoption as a valuable diagnostic tool in supporting clinical decision-making for early detection and decreasing the healthcare burden [23] without excessive interruption to workflow [24].

POCT has been used routinely in clinical practice in some European countries since its incorporation into the National Institute of Health and Care Excellence (NICE) testing for pneumonia diagnosis in 2014 [25]. Yet despite the ease of access to POCT and its demonstrated effectiveness in supporting appropriate prescribing practices for respiratory conditions, adoption of these valuable diagnostic tools in other high-income countries, including Australian primary care (and the US), remains low. Understanding the factors associated with the use of POCT could drive its adoption. In recent years, the barriers and facilitators to the uptake of POCT devices in primary care have been researched [26,27] and several evidence-based reviews on POCT applications, their cost-effectiveness and the perceptions of GPs have been published [28-33]. To allow for context-specific POCT implementation, a localised understanding of the perceived barriers and facilitators is needed. Identifying the key barriers and facilitators to the routine use of respiratory POCT in the primary care sector of high-income countries will help inform the design of a qualitative survey to be given to Australian primary care settings to validate these findings from the literature and identify strategies to drive implementation. This review summarises the current evidence on the challenges and facilitators of respiratory POCT implementation for RTIs in primary care in high-income countries to drive the adoption of POCT in primary care in Australia and improve antimicrobial stewardship and patient outcomes.

2. Materials and methods

Data from five electronic databases (ERIC, EMBASE, PsychINFO, PubMed and Scopus) and one journal (Point of Care: The Journal of Near-Patient Testing & Technology) were accessed and searched for using the following key terms: ‘primary care’, ‘POCTs’, ‘point of care tests’, ‘RDTs’, ‘rapid diagnostic tests’, ‘high-income countries’, ‘RTIs’ and ‘respiratory tract infections’ from inception to 2022. This was supplemented by manual searches of citations and reference lists within the identified articles. The eligibility criteria for these searches are given in Table S2.

3. Results

A total of 2,858 records were identified through database searching and an additional 14 were identified through other sources. After duplicates were removed, 1,990 records remained. These records were screened and 1,926 were excluded. The remaining 64 full-text studies were assessed for eligibility with 35 records excluded for not reporting barriers (n=14), respiratory POCT (n=12), primary care (n=3), other reasons (n=3), abstract-only (n=2) and a review (n=1). Of the 29 remaining studies, one was removed as it related to nursing homes only. The key barriers and facilitators were then identified from the 28 included studies. Table 1 and Table 2 summarise the main characteristics of the included studies and the key barriers in the identified literature, respectively.

3.1. Barriers to adoption of respiratory POCT in primary care settings

Our review of the literature identified the following barriers to the adoption of respiratory POCT devices in primary care settings in decreasing frequency of which they were reported: time pressures (82 %; 23/28); financial issues, including cost and reimbursement (64 %; 18/28); practicalities relating to the test, such as technical, logistical, and operational issues (64 %; 18/28); clinical utility of the test, including accuracy, specificity, and usefulness (57 %; 16/28); and patient acceptability (32 %; 9/28) [22,34-60].

3.1.1. Time pressure

Time was identified as the most common barrier and appeared in 82 % of the studies assessed. Time pressure was due to the increased workload, additional time required for administering the test during the consultation and waiting for test results, with resulting impacts on practice workflow. The need for staffing resources to mitigate the impact on workloads and resulting time pressure was also raised.

3.1.2. Financial concerns

The cost of POCT implementation was identified as a common barrier and raised in 64 % of the studies assessed. Financial concerns included the cost of tests and devices and ongoing running costs for materials (e.g. cartridges), maintenance, and servicing. Concerns around the cost-effectiveness of POCT and uncertainty about reimbursement were also identified as constraints to POCT implementation.

3.1.3. Practicalities

Technical performance concerns were a common barrier and were raised in 64 % of the studies assessed. Concerns included ease of testing; device performance (test quality robustness/detection level/reliability); device accessibility and storage; and IT management (integration with electronic health records). Concerns were raised around a lack of clarity about how POCT delivery would be optimised in primary care clinics and integrated into clinic workflows, and specifically, who would perform testing and when it would occur. The issues of responsibility for device maintenance and awareness of the shelf life of test cartridges were raised. Concerns around ongoing quality control and oversight were raised and whether staff would be trained for these aspects or an external body used to provide these services. The need for additional staffing resources to minimise the risk of medication errors from POCT testing secondary to the increased workload was also raised.

