

## REVIEW ARTICLE

## FREQUENCY AND CHARACTERISTICS OF MEDICAL COMPLICATIONS IN REHABILITATION SETTINGS: A SCOPING REVIEW

Elyse LADBROOK<sup>1</sup>, MNURSPRAC, Stephane BOUCHOUCHA<sup>2</sup>, PhD and Ana HUTCHINSON<sup>2</sup>, PhDFrom the <sup>1</sup>School of Nursing, Midwifery & Public Health, University of Canberra, Canberra and <sup>2</sup>Centre for Quality and Patient Safety Research, School of Nursing & Midwifery, Deakin University, Burwood, Victoria, Australia

**Objective:** To synthesize the available evidence on medical complications occurring in adult patients in subacute inpatient rehabilitation, and to describe the impact on subacute length of stay and readmission to acute care.

**Design:** Scoping review.

**Subjects:** Adult patients, within the inpatient rehabilitation environment, who experienced medical complications, clinical deterioration and/or the requirement of transfer to acute care.

**Methods:** A systematic search of MEDLINE and CINAHL electronic databases was undertaken to identify primary research studies published in English and French during the period 2000-2021. Study reporting followed the standards indicated by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews checklist (PRISMA-ScR).

**Results:** A total of 47 studies were identified for inclusion. Key results included differences in the type and frequency of complications according to admission type, the proportion of patients experiencing at least 1 complication, and complications associated with transfer to acute care.

**Conclusion:** Patients admitted for inpatient rehabilitation are at high risk of medical complications and may not be medically stable during their admission, requiring care by clinicians with expertise in functional rehabilitation, and ongoing management by members of the multidisciplinary team with expertise in acute general medicine, infectious diseases and recognition and response to clinical deterioration.

**Key words:** rehabilitation; healthcare utilization; healthcare delivery; infection; clinical deterioration.

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Correspondence address: Elyse Ladbrook, School of Nursing, Midwifery & Public Health, University of Canberra, 11 Kirinari Street Bruce, ACT 2617, Canberra, Australia. E-mail: elyse.ladbrook@canberra.edu.au

Inpatient rehabilitation is an integral component of healthcare delivery, providing opportunity for

## LAY ABSTRACT

Medical complications are associated with negative patient health outcomes and significant impact on healthcare utilization and delivery. A review was undertaken to scope available literature and explore medical complications as an important concept in relation to healthcare delivery and utilization for patients admitted to subacute care for inpatient rehabilitation. The results of the review highlighted that patients admitted for inpatient rehabilitation are at high risk of medical complications, with infections, neurological and cardiorespiratory complications being prominent. Patients admitted following stroke, traumatic brain injury/trauma or cancer are particularly vulnerable. The findings of this review emphasize the importance of including clinicians within the multidisciplinary rehabilitation team who have expertise in acute medicine and nursing, infection prevention and control, and recognition and response to clinical deterioration, to support the delivery of high-quality and safe care within inpatient subacute settings.

functional recovery and promotion of independence for patients during the post-acute care phase and ongoing support for complex medical conditions (1). Inpatient rehabilitation is typically provided in a geographically separate subacute care setting, and the availability of subacute care beds may improve patient flow through acute care and decrease acute care costs. Medical complications (complications), including adverse events and clinical deterioration, have the potential to interrupt rehabilitation programmes, lead to acute care readmission, and result in suboptimal outcomes, including increased costs to the patient and healthcare organizations (1).

The impact of complications and clinical deterioration on both patient outcomes and acute care costs is well documented (2, 3). Delivery of safe and high-quality healthcare, that promotes positive patient health outcomes, centres on the mitigation of risk, errors, and harm (4). Key policies and clinical practice guidelines are focused on core patient safety goals including decreasing risk for healthcare-associated complications, such as infections and falls, early recognition and prompt intervention for clinical deterioration, as well as effective interdisciplinary and consumer communication (3, 4).

Adverse patient health outcomes are associated with poor organizational leadership and failure to promptly recognize and respond to clinical deterioration (5). To improve patient outcomes, the organizational leadership team must exemplar clinical governance processes that support timely recognition of physiological variance and activation of rapid clinical review systems (5, 6). Rapid response teams and clinical escalation pathways are embedded into practice in acute care (7, 8); however, recent research suggests that in the subacute care setting recognition and response systems require development (9).

Subacute care services are an integral part of the healthcare system, supporting individuals to maintain their highest level of functional ability and quality of life at the interface between acute and community-based healthcare (10, 11). Although there has been extensive research evaluating the incidence and prevalence of healthcare-associated complications and clinical deterioration meeting escalation criteria in acute care, there is less research evaluating the impact of complications and clinical deterioration in sub-acute care.

The purpose of this scoping review is to synthesize the available evidence on frequency and type of complications occurring in the inpatient rehabilitation context, in different cohorts of patients (e.g. post-stroke, trauma, orthopaedic and cardiac rehabilitation) and to describe the impact of complications on patient health outcomes, healthcare utilization, the incidence of readmission to acute care and patient mortality.

## METHODS

### Design

A scoping review of the literature was performed, involving a systematic search of relevant electronic bibliographic databases and hand searching of reference lists. The methods used for this scoping review were informed by the methodology outlined by Peters et al. (12) to ensure a consistent approach to the conduct and reporting of the review (13). Study reporting followed the standards indicated by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews checklist (PRISMA-ScR) (13, 14). This review is registered with the OSF Registries (<https://osf.io/9xyhk>).

### Research questions

The scoping review aimed to address the following questions:

- What proportion of patients, admitted to inpatient rehabilitation settings, experience at least 1 medical complication?

- What are the reported characteristics of medical complications experienced by patients admitted to inpatient rehabilitation settings?
- What are the reported characteristics of medical complications that result in an interruption to rehabilitation and/or return to acute care?

### Search strategy

Electronic searches were performed of MEDLINE Complete and CINAHL Complete via the EBSCO-host platform. Key search terms included: Medical Complications OR Complications, and Sub-acute Care, Rehabilitation OR Inpatient rehabilitation, AND Adverse Events OR acute care transfer OR, sub-acute care length of stay. Search terms were combined according to a PCC (Participant, Concept, Context) search strategy and included: adults requiring inpatient rehabilitation who experienced the occurrence of medical complications, clinical deterioration and/or the requirement of transfer to acute care (15, 16). An example of the search strategy used is outlined in Appendix S1.