3.1.4. Clinical utility

Concerns around clinic utility were raised in 57 % of the studies assessed. Clinicians expressed concerns with testing validity, sensitivity and accuracy; the lack of robust evidence to support the clinical validity of POCT for RTIs, its diagnostic and prognostic value, and limitations of its usefulness. Ambiguity in interpreting test results and lack of training in interpretation were identified as barriers. Clinicians cited concerns around diagnostic uncertainty for certain patient groups, particularly those at increased risk of complications, such as those with acute infective exacerbations of chronic obstructive pulmonary disease and asthma, who were more likely to require precautionary antibiotic prescribing for patient safety reasons. Testing in children, who are more

Table 1
Description of the 28 identified studies on the barriers to adopting respiratory POCT in primary care.

Study (Year)	Country	Setting (Location)	Study duration†	Participants (Patients tested)	Type of POCT [Device brand]	RTI or related symptoms	Barriers
Brust-Sisti et al. (2022) [36]	USA	Community pharmacies	Cross-sectional survey §	311 Pharmacists 16 % used POCT Practice experience: 1-5 years (majority)	Diagnostic COVID-19 testing: Molecular or antigen testing (general survey)	SARS-CoV-2	1) Space: lack of a pharmacy drive through 2) Inadequate staffing 3) Time and workflow disruptions 4) Test quality 5) Lack of reimbursement
Czarniak et al. (2022) [34]	Australia	5 community pharmacies (City)	8 weeks	10 Pharmacists Mean age: 36 years (range: 22–53 years) Practice experience: Mean 13 years (131 patients)	CRP testing [Alere Afinion AS100 Analyzer, USA]	General respiratory symptoms (sore throat, cough, blocked nose)	1) Lack of access to medical records and laboratory data 2) Time constraints 3) Staff shortages 4) Inadequate remuneration 5) Challenging interactions with general practitioners 6) Patient awareness of testing
Hansell et al. (2022) [35]	Australia	Physiotherapy	Cross-sectional survey	39 Physiotherapists: 26 % used LUS Mean age: 41 years Practice experience: Mean 17.6 years	POCUS: Lung ultrasound (LUS)	Respiratory conditions	1) Lack of clinical time to commit to up-skilling and ongoing training 2) Finding an accredited supervisor to practice LUS 3) Accessibility of device
Hayward et al. (2022) [41]	UK	Respiratory physiotherapy	Semi-structured interviews	8 Senior Critical Care Respiratory Physiotherapists Practice experience: ≥ 5 years in specialist area	POCUS: Lung ultrasound (LUS)	Respiratory conditions: lung pleural effusion, interstitial syndrome or pneumothorax	1) Difficulty accessing mentorship 2) Lack of machine availability 3) Limited time for training 4) Lack of governance clarity 5) Lack of support from managers
Borek et al. (2021) [40]	UK	9 General practices (rural & urban)	Semi-structured interviews§	50 Health Professionals: 25 GPs, Nurses, Pharmacists, Health Care Assistants (HCAs) No practice had used POCT	CRP testing	Respiratory tract infections	1) Time 2) Clinical utility (sensitivity, specificity, interpreting) 3) Logistical difficulties: storage and maintenance of equipment 4) Disruption to workflows & added workload 5) Funding 6) Over reliance could lead to loss of clinical skills 7) 'Medicalising' common infections
Gallimore et al. (2021) [42]	USA	Community pharmacies	Cross-sectional survey §	147 Pharmacists: 44 % in rural areas 17 % offered POCT	Diagnostic COVID-19 testing: Molecular or antigen testing (general survey)	SARS-CoV-2	1) Staffing availability to oversee testing 2) Time/ workflow impact 3) Overlaps with what other clinicians offered 4) Financial barriers
Khalid et al. (2021) [43]	UK (England)	4 GP practices (City)	6 weeks	13 Clinicians (9 GP/4 Nurses) 7 Test Processors: (2 HCA/ 5 Research Nurse) 2 Administrators (93 patients: 29 years)	Multiplex PCR: Biofire Filmarray v1.5 instrument (BioFire Diagnostics, Utah) Respiratory Panel v1.7 (bioMérieux)	Upper RTI (48 %) Lower RTI (30 %) viral/influenza (18 %) other symptoms (4 %)	1) Cost: equipment £30–35K; per test £90 2) Limited array of microbes detected 3) Location of device (noise) 4) Clinical utility
Ngyugen et al. (2021) [44]	USA	Community pharmacies	Cross-sectional survey §	229 pharmacists	Diagnostic COVID-19 testing: Molecular or antigen testing (general survey)	SARS-CoV-2	1) Storage 2) Logistical feasibility in busy pharmacies, workload & logistics 3) Inadequate staffing 4) IT to bill and document 5) Cost
de Lusignan et al. (2020) [45]	UK	6 GP practices	15 weeks	Practice staff: Clinicians, Nursing Practitioners, Health care Assistants (312 patients)	Molecular POCT: Abbott ID Now POCT for influenza (Abbott Diagnostics)	Acute influenza-like illness and acute respiratory illness	1) Implementation of clinical governance measures and quality control of POCT 2) Clinical pathways: how to identify eligible patients

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Table 1 (*continued*)

Study (Year)	Country	Setting (Location)	Study duration[†]	Participants (Patients tested)	Type of POCT [Device brand]	RTI or related symptoms	Barriers
							for swabbing and how POCT was operationalised in the practice
Phillips et al. (2020) [46]	UK	19 GP practices	4 Weeks	20 Primary care staff: 12 GPs 5 Nurse practitioners 1 Practice nurse 1 Research assistant 1 Pharmacist	CRP testing [Afinion CRP; Alere Inc.]	Acute exacerbation of chronic obstructive pulmonary disease (AECOPD)	1) Lack of machine portability 2) Need for regular calibration 3) Storage of test cartridge in fridge 4) Portability 5) Cost 6) Patient expectations for antibiotics
Dulaney et al. (2018) [47]	USA	Community pharmacies	Cross-sectional survey [§]	146 Pharmacists	POCT for Influenza & streptococcus pharyngitis	Influenza & streptococcus pharyngitis	1) Lack of resources to perform POCT 2) Lack of training 3) Absence of remuneration for services provided 4) Facility limitations 5) Lack of patient & provider awareness of service offered
Eley et al. (2018) [48]	UK (England)	12 GP Practices	6 months	26 Practice staff: 15 GPs 5 Practice managers 3 Practice nurses 1 Pharmacist 1 Community nurse 1 HCA	CRP testing: Alere Afinion CRP POCT	Lower RTI: Acute cough (57 %) Chest infection (24 %) Other RTI (12 %)	1) Cost 2) Time 3) Access to POCT machine for all general practice staff 4) Effects on clinical workflow 5) Lack of reimbursement to pay for the service
Gal et al. (2018) [37]	Australia Europe (9 countries) USA	Primary care practices	Cross-sectional survey	45 Primary care clinicians (33 % used POCT)	CA-LRTI POCT	Lower RTIs: Community acquired pneumonia, influenza, acute exacerbations of chronic obstructive airways disease, acute exacerbations of asthma & bronchitis	1) Cost 2) In many cases, diagnosis & prognosis was evident on clinical presentation alone. 3) Test complexity and ease of use 4) Time and workload 5) Clinical benefit, performance/accuracy and reliability 6) Patient acceptability (esp children)
Johnson et al. (2018) [38]	UK	Primary care practice	Cross-sectional survey	7 Health care professionals	CRP testing	Lower RTIs	1) Integration of POCT into practice workflow 2) Lack of dedicated space & limited consultation to test 3) Implementation and continued use cost 4) Resistance to change 5) Maintaining motivation
Schot et al. (2018) [39]	The Netherlands	9 GP practices	Semi-structured interviews	11 GPs: All had experience using POCT in adult	POCT CRP	Children with Lower RTIs	1) Optimal cut-off values for children unclear 2) No guidelines for children 3) Blood sampling invasive in children 4) Additional risk for vulnerable cohort (children)
Bruning et al. (2017) [22]	The Netherlands	One large family practice	5 months	7 GPs (202 patients)	mariPOC Respi test [ArcDia International Oy Ltd, Finland]	RTI symptoms	1) Extra costs 2) Time taken before final test results are reported which require change in work flow
Hardy et al. (2017) [49]	USA	5 Family medicine clinics	Semi-structured qualitative interviews [§]	30 Clinicians: 18 Physicians 9 Physician residents 2 Physician assistants 1 Nurse practitioner Mean age: 46.9 years	CRP POCT	Acute RTIs in adults	1) Potential for overuse & risk of inaccuracy of CRP POCT 2) Integration into clinical workflow: time to administer & interpret results

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Table 1 (*continued*)