### Inclusion/exclusion criteria

Study inclusion criteria were: primary research studies, undertaken in the inpatient rehabilitation or sub-acute environment, and published in English and French between 2000 and 2021. One team member is a native French speaker and this time-frame was used to support the identification of current literature, in French and English, in relation to trends in health service delivery and models of care. Studies conducted outside the inpatient rehabilitation/subacute environment were excluded.

### Definitions

The following definitions were used in this study:

*Medical complications (complications).* A working definition was used to include physiological variation away from homeostasis, resulting from new onset or exacerbation of ongoing disease process (17) and/or occurrence of a hospital-acquired complication (for example falls, venous thromboembolism). Complications were broadly categorized into body systems and broader concepts, such as infection, pain, psychiatry, and adverse events.

*Classification of hospital-acquired diagnoses.* Classifications generated from medical record data that support hospitals to identify and monitor any adverse events, to improve the safety and quality of healthcare (18).

*Clinical deterioration requiring escalation of care.* Significant physiological variation leading to decompensation, associated with increased risk for adverse events including death, requiring prompt involvement of relevant clinical specialties and implementation of

definitive care to address time-critical health needs (19, 20).

*Hospital-associated complications.* A list of adverse events used to monitor safety in addition to the Classification of Hospital Acquired Diagnoses (21).

*Return to acute care.* Inter-hospital transfer for the purposes of readmission to an acute care facility from an inpatient rehabilitation setting or subacute care facility (22).

*Subacute phase.* Care that occurs post-acute admission, where interventions are designed to support patients experiencing functional impairment and/or physical deconditioning to optimize functional recovery and quality of life. (23).

*Inpatient rehabilitation setting.* Healthcare setting where patients are admitted to a sub-acute care facility, either located within the acute hospital or in a stand-alone site, during the subacute phase of care where they are supported by nursing, medical and allied health professionals (1).

*Study screening, quality appraisal and data analysis.* Two researchers (EL and AFH) independently screened citations by title and abstract to exclude irrelevant articles and identify potential studies for full-text review. The same researchers reviewed the full text of articles retained following initial screening. Final decisions to include or exclude studies from the review were made independently, with discrepancies resolved by a third reviewer (SB). Data from included studies was extracted into a spreadsheet: author; publication year; study purpose and design, outcomes measures and study findings. Two authors (EL and AFH) separately checked the data extraction of study findings.

Although not essential for scoping reviews, quality appraisals were conducted to provide an overview of the methodological rigour of included studies. Articles included in the review were appraised for methodological quality using the Joanna Briggs Institute Appraisal Checklists for cross-sectional, case-control or cohort studies, as appropriate (24). As the purpose of this review was to scope and synthesize extant peer-reviewed publications, studies were not excluded based on the quality review.

Data from the studies included the study location and design, type and frequency of complications reported, the proportion of patients that were reported to have experienced at least 1 medical complication, and the proportion who required return to acute care. Incomplete data or outcomes reported using different denominators were identified and described as required.

Data were summarized into studies that reported the prevalence of complications, the proportion of patients requiring return to acute care (RTAC) and the type and

frequency of complications that resulted in RTAC. Data related to the type and frequency of complications and reasons for RTAC, are outlined in the appendices S3 and S4, respectively. This was undertaken to identify the most common type of medical complication reported, and to identify further research opportunities where additional systematic review and meta-analysis may be relevant.

## RESULTS

Database searching identified 280 records, with 2 additional studies found through hand-searching by title and abstract. A total of 56 papers were identified for full-text review, by 2 independent researchers (EL and AFH). Following full-text review against the study criteria 47 papers were included in this review (Fig. 1).

### *Description of included studies*

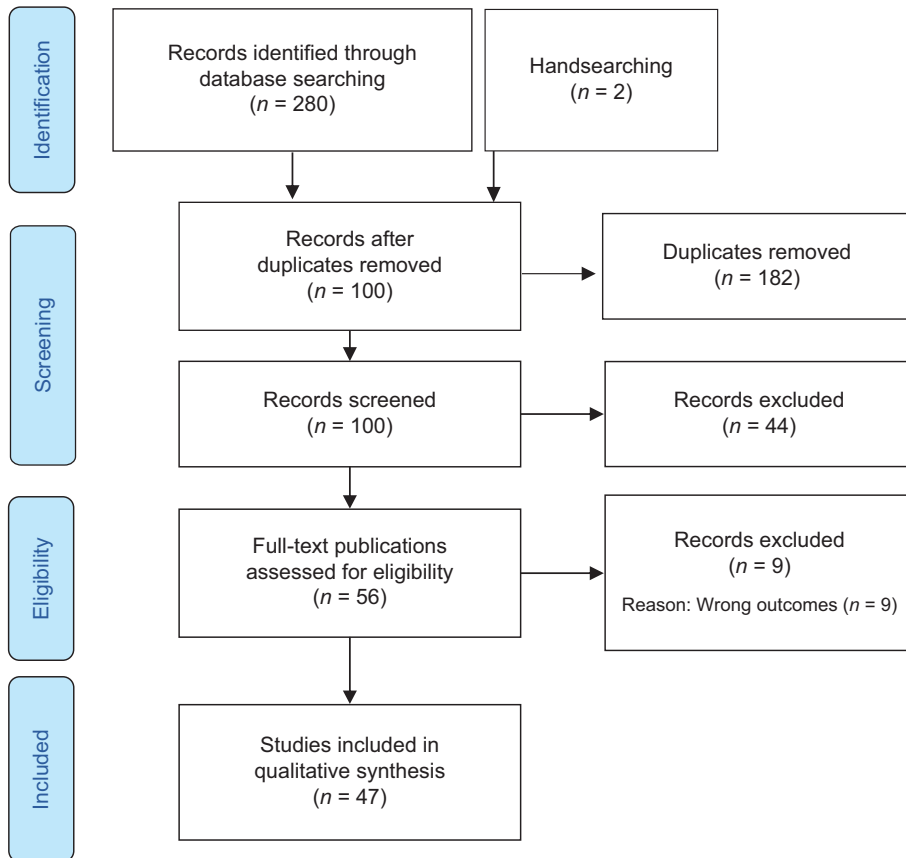
A total of 47 studies were identified relating to complications (2, 17, 25–69). Studies were conducted across a variety of international healthcare settings, including North America ( $n=22$ ) (17, 27, 31, 33, 36–38, 40, 42, 44–46, 50, 51, 54, 59, 60, 62–66), Europe ( $n=9$ ) (26, 29, 34, 35, 43, 49, 52, 55, 69), Asia ( $n=11$ ) (28, 41, 47, 48, 53, 56–58, 61, 67, 68) and Oceania ( $n=5$ ) (2, 25, 30, 32, 39). Study cohorts included general rehabilitation (2, 25, 44, 47, 51, 56, 60, 65) and rehabilitation following: cerebrovascular accident (CVA) (17, 26, 28, 30, 35, 36, 38, 52, 57, 58, 61, 67, 68), acquired brain injury (32, 34, 43, 49, 54, 64, 66), spinal cord injury (37, 41, 48, 53, 55, 59, 62), post cardiac intervention (27, 39, 69), as well as musculoskeletal, cancer, and older persons with functional decline (29, 31, 33, 40, 42, 45, 46, 50, 63).