Study (Year)	Country	Setting (Location)	Study duration†	Participants (Patients tested)	Type of POCT [Device brand]	RTI or related symptoms	Barriers
				Practice experience: Mean 8.6 years			3) Financial viability 4) Over-reliance on diagnostic tests may lead to undermining clinician's skills 5) Diagnostic need for recognising bacterial from viral aetiology
Huddy et al. (2016) [50]	Europe	Primary care	Stage 1: Semi-structured interviews of GPs Stage 2: Workshop	Stage 1: 8 GPs Stage 2: 10 experts (UK): 3 Industry representatives 2 GPs, 2 pharmacists, 1 Biochemist 1 Lab scientist 1 Primary care research manager	POC CRP	Lower RTIs	1) Absence of a funding model for the test 2) Quality assurance, training & maintenance of device 3) Time & human resource requirements 4) Evidence on clinical utility 5) Unacceptable increase in patient consultation time
Mengel-Jørgensen and Jensen (2016) [51]	Europe (12 countries)	General practice	Cross-sectional survey of LUS users	15 GPs	POCUS: Lung ultrasound (LUS)	Respiratory conditions	1) Financial aspects ultrasound device expenses & lack of/little payment for scanning 2) Time 3) Training/ skills on use of POCT
Anthierens et al. (2015) [52]	Europe (6 countries)	General practice	Semi-structured qualitative interviews	66 clinicians Mean age: 45.4 years Practice experience: Mean 17 years	POC CRP	Acute RTIs	1) Support and training/ education on use of POCT for infection management. 2) Training/ education on communicating to manage patient expectations.
Gröndal et al (2015) [53]	Sweden	General practice	Semi-structured qualitative interviews	16 GPs Majority: ≥45 years	POC CRP or Rapid Antigen Detection Tests (RADT) for group A streptococcal infections (GAS)	Acute sore throat GAS, tonsillitis	1) Confidence in clinical assessment without testing 2) Negative RADT not reliable/ outweighed by clinical picture
Michel-Lepage et al. (2014) [54]-	France	General practice	Cross-sectional survey	1,126 GPs (60 % used testing for children 3-16 years)	Rapid antigen diagnostic tests (RADTs) for group Group A streptococcal infections (GAS)	Acute pharyngitis in children	1) Declaring a <15 minute consultation 2) Not having participated in continuing medical education in the past year 3) Being a more alternative practitioner 4) Receiving pharmaceutical representatives
Leydon et al. (2013) [55]	UK	General practice (city & rural)	Semi-structured qualitative interviews	Total: 42 29 GPs 13 Nurse practitioners	Rapid streptococcal antigen detection tests (RADTs)	Acute sore throat	1) Validity of the test (detection of other bacteria, carrier states) 2) Potential disagreement between test results and clinical assessment 3) Time consuming & resourcing 4) Additional cost 5) Potential over medicalisation of self-limiting viruses
Pulcini et al. (2012) [56]	France	General practice	Cross-sectional survey	367 GPs: 41 % used POCT routinely	Rapid antigen diagnostic tests (RADTs)	Acute pharyngitis	1) Time to perform test 2) Perception that clinical examination is sufficient 3) Patient expectation of receiving antibiotics 4) Concerns about validity of RADT results
Wood et al. (2011) [57]	Europe (9 countries)	9 Primary care centres	Semi-structured qualitative interviews	80 clinicians: Only clinicians from Norway had	CRP POCT	Acute cough/lower RTIs	1) Test performance: analytical accuracy of test, interpreting result

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Table 1 (*continued*)

Study (Year)	Country	Setting (Location)	Study duration†	Participants (Patients tested)	Type of POCT [Device brand]	RTI or related symptoms	Barriers
				experience using POCT			2) Time consuming & increased workload 3) Financials costs: test, equipment, servicing & monitoring 4) Patient expectation/ demand 5) Over-reliance on test over clinical examination
Cals et al. (2010) [58]	The Netherlands	10 General practices	Semi-structured qualitative interviews	20 GPs: All used testing for 3 years	CRP POCT	Lower RTIs	1) Potential over-reliance 2) Absence of reimbursement 3) Ambiguity and need for training on interpreting test results
Butler et al. (2008) [59]	UK (Wales)	32 General practices	Semi-structured qualitative interviews	40 GPs: No experience	POCT to distinguish viral from bacterial RTIs	Common respiratory infections	1) Costs 2) Clinical utility (add little to clinical assessment and only useful for limited patients) 3) Quality control 4) Practicalities of implementation and equipment maintenance 5) Additional workload 6) Acceptability to patients (especially children)
Turner et al. (2006) [60]	Australia	2 General practices (city)	6 months	GPs from 2 general practices	Binax Now Flu A Test Kit	Influenza-like illness	1) Time taken for results too long (15 min) 2) Lack of remuneration