### *Quality appraisal*

Quality appraisal was undertaken according to study design using recommended appraisal tools, the results are outlined in Appendix S2 (24). Overall, the included studies that used cross-sectional, case-control, quasi-experimental and randomized control trial designs met recommended quality appraisal criteria (2, 25, 33, 37). Only 1 study was noted to have not identified or described management of confounding variables (56). Quality appraisal of cohort studies showed recruitment of patients that were representative of the study population with exposure and outcomes measured using valid and reliable criteria (17, 26–32, 35, 36, 38–40, 68).

### *Frequency of complications*

Thirty-two studies reported the type and/or frequency of complications occurring in subacute inpatient rehabilitation. Twenty-four studies (17, 26, 28, 29, 31, 34–36,



**Fig. 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

38–41, 47, 52, 53, 57, 58, 61–63, 66–69) reported the number of patients who experienced at least 1 medical complication during their episode of care, with the reported incidence varying from 3.4% (61) to 96.8% (63) (Table I). Six studies identified a proportion of patients who experienced 3 or more complications (28, 35, 36, 47, 58, 68), including Kuptniratsaikul et al. (58) who reported that 64.8% experienced at least 3 complications, and 53.5% experienced 4–5 complications during their rehabilitation admission (Table II).

Twenty-four studies reported data on the frequency of complications in different patient cohorts (Table III) and 66.67% of these studies ( $n = 16$ ) reported at least 1 complication in more than half of the study population. Studies reporting outcomes for patients receiving rehabilitation following cerebrovascular accidents (CVA) accounted for 54.17% ( $n = 13$ ) (17, 26, 28, 31, 35, 36, 38, 52, 57, 58, 61, 67, 68) and 10 of these studies (76.92%) reported that more than 60% of patients with a CVA experienced a complication during their rehabilitation admission. Gökkaya et al. (52) reported that patients admitted following CVA experienced, a mean of, 7.1 ( $\pm 2.2$ ) complications during their rehabilitation admission.

Whyte et al. (34) identified a substantial burden of complications in patients following non-penetrating

brain injury (mean rate 2.85 complications per patient), with 70% experiencing moderate to severe complications. Lew et al. (31) reported the complication rate amongst patients with traumatic brain injury (TBI), CVA and orthopaedic groups as 1.5, 1.2 and 1.0, respectively. Interestingly, Lew et al. (31) demonstrated that the presence of comorbidities increased complication risk in the TBI group ( $p < 0.05$ ), but not in the orthopaedic or CVA cohorts. Both Janus-Laszuk et al. (35) and Kitisomprayoonkul et al. (57) found that, for patients with a CVA, the number of complications experienced impacted negatively on their functional recovery.

Marcassa et al. (69) found that the rate of complications was higher in patients with diabetes ( $p < 0.01$ ), noting significant differences in the frequency of infectious complications ( $p < 0.01$ ), renal dysfunction ( $p < 0.001$ ), and heart failure ( $p < 0.05$ ). The study conducted by Ikbali Afsar et al. (55) noted that urinary tract infections (UTI) and decubitus ulcers were more common in the traumatic spinal cord injury (TSCI) group compared with the neoplastic group ( $p < 0.05$ ). Similarly, McKinley et al. (59) found that patients with TSCI were more likely to experience deep vein thrombosis (DVT), pressure injuries, pneumonia, orthostatic hypertension and spasticity ( $p < 0.05$ ) than the non-traumatic spinal injury group.

**Table I.** Characteristics of studies reporting prevalence of medical complications in inpatient rehabilitation settings