† Duration that POCT was implemented at the practice

§ Pre-implementation of POCT; participants had no prior experience with POCT

Abbreviations: CA-LRTI: community-acquired lower respiratory tract infections; CRP C-reactive protein; GP: general practitioner; HCA: healthcare assistant; LUS: lung ultrasound; PCR: polymerase chain reaction; POCT: point of care testing; POCUS: point of care ultrasound; RTI: respiratory tract infection; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

vulnerable than adults and inherently have more uncertainty around further deterioration and the parental role in the follow-up of suspected RTIs, was raised as a barrier. Some clinicians questioned the added diagnostic value of the result, citing problems with interpreting values and cut-off points for ranges of results and false positives and negatives. Others expressed concerns about the risk of falsely elevated results in patients with underlying inflammatory conditions for whom CRP POCT might not be appropriate and the consequences of getting a false negative result in the case of serious bacterial infections. Clinicians supported the use of POCT to verify their professional diagnosis but expressed concerns about the confirmation of diagnosis when there was a conflict between the test results and their clinical assessment of the most likely diagnosis. Concerns about overreliance on POCT and undermining of their clinical expertise were also raised.

3.1.5. *Patient acceptability*

Managing patient expectations and their acceptance of POCT was identified as a barrier in 32 % of the studies assessed. Clinicians

Table 2
Summary of the key barriers to respiratory POCT adoption in primary care.

Factors	Barriers	General practice	Community pharmacy	Physiotherapy
Time pressure (82 %)	Training/testing/interpreting results/ additional workload/ disruption to workflow	✓	✓	✓
Financial concerns (64 %)	Cost of equipment/ cartridges/ongoing servicing/maintenance	✓	✓	✓
	Reimbursement uncertainty	✓	✓	✓
Practicalities (64 %)	Interpreting results	✓	✓	✓
	Device performance: test quality/detection level/accuracy/reliability/interpreting results	✓	✓	
	Data management: integration with electronic health records	✓	✓	
	Quality control and ongoing monitoring	✓		
	Accessibility	✓	✓	✓
	Dedicated space/storage issues	✓	✓	
	Human resource shortage/lack of training	✓	✓	✓
	Management support	✓		✓
Clinical utility (57 %)	Evidence on clinical utility/additional value in children	✓		
	Diagnostic/prognostic value (differentiate between bacterial and viral RTIs)	✓		
	Over-reliance/ undermining of clinical expertise	✓		
	Limited usefulness/scope for services	✓	✓	
Patient acceptability (32 %)	Patient awareness of testing/expectations or demands for antibiotics/ reluctance or insistence on testing/invasive testing for children (prick)	✓	✓	

Note: For details on studies of the key barriers, see Table S3.

Table 3
Description of identified studies on the facilitators of respiratory POCT adoption in primary care.

Primary care setting	Study (Year) country	Type of POCT technology	Facilitators for successful adoption of POCT
General practice	de Lusignan et al. (2020) [45] UK	LRTI POCT	1) Staff member is a dedicated champion/ clinical lead of the POCT 2) Electronic system/ process to identify patients for testing.
	Eley et al. (2018) [48] UK	CRP testing	1) Training on use of device to increase knowledge, confidence & skills 2) Dedicated staff member for POCT 3) Accessible to general practice staff or portable 4) Funding for costs and additional staffing
	Johnson et al. (2018) [38] UK	CRP testing	1) Mentoring by early adopter and champions to support, engage and clinicians 2) Training & education support 3) Staffing 4) Collaboration at local and national level 5) Better IT utilisation
	Huddy et al. (2016) [50] Europe	CRP testing	1) Reimbursement and incentivisation 2) Quality control, training and maintenance by external centralised laboratory services 3) Staffing 4) Training
	Michel-LePage et al. (2014) [54] France	RADTs for pharyngitis	1) Education/ training: attending CME on infectious diseases in the past year.
	Wood et al. (2011) [57] Europe	CRP POCT	1) QC and test accuracy (sensitivity and specificity) 2) Rapid time to result 3) Cost (including reimbursement) 4) Simplicity/ ease of use of test
	Cals et al. (2010) [58] The Netherlands	CRP POCT	1) Recommendations for diagnostic value and interpretation of results 2) Reimbursement
Pharmacy	Czarniak et al. (2022) [34] Australia	CRP testing	1) Accessibility and credibility of staff 2) Rapport with general practitioners 3) Supportive team 4) Consumer demand for the service
	Gallimore et al. (2021) [42] USA	COVID-19 testing	1) Staffing 2) Training and credentialling 3) Financial reimbursement
	Nguyen et al. (2021) [44] USA	COVID-19 testing	1) Access to a drive-through 2) Reimbursement
	Delaney et al. (2018) [47] USA	POCT for influenza & streptococcus pharyngitis	1) Adequate training 2) Strategic partnerships with providers to increase awareness and referral
Physiotherapy	Hansell et al. (2022) [35] Australia	LUS	1) Adequate training and access to online resources 2) Support from supervisor/ mentor
	Hayward et al. (2022) [41] UK	LUS	1) Education and training of LUS evidence and skills to use 2) Mentoring from manager