Study Author Country Study design	Patient population	Sample size N	At least 1 complication, n (%)	Overall length of stay (days) Mean (SD)		
Abdul-Sattar (41) Saudi Arabia Prospective cohort	Traumatic spinal cord injury	90	63 (70.0)	123 (45)		
Aras et al. (43) Turkey Prospective cohort	Traumatic brain injury	40	NA	78.4		
Chen et al. (68) Taiwan Retrospective cohort	Post stroke rehabilitation	568	432 (76.1)	25.29 (11.72)		
Chu et al. (46) USA Retrospective cohort	Bilateral Knee Arthroplasty	94	NA	11.7 (4.2)		
Civelek et al. (26) Turkey Retrospective cohort	Post stroke rehabilitation	81	72 (88.9)	Median 30.0 (IQR 19.3–54.3)		
Doshi et al. (47) Singapore Retrospective cohort	Inpatient rehabilitation	140	76 (54.2)	-		
Equebal et al. (48) India Retrospective cohort	Spinal cord injury	47	NA	93.34 (40.95)		
Ganesh et al. (51) USA Prospective cross-sectional	Acquired brain injury rehabilitation	68	NA	64.1 (47.0)		
Gökkaya et al. (52) Turkey Prospective cohort	Post stroke rehabilitation	83	75 (90.0)	45.7 (23)		
Gupta et al. (53) India Prospective cross-sectional	Non traumatic spinal cord lesions	64	58 (90.6)	55.75 (40.91)		
Hung et al. (28) Taiwan Cohort study	Post stroke	346	151 (43.6)	28.0 (13.8)		
Ikbali Afsar et al. (55) Turkey Retrospective cohort	Spinal cord injury	338	NA	Neoplastic SCI 34.8 (41.03)	Traumatic SCI 60.2 (53.1)	p < 0.01
Janus-Laszuk et al. (35) Poland Retrospective cohort	Post stroke	1075	827 (76.9)	35.7 (18.1)		
Kennedy et al. (66) USA Retrospective cross-sectional	Traumatic brain injury	373	120 (32)	19.8 (13.9)		
Kim et al. (67) South Korea Before and after study	Post stroke	497		53.8 (38.9)		
Implementation of clinical pathway		Before 196	181 (92.3)	p = 0.077		
		After 301	262 (87.3)			
Kitisomprayoonkul et al. (57) Thailand Prospective cohort	Post stroke	118	83 (70.3)	No complications 23.04 (6.18)	Complications 60.66 (32.83)	p = 0.066
Kuptniratsaikul et al. (58) Thailand Prospective cohort	Post stroke	327	71.0 (n = 232)	> 21 days (OR = 2.36; 95% CI = 1.26–4.43)		
Lew et al. (31) USA Retrospective chart audit	General rehabilitation	175	59 (33.7)	7.3 (4.2)		
	Orthopaedic	n = 107	22 (20.5)	36.9 (23.4)		
	Traumatic brain injury	n = 42	26 (61.9)	22.4 (11.5)		
	Stroke	n = 26	11(42.3)	Median 26 (IQR 13.5-34)		
Mathews et al. (27) USA Retrospective cohort	Cardiac patients with left ventricular assist devices and subsequent stroke	21	NA	22 (+/-12)		
Marcassa et al. (69) Italy Prospective cohort	Post cardiac surgery	1200	274 (22.8)	22 (+/-12)		
McKinley et al. (59) USA Prospective cohort	Spinal cord injury	117	NA	Traumatic 42.97 (28.35)		
	Non-traumatic	n = 38		Non-traumatic 26.36 (15.4)		
	Traumatic	n = 79		p < 0.05		
McLean (36) <sup>a</sup> Canada Prospective cohort	Stroke	133	89 (67.0)	39.5 (20.9)		
Mulroy et al. (29) Ireland Retrospective analysis	Functional decline	155	106 (68.4)	Median 83 (IQR 2–460)		
Pongratanakul et al. (61) Thailand Retrospective cohort	Post stroke	995	34 (3.4)	26.7 (± 14.1)		
Richard-Denis et al. (62) Canada Retrospective cohort	Traumatic spinal cord injury	150	68 (45.6)	28.0 (± 14.1)		
Roth et al. (38) USA Retrospective chart audit	Post stroke	1845	1413 (76.6)	28.0 (± 13.8)		
Roth et al. (17) USA Retrospective chart audit	Post stroke	1029	773 (75.1)	NA		
Shiner et al. (39) Australia Retrospective cohort	Post cardiac transplant	116	39 (33.6)	26.9 (± 21.2)		
Tennison et al. (63) USA Retrospective cohort	Cancer rehabilitation	165	158 (96.8)	NA		
Whyte et al. (34) Denmark, Germany & USA Randomized control trial	Non-penetrating traumatic brain injury	184	152 (82.6)	NA		
Yeung et al. (40) Canada Retrospective cohort	Musculoskeletal	275	119 (43.3)	29.6 (± 16.4)		
Zhang et al. (64) USA Retrospective cohort	Disorder of consciousness	146	10.4 (SD 3.1) /patient			

<sup>a</sup>Full data only available for 112 patients within the sample, shown as 94.6% of the study sample experiencing medical complications.

NA: not available; SD: standard deviation; IQR: interquartile range; SCI: spinal cord injury, OR: odds ratio; 95% CI: 95% confidence interval.

**Table II.** Studies that reported the number of complications per patient during their sub-acute care admission

Study	Population Sample size	Number of medical complications <i>n</i> (%)				At least 1 complication <i>n</i> (%)
		0	1	2	3 or more	
Chen et al. (68)	Post-stroke rehabilitation <i>N</i> = 568	136 (23.9)	163 (28.7)	132 (23.2)	137 (24.1)	432 (76.1)
Doshi et al. (47)	Inpatient rehabilitation <i>N</i> = 140	54 (45.7)	32 (22.9)	-	25 (17.9)	76 (54.2)
Hung et al. (28)	Post-stroke rehabilitation Inpatient rehabilitation ward <i>N</i> = 346	195 (56.4)	110 (31.8)	29 (8.4)	12 (3.5)	151 (43.6)
Janus-Laszuk et al. (35)	Post-stroke rehabilitation <i>N</i> = 1,075	248 (23.1)	338 (31.4)	276 (25.7)	213 (19.8)	827 (76.9)
Kitisomprayoonkul et al. (57)	Post-stroke rehabilitation <i>N</i> = 118	35 (29.7)	34 (28.8)	23 (19.4)	-	83 (70.3)
Kuptniratsaikul et al. (58)	Post-stroke rehabilitation <i>N</i> = 327	95 (29.1)	7 (2.1)	13 (4.0)	212 (64.8)	232 (71.0)
Marcassa et al. (69)	Rehabilitation post cardiac surgery <i>N</i> = 5261	4,061 (11.0)	604 (11.5)	596 (11.3)	-	1,200 (22.8)
McLean (36) <sup>a</sup>	Stroke rehabilitation unit <i>N</i> = 133	44 (33.0)	43 (32.0)	24 (18.0)	9 (7.0)	89 (67.0)
Yeung et al. (40)	General medical <i>N</i> = 269	185 (67.3)	75 (27.3)	9 (3.3)	-	84 (31.2)
	Orthopaedic <i>N</i> = 273	218 (81.0)	46 (16.4)	9 (3.3)	-	55 (20.2)

<sup>a</sup>Incomplete percentages reported.

### Characteristics of medical complications

There was heterogeneity in the type and frequency of complications reported across the identified studies

**Table III.** Prevalence of complications during admission per patient cohort

Authors	Medical cohort Study setting	Population ( <i>N</i> )	At least 1 complication <i>n</i> (%)
<i>Spinal cord injury</i>			
Abdul-Sattar (41)	Saudi Arabia	90	63 (70.0)
Gupta et al. (53)	India	64	58 (90.6)
Richard-Denis et al. (62)	Canada	150	68 (45.6)
<i>Traumatic brain injury</i>			
Kennedy et al. (66)	USA	373	120 (32.0)
Lew et al. (31)	USA	42	26 (61.9)
Whyte et al. (34)	Denmark, Germany, USA	184	152 (82.6)
<i>Cerebral vascular accidents</i>			
Chen et al. (68)	Taiwan	568	432 (76.1)
Civelek et al. (26)	Turkey	81	72 (88.9)
Gökkaya et al. (52)	Turkey	83	75 (90.0)
Hung et al. (28)	Taiwan	346	151 (43.6)
Janus-Laszuk et al. (35)	Poland	1,075	827 (76.9)
Kim et al. (67)	South Korea	497	181 (92.3)
Kitisomprayoonkul et al. (57)	Thailand	118	83 (70.3)
Kuptniratsaikul et al. (58)	Thailand	327	232 (71.0)
Lew et al. (31)	USA	26	11 (42.3)
McLean (36)	Canada	133	89 (67.0)
Pongratanakul et al. (61)	Thailand	995	34 (3.4)
Roth et al. (38)	USA	1,845	1413 (76.6)
Roth et al. (17)	USA	1,029	1413 (76.6)
<i>General and aged care</i>			
Doshi et al. (47)	Singapore	140	64 (45.7)
Mulroy et al. (29)	Ireland	155	106 (68.4)
<i>Musculoskeletal conditions</i>			
Lew et al. (31)	USA	107	22 (20.5)
Yeung et al. (40)	Canada	275	119 (43.3)
<i>Cardiac</i>			
Marcassa et al. (69)	Italy	5,261	1,200 (22.8)
Shiner et al. (39)	Cardiac transplant (Australia)	116	39 (33.6)
<i>Cancer</i>			
Tennison et al. (63)	USA	165	158 (96.8)

(Appendix S3) (17, 26–29, 31, 32, 34–36, 38, 39, 47, 48, 51–53, 55, 57–59, 61, 63, 68, 69). Hospital-acquired complications were noted to occur throughout most studies and included venous thromboembolism, pressure injuries, adverse drug events and falls. The most commonly reported complications were infections, and non-infectious neurological alterations. Infectious complications were identified in 26 studies, with UTIs, pneumonia and cellulitis reported as the most common (17, 26–28, 31, 34–36, 38, 41, 46–48, 51–53, 55, 57–59, 61, 64, 66–69). Six studies noted infection to have occurred in over half of the study population (26, 51, 53, 55, 59, 68). Neurological alterations were reported in 20 studies, with a variety of complications reported, including alterations in cognition, challenging behaviours, hydrocephalus, stroke progression, epilepsy, seizure and seizure-like activity (17, 26, 28, 29, 31, 34–36, 43, 46, 47, 51, 52, 57, 59, 61, 64, 67–69).

Risk factors for complications varied and included higher comorbidity scores, lower Functional Independence Measure (FIM) scores on admission or discharge, longer rehabilitation length of stay and/or greater neurological deficits (26, 28, 33, 68). Janus-Laszuk et al. (35) identified severe disability as associated with a 2.5-fold increase in the incidence of complications. Roth et al. (17) identified the following factors as increasing complication risk: greater neurological deficits, pressure ulcers, use of indwelling devices such as feeding tubes, indwelling urethral catheters, or tracheostomy tubes, abnormal serum electrolyte levels ( $p < 0.0001$ ), hypoalbuminaemia ( $p < 0.001$ ) and comorbidities, such as renal failure, anaemia or hypertension ( $p < 0.01$ ). In addition to

anxiety present on admission (adjusted odds ratio (adjusted OR)=6.87; 95% confidence interval (95% CI)=2.45–19.29), Kuptniratsaikul et al. (58) identified a timeframe of  $\geq 1$  month since the onset of stroke (adjusted OR=2.12; 95% CI=1.07–4.17) as an independent risk factor for complications. Hung et al. (28) showed a significant association between the occurrence of complications and female sex ( $p=0.004$ ), patients with greater neurological deficit ( $p<0.0001$ ), severe disability ( $p<0.0001$ ), use of an indwelling urinary catheter ( $p<0.0001$ ), and increased length of rehabilitation stay ( $p<0.0001$ ). Equebal et al. (48) found that there was no correlation between age and commonly reported complications; however, Chen et al. (68) highlighted an increase in the incidence of complications in patients aged  $>65$  years. Of note were complications occurring in patients aged  $>75$  years with a significant increase in the incidence of upper gastrointestinal bleeding ( $p=0.011$ ), the presence of pressure ulcers ( $p<0.001$ ), hyponatremia ( $p=0.029$ ), and infections including symptomatic UTIs ( $p<0.001$ ) and scabies ( $p<0.027$ ) (68).

There was variation in the reported mean length of stay in subacute care across studies. The occurrence of complications was associated with an increased length of stay (LOS) in 10 studies, (26, 28, 31, 35, 40, 57–59, 62, 69). Yeung et al. (40) found that complications was a significant risk factor for an increased length of stay ( $p=0.011$ ). Marcassa et al. (69), Hung et al. (28) and Kitisomprayoonkul et al. (57) also reported a greater LOS amongst patients who experienced a complication compared with those that did not ( $p<0.001$ ,  $p<0.001$  and  $p<0.001$ , respectively). Janus-Laszuk et al. (35) reported a mean increase in LOS per medical complication of approximately 5 days when a person experienced 2 or more complications during their rehabilitation admission. Kuptniratsaikul et al. (58) found that a LOS  $>21$  days (adjusted OR=2.34; 95% CI=1.44–0.382) as well as the presence of anxiety on admission to rehabilitation (adjusted OR=2.36; 95% CI=1.26–4.43) were independent risk factors for the development of complications.

#### *Characteristics of complications requiring acute care transfer*

A total of 30 studies (2, 17, 25–30, 32–34, 36, 37, 39, 40, 42, 44–47, 49, 50, 54, 56, 57, 60, 61, 63, 65, 69) measured the proportion of patients RTAC following subacute care admission as ranging from 2.89% (28) to 52.38% (27) (Table IV). Most studies reported patients RTAC only once, 4 studies identified patients requiring  $>1$  RTAC (25, 27, 32, 46), with McKechnie et al. (32) reporting that 18 patients (4.7%) had  $\geq 3$  acute care transfers. Patient cohorts commonly associated with higher rates of RTAC included: spinal cord injury,

post cardiac transplant and frail, older adults whereas, stroke rehabilitation cohorts were associated with lower rates (26–30, 36, 37, 44). However, Alam et al. (42) found higher rates of RTAC in stroke ( $p=0.001$ ), brain ( $p=0.004$ ), and spinal cord injuries ( $p=0.009$ ). Other patient cohorts commonly reported as requiring RTAC included general rehabilitation (2, 25, 30, 47, 56, 65), orthopaedic (46), neoplasm (33, 42, 50), traumatic brain injury (44, 49, 54) and amputation (44, 45).