Note: For details on studies of the key barriers, see Table S4.
Abbreviations:
CRP: C-reactive protein
CME: continuing medical education
LRTI: lower respiratory tract infection
LUS: lung ultrasound
RADTs: rapid antigen diagnostic tests

expressed concerns about clinical samples and clinical pathway considerations concerning patient acceptability and expectations, as some patients expect or want to receive antibiotics, even for a viral infection. Clinicians expressed concern about patient willingness to test if testing is invasive, such as finger prick tests for children.

3.2. Facilitators of the clinical adoption of respiratory POCT

The reviewed literature on facilitators to the adoption of respiratory POCT in primary care is summarised in Table 3. The following are the key facilitators identified (reported in more than one study) in decreasing frequency of which they were reported: training and education (62 %; n = 8/13); reimbursement (46 %; n = 6/13); staffing (46 %; n = 5/13); and mentoring (23 %; n = 3/13) [34,35,38,41,42,44,45,47,48,50,54,57,58].

3.2.1. Training and education

Training or education was the most commonly identified facilitator and raised in 62 % of the studies assessed. Training on POCT device usage to increase confidence and skills and ensure that protocols are consistently followed was identified as an enabler.

3.2.2. Financial and reimbursement concerns

Financial resources are required to implement and perform POCT and were identified as a facilitator in 46 % of the studies. Concerns around financial support to reduce implementation and ongoing running costs and incentivise testing were raised.

3.2.3. Staffing

Additional staffing resources for testing and reducing workload were identified as a facilitator in 46 % of the studies assessed. The importance of a staff member as a mentor was also a facilitator, mentioned in 23 % of studies.

3.2.4. Practicalities of POCT

Ease of access, portability, and the availability of a dedicated area for the device; strategic partnerships with providers for referral; patient awareness of testing; and recommendations for diagnostic value and interpretation of results were raised as enablers in the studies assessed. Ease of use was a cited facilitator by the general practices, including simplicity and accuracy of the test results with a rapid turn-around of results within short consultation times. Accessibility of the POCT device in their consultation room or the device being small, cheap, and portable was also highlighted. Integration of IT to flag patients for testing and record test results in the practice management system was also identified as an enabler.

4. Discussion

This qualitative review found several barriers and facilitators to the mainstream adoption of POCT in primary care in high-income countries for RTI clinical management. Many of these challenges have been mitigated in European countries where POCT is more widely used, such as The Netherlands, Norway, and Sweden [61,62] and lessons can be learnt for effective implementation in Australia.

4.1. Barriers to implementation of respiratory POCT

The most common barrier to implementation was identified as the lack of time, which is unsurprising given typically short consultation times and time pressures in general practice and the challenges of incorporating new practices within them. This was a particular concern for adoption in single-clinician practices. Having additional staffing, dedicated staff to undertake all the testing, and outsourcing quality control to an external provider could mitigate the additional workload and reduce time pressures.

Financial concerns are also important to address, particularly in light of current concerns in Australia regarding funding for primary care services, with an associated increase in out-of-pocket costs for patients accessing these services. To facilitate adoption, clinicians will need to be incentivised to adopt POCT. It has been suggested that specification of POCT use in the guidelines [58], government supply of POCT tests to clinicians [56] and ensuring adequate reimbursement could address these barriers [56]. Our review highlights financial concerns raised around the costs of tests themselves and the cost burden of maintenance, stocking, and quality assurance of the test device and cartridges. We suggest that possible solutions exist in European countries, including direct cost reimbursement through insurance companies or the government, reimbursement for performing the test above its direct cost, and contractual device provision by commercial laboratory services [50].