Complications noted as contributing factors for unplanned RTAC included infection, respiratory failure/distress, cardiac complications, changes to neurological function, seizure activity, renal failure, venous thromboembolism, fractures, dislocations, and adverse events, such as falls (2, 17, 27, 32, 33, 37, 39, 40, 45). A detailed breakdown of each category of contributing factors is provided in Appendix S4. Infectious complications were noted as the most common cause of RTAC in 12 studies (26, 30, 33, 37, 39, 44–46, 56, 57, 61, 63). Hammond et al. (54) noted infection as the most common reason for RTAC in medical patients. Whyte et al. (34) identified pneumonia as the most common reason for RTAC, and Carney et al. (44) showed infections (including pneumonia) and other pulmonary complications as the most common causes for RTAC. Alam et al. (42) identified that infection was the most common reason for RTAC ( $p=0.001$ ) within the neoplasm cohort and cardiopulmonary factors the most common reason in patients without neoplasm ( $p<0.001$ ).

There was variation in findings regarding risk factors associated with the need for RTAC. Pongratanakul et al. (61) noted that age (adjusted OR 1.08; 95% CI 1.04–1.13;  $p<0.001$ ), the presence of a feeding tube (adjusted OR 3.94; 95% CI 1.30–11.96;  $p=0.015$ ) and anaemia (adjusted OR 2.62; 95% CI 1.04–6.57;  $p=0.04$ ) were independently associated with interruption to stroke rehabilitation programmes. Whereas, Mathews et al. (27) found that age was not a significant risk factor for RTAC. Faulk et al. (65) noted time of admission and total Functional Independence Measure (FIM) score were significant predictors for RTAC, ( $p=0.0017$  and  $p<0.0001$ , respectively). Similarly, McKechnie et al. (32) found that motor FIM score ( $p<0.001$ ) and Glasgow Coma Score (GCS) ( $p=0.001$ ) were independent risk factors for RTAC. In their prediction model Cheng et al. (45) found male sex was the only significant risk factor ( $p=0.01$ ). Tension et al. (63) found both tachycardia and the need for frequent blood transfusions were independent risk factors for RTAC. Considine et al. (25) highlighted several factors that increased the risk of emergency inter-hospital transfer including: serious adverse events during the index acute care admission, increased vital sign monitoring in the 24 h prior to transfer, male sex,

**Table IV.** Characteristics of studies reporting the proportion of people requiring return to the acute care setting and associated medical complications

Study author Study design	Country	Population N	RTAC N (%)	Infection n (%)	Cardiac n (%)	Respiratory n (%)	Renal/urology n (%)	Neurological n (%)	Haematology n (%)	GI n (%)	Surgical n (%)	General medical n (%)	Other n (%)	Falls/ fracture n (%)
General														
Alam et al. (42)	USA	293	293 (10.5)	-	-	-	-	-	-	-	-	-	-	-
Retrospective cohort														
Carney et al. (44)	USA	3,072	250 (8.1)	55 (22.0)	20 (8.0)	35 (14.0)	-	23 (9.0)	-	18 (7.0)	13 (5.0)	23 (9.0)	43 (17.0)	-
Retrospective cohort														
Considine et al. (2)	Australia	136	136 (100)*	17 (12.5)	20 (14.7)	14 (17.6)	4 (3.0)	22 (16.2)	-	17 (12.5)	-	-	17 (12.5)	15 (11.0)
Cross-sectional														
Considine et al. (25)	Australia, Prospective case-time matched control study	1,763	557 <sup>b</sup>	77 (12.8)	82 (13.6)	84 (13.9)	22 (3.6)	113 (18.7)	-	81 (13.4)	31 (5.1)	-	30 (5.0)	46 (7.6)
Doshi et al. (47)	Singapore	140	8 (5.7)	2 (25.0)	3 (37.5)	-	-	1 (12.5)	-	2 (25.0)	-	-	-	-
Retrospective cohort														
Faulk et al. (65)	USA	2,282	256 (11.22)	57 (22.3)	28 (10.9)	68 (26.7)	-	23 (8.9)	-	-	-	-	-	27 (10.5)
Retrospective cohort														
Im et al. (56)	Korea	1,301	121 (9.3)	31 (25.6)	26 (21.5)	-	53 (4.1)	22 (18.2)	4 (3.3)	4 (3.3)	18 (14.9)	-	11 (9.1)	-
Retrospective chart audit														
Pinto et al. (60)	USA	2,312	228 (9.9)	-	-	-	-	-	-	10 (4.4)	30 (13.2)	-	-	188 (82.4)
Retrospective cohort														
Orthopaedic														
Cheng et al. (45)	USA	118	19 (16.1)	6 (31.6)	2 (10.5)	3 (15.8)	4 (21.1)	1 (5.3)	-	1 (5.3)	2 (10.6)	-	-	-
Cross-sectional														
Chu et al. (46)	USA	94	8 (8.5)	20 (21.3)	5 (5.3)	-	-	1 (1.1)	4 (4.3)	1 (1.1)	2 (2.1)	1 (1.1)	2 (2.1)	-
Cross-sectional														
Post cerebrovascular accident														
Civelek et al. (26)	Turkey	81	9 (11.1)	3 (3.7)	3 (3.7)	-	-	1 (1.2)	1 (1.2)	1 (1.2)	-	-	-	-
Retrospective cohort Study														
Hung et al. (28)	Taiwan	346	10 (2.89)	3 (30.0)	-	-	-	5 (50.0)	-	-	1 (10.0)	-	1 (10.0)	-
Retrospective cohort														
Katrak et al. (30)	Australia	29	80 (11.0)	13 (16.23)	8 (10.0)	-	-	7 (8.8)	7 (8.8)	2 (2.5)	12 (15.0)	-	26 (32.5)	5 (6.3)
Retrospective cohort														
Kitisomprayoonkul et al. (57)	Thailand	118	14 (11.8)	5 (35.7)	3 (21.4)	-	-	4 (3.4)	1 (7.1)	-	-	1 (7.1)	-	-
Prospective cohort														
McLean (36)	Canada	133	2 (1.5)	-	-	-	-	-	-	1 (0.75)	-	-	-	1 (0.75)
Prospective cohort														
Pongratanakul et al. (61)	Thailand	995	32 (3.2)	15 (46.9)	3 (9.4)	-	-	10 (31.2)	-	-	-	-	4 (12.5)	-
Retrospective chart audit														
Roth et al. (17)	USA	1,029	197 (19.0)	30 (15.2)	52 (26.4)	-	4 (2.0)	30 (15.2)	48 (24.4)	18 (9.1)	-	-	4 (2.0)	5 (2.5)
Retrospective chart audit														
Acquired brain injury														
Formisano et al. (49)	Italy	1470	451 (30.7)	-	-	-	-	-	-	-	-	-	-	-
Retrospective cohort														
Hammond et al. (54)	USA	2130	183 (8.6)	-	-	-	-	-	-	-	110 (52.0)	94 (45.0)	5 (3.0)	-
Prospective cohort														
McKechnie et al. (32)	Australia	383	83 (22.0)	-	-	-	-	-	-	-	-	-	-	-
Retrospective cohort														
Whyte et al. (34)	Denmark, Germany & USA	184	29 (15.8)	-	-	-	-	-	-	-	-	-	-	-
Randomized control trial														
Marcassa et al. (69)	Italy	5261	212 (4.0)	-	-	-	-	-	-	-	-	-	-	-
Prospective cohort														

**Table IV (Continued...).** Characteristics of studies reporting the proportion of people requiring return to the acute care setting and associated medical complications

Study author Study design	Country	Population N	RTAC N (%)	Infection n (%)	Cardiac n (%)	Respiratory n (%)	Renal/urology n (%)	Neurology n (%)	Neurological n (%)	Haematology n (%)	GI n (%)	Surgical n (%)	General medical n (%)	Other n (%)	Falls/ fracture n (%)
Mathews et al. (27)	USA	21	11 (52.4)	3 (27.3)	1 (9.1)	-	-	4 (36.4)	4 (36.4)	-	7 (63.6)	-	-	-	-
	Retrospective cohort														
Shiner et al. (39)	Australia	116	39 (33.6)	13 (33.3)	3 (7.7)	14 (35.9)	3 (7.7)	1 (2.6)	1 (2.6)	1 (2.6)	1 (2.6)	-	-	3 (7.7)	-
	Retrospective cohort														
Other															
Fu et al. (33)	USA	122	32 (26.0)	11 (34.4)	6 (18.75)	1 (3.1)	2 (6.3)	2 (6.3)	2 (6.3)	7 (21.9)	1 (3.1)	1 (3.1)	-	1 (3.1)	-
	Cross-sectional														
Fu et al. (50)	USA	30	9 (30.0)	2 (22.2)	-	-	-	1 (16.7)	1 (16.7)	-	-	-	3 (33.3)	1 (16.7)	-
	Retrospective cohort														
Mulroy et al. (29)	Ireland	155	20 (17.8)	-	-	-	-	-	-	-	-	-	-	-	-
	Retrospective cohort														
Robinson et al. (37)	USA	137	37 (19.8)	10 (27.0)	3 (8.0)	6 (16.0)	-	10 (27.0)	10 (27.0)	-	1 (3.0)	6 (16.0)	-	1 (3.0)	-
	Retrospective case-control														
Tennison et al. (63)	USA	165	31 (18.8)	9 (29.0)	2 (6.5)	5 (16.1)	1 (3.2)	3 (9.7)	3 (9.7)	4 (12.9)	-	-	4 (12.9)	3 (9.7)	-
	Retrospective cohort														
Yeung et al. (40)	Canada	275	8 (2.9)	-	-	-	-	-	-	-	-	-	-	-	-
	Retrospective														

<sup>a</sup>Inclusion criterion required need for acute care transfer.

<sup>b</sup>Case refers to number of patients requiring acute care transfer; control refers to patients not requiring acute care transfer.  
RTAC: return to acute care; GI: gastrointestinal.

being born in a non-English speaking country, and a lower FIM score on admission to subacute care (25). Other risk factors identified across studies included: elevated white blood cell count, abnormal haemoglobin level on admission, indwelling devices, such as an indwelling urethral catheter or feeding tube, greater neurological deficit, or a history of pneumonia ( $p < 0.001$ ), cardiac arrhythmia ( $p < 0.01$ ) and dyspnoea requiring oxygen (17, 27).

Timing of transfers varied; Robinson et al. (37) noted that 73% of RTAC occurred within 10 days of subacute care admission, Carney et al. (44) found 22% ( $n = 55$ ) were transferred within 3 days of admission, Faulk et al. (65) reported 22.3% ( $n = 57$ ) returned within 72 h of subacute admission, and Fu et al. (2019) found a median of 10 days until RTAC. Considine et al. (25) found the median subacute length of stay prior to RTAC, was 11 days, with only 8.9% of all transfers occurring within the first day of subacute care admission. Amongst patients who required RTAC the subacute care LOS ranged between 11.7 days ( $SD \pm 6.4$  days) (54) and 29.6 days ( $SD \pm 16.4$  days) (40). Four studies, Hammond et al. (54), Im et al. (56), Matthews et al. (27) and McKechnie et al. (32), reported a significant increase in overall LOS associated with patients requiring RTAC ( $p \leq 0.001$ ,  $< 0.001$ ,  $0.003$ , and  $< 0.001$ , respectively). In contrast, Civelek et al. (26) and Robinson et al. (37) found no difference in LOS, while Faulk et al. (65) found the LOS of patients requiring RTAC was shorter.

Eight articles (2, 17, 25, 36, 39, 44, 50, 61) reported death as an outcome in relation to complications or when patients required RTAC. Pongratanakul et al. (61) noted that all deaths were amongst patients who had experienced complications during their subacute care admission. Studies by McLean (36) and Roth et al. (17), noted 3 deaths during the study period, with McLean (36) highlighting that 2 deaths were related to infectious complications. Shiner et al. (39) noted that all recorded deaths ( $n = 5$ ) were related to underlying disease states and were amongst patients who had required RTAC, and subsequently died in acute care (39). Carney et al. (44) reported an increased proportion of deaths in patients who required RTAC within the first 3 days of admission for rehabilitation (11%) in comparison with those who were transferred later (5%). In a single site study Considine et al. (2) reported an increase in the proportion of patients who died after transfer to acute care, noting an inpatient mortality rate of 14.7% ( $n = 15$ ). In their multi-site study Considine et al. (25) noted that 1.3% of patients ( $n = 8$ ) died in emergency following RTAC, and 10.2% ( $n = 50$ ) died during their subsequent acute care readmission. Fu et al. (50) noted that patients who required RTAC had a median survival of 4.1 months in comparison with

patients who were discharged home or to a skilled nursing facility (median survival 9.4 months,  $p=0.107$ ).