Our review identified concerns raised by clinicians around the clinical utility, validity, and usefulness of respiratory POCT. We suggest that these may be perceived risks that are due to knowledge gaps in the evidence of the benefit of POCT, which highlights the importance of addressing concerns around the sensitivity and specificity of respiratory POCT and the need for support from external quality control for improved diagnostic certainty. Training and education could address these knowledge gaps and communicate the importance and feasibility of POCT. A French study looking at barriers to POCT adoption in primary care suggested a national education campaign targeting clinicians and the public to raise awareness of the validity of rapid antigen diagnostic tests and the limitations of clinical examination in accurately differentiating viral and bacterial infections [56]). This aligns with findings from another study that showed that clinicians who had recently participated in relevant CME (within the past year) were more likely to use POCT [54].

Quality assurance in performing the test and the clinical application of results was frequently raised, and quality assurance has been shown to account for most testing errors [63,64]. Decisions around the responsibility for quality control belonging to primary care practitioners or being outsourced to external bodies, and the responsibility for device maintenance, quality control, and managing test cartridge shelf life are required to facilitate widespread adoption. Successful European examples include local and national external quality control organisations where laboratories take part in primary care POCT with service agreements to act as test administrators, quality controllers, and trainers [50]. A central POCT management system set up by a national authority organisation that supports implementation and provides appropriate guidance has facilitated widespread uptake in Europe [65]. In The Netherlands, as per guideline recommendations, GPs closely collaborate with local laboratories with experience in quality control to address maintenance issues and reduce workload. In Norway, ongoing support and monitoring for POCT use are provided to general practices by a dedicated local adviser assigned through the national authority, Noklus, who collaborates with the national medical association, manages the administration of POCT and provides ongoing support to clinicians through site visits, courses, training, and guidance [66]. Clinicians also expressed concerns about the ambiguity in interpreting test results and noted that experience in interpretation is necessary to gain full benefit, requiring training on the recommendations on use, interpretation, and the role of POCT in the diagnostic workup [58]. Ideally, devices should also offer IT connectivity so that results can be integrated into patient information systems.

4.2. Facilitators for effective implementation of respiratory POCT

The most commonly identified facilitators were training, education, and mentoring support. Training mainly related to the use of POCT devices to increase confidence and skills and ensure that protocols are consistently followed [38,48]. Provision for assigning a dedicated staff member to do the testing [48] was raised as an enabler that could mitigate the impact on workload and minimise the risk of medication errors secondary to the increased workload. Training and education in POCT use could be delivered by relevant industry or central laboratory services either in-house or online, and some European reimbursement schemes require training as a component of POCT [50]. Access to a centralised database of available and qualified supervisors accessible to clinicians was suggested to increase accreditation and enable the adoption of LUS among physiotherapists [35]. A feasibility study by de Lusignan, Hoang, Liyanage, Tripathy, Yonova, Byford, Ferreira, Diez-Domingo, Clark [45] recommended the appointment of a clinical champion per location responsible for the POCT technology.

Understanding and meeting patient expectations is another important consideration that warrants further research in POCT adoption. Primary care clinicians believed that respiratory POCT improved diagnostic certainty by differentiating between bacterial and viral pathogens and informing appropriate treatment decisions, which facilitated the appropriateness of antibiotic prescribing [48,58,59]. The perception of GPs on the impact of POCT for RTIs was positive, as it reassured patients, built trust, allowed for more effective and appropriate treatment, and provided an independent, objective measure of their illness [58,59]. Several studies reported that POCT utilisation empowered clinicians in decision-making that was trusted by their patients, especially where antibiotics were not needed. Moreover, the use of POCT improved satisfaction with clinical care and made patients feel heard [52,55,57-59]. We intend to survey Australian primary healthcare professionals and validate these findings using a qualitative semi-structured survey

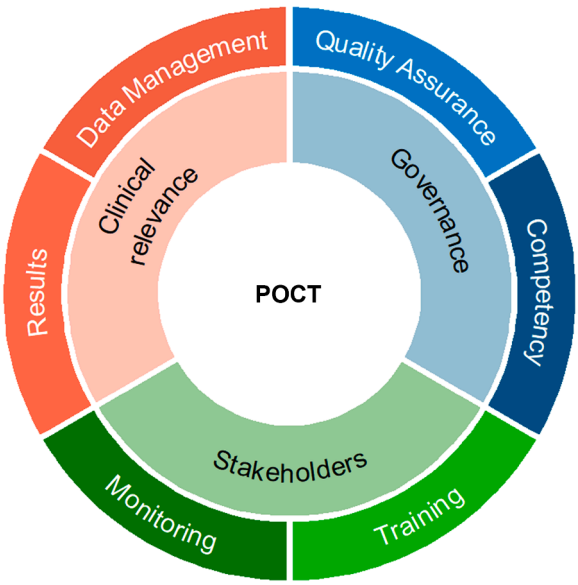

Fig. 1. Key drivers for decision-making to uptake of POCT for RTI management in primary care as identified by this review.

evaluation.