## DISCUSSION

The findings in this scoping review highlight the variation and frequency of complications occurring amongst patients admitted for inpatient rehabilitation, with patients admitted following CVA, TBI or cancer diagnosis being particularly vulnerable. Infectious complications were prominent across the included studies, highlighting the need for improved infection prevention and control practices in the subacute inpatient rehabilitation setting. The high reported frequency of neurological complications and patients requiring acute care readmission emphasizes the importance of developing sub-acute care clinicians' skills in recognition and response to clinical deterioration.

Despite considerable concordance in the reported prevalence estimates across different patient cohorts, there was considerable methodological heterogeneity across the identified studies that would make conducting a formal systematic review and meta-analysis inappropriate. In addition, there was limited critical evaluation of individual patient risk factors for complications and the impact of complications on patient outcomes. Where individual risk factors were explored there was limited analysis to identify and adjust for possible confounding variables, with the majority of studies only presenting descriptive rather than analytical data. Further rigorous multi-site research using large sample sizes is required to evaluate the impact of pre-existing conditions, reasons for rehabilitation admission and other patient risk factors on the incidence, type, and severity of complications. In addition, in-depth organizational case studies are needed to support a greater understanding of the contextual factors that contribute to the incidence of complications occurring within individual health services.

Whilst the identified studies describe complications occurring within inpatient rehabilitation settings, the literature does not address strategies to decrease the incidence, severity and need for RTAC for ongoing management. The occurrence of complications was both a predictor and consequence of a prolonged length of stay in the rehabilitation setting (28, 57, 58). Although some complications may be considered minor, studies evaluating the frequency of acute care readmission following clinical deterioration highlights that these episodes contribute to adverse patient outcomes, including increased risk of death (2, 17, 25, 36, 39, 44, 50, 61). Understanding both contributing factors and key characteristics of complications that cannot be managed within the subacute setting, could support a

deeper understanding of the impact of complications on patient outcomes, health service utilization and delivery. This supports the argument by Hammond et al. (54) that RTAC is influenced by patient characteristics as well as contextual factors related to the specific site, resources, and staff skill mix.

Infections, such as UTI and pneumonia, as well as cardiorespiratory and neurological complications, were prominent events that resulted in acute clinical deterioration and the need for RTAC across all patient cohorts (2, 25, 26, 33, 37, 39, 42, 44–47, 56, 57, 61, 63, 65). This is an important finding, as it highlights focused areas for practice improvement. In the area of infection prevention and control specifically, there is a need for strategies to prevent worsening of minor infections present at the time of admission and to decrease the incidence of new-onset infections (51). A consistent association was found between the use of indwelling devices, such as urinary catheters, and an increased frequency of infectious complications (26, 57). This finding demonstrates the importance of developing targeted quality improvement initiatives to promote best practice in the management of indwelling devices and care pathways with explicit goals to optimize duration of use. However, further research is required to understand individual risk factors for different type of infections within patient cohorts.

Neurological complications were also prominent complications identified by studies reporting both type and frequency of complications, and patients requiring RTAC (17, 25–31, 33–37, 39, 42–44, 46, 47, 50–52, 57, 59, 61, 63–65, 67–69). Across the included studies there was considerable heterogeneity in reason for subacute care admission, cohorts included patients admitted for rehabilitation following neurological, orthopaedic, or cardiac events, and those admitted for general rehabilitation. This is an important finding that highlights the diverse nature of complications that exist within inpatient rehabilitation cohorts. Demonstrating the need for safe, evidence-based and quality healthcare that is tailored to individual patient needs, to minimize adverse patient outcomes and financial costs associated with increased length of stay, morbidity, and mortality (31, 43, 51).

In addition, the high frequency of cardiorespiratory complications, electrolyte or haematological abnormalities further confirms the argument posed by Hung et al. (28), that admission for inpatient rehabilitation does not equate to medical stability. The need for models of care in inpatient rehabilitation settings that include timely access to medical review of unstable patients is also demonstrated by these findings (70).

The results of this review highlight the complex health issues experienced by patients admitted to inpatient rehabilitation and challenge the notion that

patients admitted to inpatient subacute rehabilitation do not require expert medical management. This also calls into question assumptions about the level of nursing skill and supervision required in inpatient rehabilitation settings, which typically employ a lower nurse to patient ratio and a higher proportion of less experienced or qualified nursing staff (71–73). Based on the available data it was not possible to differentiate whether reported complications occurred: (i) due to deterioration of a pre-existing condition, (ii) associated with the primary reason for subacute care admission, (iii) as a result of hospital-acquired complication, or (iv) as a new-onset condition. Prospective interventional studies are needed to evaluate whether changes in the model of care and introduction of clinical pathways that include proactive monitoring, identification and response to clinical deterioration, decrease the incidence and adverse sequelae of these events.

#### Study limitations

One limitation of this review is that most included studies were observational and relied on retrospective analysis of administrative datasets. It was therefore not possible to evaluate or control for all the causative factors driving the high rates of complications reported. Moreover, the heterogeneity in study design and definitions used across studies does not support the use of meta-regression statistical techniques to evaluate the impact of patient factors on the occurrence of complications.

### CONCLUSION

Patients admitted for inpatient rehabilitation are at high risk of medical complications during their admission to sub-acute care. The review findings highlight the complexity and heterogeneity of patients admitted for inpatient rehabilitation and their increased risk for cardiorespiratory, neurological, and infection-related complications. In addition to care by clinicians with expertise in functional rehabilitation, these patients require ongoing management by a multidisciplinary team with expertise in acute general medicine, infection prevention and control, and recognition and response to clinical deterioration.

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The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Detailed data collection tables are included in Appendices S1–S4.

*The authors have no conflicts of interest to declare.*

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