Our results largely align with a recent synthesis of Australian healthcare compared to the UK, Norway and The Netherlands, which identified the lack of a support structure for guidance, resources to assist with workflow integration, ongoing monitoring, and quality control as key factors influencing the successful adoption and implementation of POCT in general practices [65]. Recent reviews of best practices in primary care of high-income countries concluded that lack of staff training and IT integration, operational costs, limited clinical evidence, and unclear regulation on quality assurance were obstacles to the successful implementation of POCT technologies [1,27]. For the effective implementation of respiratory POCT in primary practice, key challenges around providing resourcing to mitigate time pressures and costs, improved training, increased quality control, improved device feasibility, and addressing patient expectations need to be resolved for seamless integration and realisation of benefits of respiratory POCT in general practice. Fig. 1 represents the drivers for the successful implementation of POCT in primary care.

5. Strengths and weakness

The major strength of this evidence-based review was the systematic search of databases to capture all relevant studies. We did not perform a critical appraisal of the included studies, since we aimed to understand important factors to clinicians in the adoption of POCT. This approach allowed us to explore perceptions and attitudes in different primary care settings in high-income countries. The findings of this review will inform a semi-structured qualitative interview with clinicians which will be used for a large quantitative survey on the perception and views of Australian clinicians on POCT adoption for RTI management. It is possible that the clinicians who participated in this review do not represent attitudes across their respective clinical settings, countries, or across all high-income countries. Country-specific health systems and cultural factors may also influence attitudes to RTI POCT implementation, and these may not apply specifically to Australian primary care.

6. Future directions

It is expected that POCTs will continue to be used as a strategy to contain antibiotic resistance and maximise patient safety. Most of the barriers identified by this paper can be overcome with appropriate resourcing, staffing, quality control, training, financial support structures, and managing patient expectations to drive routine respiratory POCT use in primary practice. Pivotal to the adoption of respiratory POCT is leadership to drive the development of an effective quality control framework and supportive resources as highlighted by international experiences. Moving forward, for sustainable integration and effective use of respiratory POCT in general practice, it is essential to establish ongoing monitoring to evaluate the performance of POCT, reduce the additional workload associated with implementation, and provide resources to support the quality assurance process. Additionally, the long-term implementation of respiratory POCT in primary care in Australia requires consideration of issues around our healthcare system, Medicare reimbursement, rural and regional issues, as well as workforce resources.

7. Conclusion

POCT has demonstrated its potential as a valuable tool for rapid and accurate microbiological diagnosis in patients with respiratory infections. Australia, despite its long-standing and well-established POCT program in remote rural areas, faces numerous challenges. Our review highlights the importance of clinical, economic, and logistical issues around the uptake of respiratory POCT and the need to address implementation barriers from the perspective of all stakeholders impacted by its use, including clinicians and patients [67]. These findings may provide insight into driving widespread respiratory POCT adoption. Additional staffing resources to mitigate the additional workload associated with implementation and not overburden stretched clinicians, the provision of training and resources to support ongoing clinical oversight and quality assurance processes, and a model to reduce the costs for clinicians, such as tests provided by the government and ongoing reimbursement, will be essential to the successful implementation of respiratory POCT. The experience of European countries with a higher prevalence of wide-scale and sustained implementation of POCT for respiratory infections in primary care provides a ready opportunity for Australia to improve the uptake of POCT for respiratory infections in primary care. It has also shown that significant system-wide changes are critical and necessitate an oversight framework for governance and leadership [68]. The experience of POCT use during the pandemic highlights the significance of collaborations and integration across healthcare systems for successful implementation, potentially paving the way for the improved perception and adoption of respiratory POCT in primary care.

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CRediT authorship contribution statement

Negar Jamshidi: Writing – original draft, Methodology, Investigation, Formal analysis. **Melissa Waine:** Writing – review & editing, Formal analysis. **Monique Binet:** Writing – review & editing. **Vathsala Mohan:** Writing – review & editing. **David J Carter:** Writing – review & editing. **Branwen Morgan:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.diagmicrobio.2024.116541.

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