DELIRIUM IN PATIENTS WITH HIP FRACTURES

Tarandeep Oberai

Stelligen behorend bij het proefschrift

DELIRIUM IN PATIENTS WITH HIP FRACTURES

Tarandeep Oberai

1. High rate (36.5%) of postoperative delirium exists in hospitalised hip fracture patients in Australia and New Zealand. (This Thesis)
2. Delirium in patients with hip fracture results in higher rates of hospital mortality, longer hospital stay and higher discharges to residential aged care facility. (This Thesis)
3. Age, male gender, pre-existing cognitive impairment, delay in surgery and delay in post-operative mobilisation are independent predictors of delirium. (This Thesis)
4. Early engagement of multidisciplinary staff including geriatricians is the key element of a successful delirium prevention program. (This Thesis)
5. Multidisciplinary clinicians believe that hypoactive delirium can be hard to recognise, and family have vital role to play in delirium recognition and management. (This Thesis)
6. Australian and Netherlands have very similar delirium clinical practice guidelines. However actual clinical practices observed in the two countries is vastly different. (This Thesis)
7. Practice guidelines developed without ongoing rigorous evaluation are more likely to be unsuccessful in changing practice. (This Thesis)
8. Translation of evidenced-based intervention model is likely to only have mixed impact on the outcome if the goals of the implementation are not aligned with wider goals of the organisation. (This Thesis)
9. I stand on the sacrifices of a million women before me thinking what can in do to make this mountain taller so the women after me can see farther- Legacy. (Rupi Kaur)
10. Our lives begin to end the day we become silent about the things that matter. (Martin Luther King Junior)
11. Remember that hope is a powerful weapon even when all else is lost. (Nelson Mandela)

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Dit proefschrift is tot stand gekomen binnen een samenwerkingsverband tussen de Universiteit van Amsterdam en Flinders University met als doel het behalen van een gezamenlijk doctoraat. Het proefschrift is voorbereid aan de Faculteit der Geneeskunde van de Universiteit van Amsterdam en aan het College of Medicine and Public Health van Flinders University.

This thesis was prepared within the partnership between the University of Amsterdam and Flinders University with the purpose of obtaining a joint doctorate degree. The thesis was prepared in the Faculty of Medicine of the University of Amsterdam and in the College of Medicine and Public Health of Flinders University.

Delirium in patients with Hip Fractures

By

Tarandeep Oberai

Thesis Submitted to
Flinders University (College of Medicine and Public Health)
and University of Amsterdam (Faculty of Medicine)
for a Cotutelle degree of Doctor of Philosophy
15th February 2024

CONTENTS

ABSTRACT

This thesis is designed to improve understanding, recognition, prevention and management of delirium in hospitalised older patients with hip fracture. Delirium is a preventable neuropsychiatric disorder characterized with acute confusion, disorientation, global cognitive deficit and is multifactorial. Delirium is considered one of the most common post-operative complication in patients with hip fracture. Research suggests that one third of delirium episodes are preventable if the identified factors can be addressed. Early recognition is also considered a key aspect of delirium prevention and management.

The thesis is divided in two parts. Part one sets to enhance our understanding of delirium in Australian and New Zealand population with hip fractures using data from Australia and New Zealand Hip Fracture Registry. We examined consequences and predictors of delirium within this population.

This thesis uses implementation research methodology. Part two focuses on development and implementation of the intervention bundle to reduce incidence of delirium through improved delirium recognition. The systematic review of the literature was performed to investigate the effect of multicomponent interventions on incidence of delirium. Focus groups with multidisciplinary clinicians from orthopaedic were performed to understand their perceptions in relation to recognition, diagnosis and management of delirium. The barriers identified in the focus groups and the best practice evidence identified in the systematic review was used to develop the intervention bundle to improve delirium recognition and care. In brief, the intervention bundle included; education, environmental restructuring, change champions, infographics and audit feedback reports. Prospective data was collected using Interrupted time series methodology to understand the efficacy of this delirium prevention bundle.

In the pre-intervention phase a gap in nurses' knowledge of delirium was identified as one of the areas for improvement hence education was one of the key components of the intervention bundle. The three-step education intervention was offered as part of the intervention strategies based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality. The pre-existing knowledge survey was used to test nurse's knowledge delirium. The survey was developed by Researchers in Western Australia and had been used widely globally by other researchers for the same purpose. However, the psychometric properties had not been tested. We utilised the responses from the pre-intervention and post-intervention phase to validate the survey. Consequently, a shorter validated survey has been developed.

This thesis demonstrated that a well-considered intervention bundle only had a mixed impact on decreasing incidence of delirium. This project also highlighted the significance of aligning clinical service improvement goals with the wider goals of the organisation. We have formed international research collaboration (Australia, Europe and United States) based on this project. We are exploring the concept of machine learning for preoperative prediction of postoperative delirium in patients with hip fractures.

DECLARATION

This thesis was prepared within the framework of the Cotutelle Program, with the purpose of obtaining a Joint Doctorate Degree. The thesis was prepared at the College of Medicine and Public Health of Flinders University and at the Faculty of Medicine of University of Amsterdam.

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: Tarandeep Oberai

Date 15-02-2024

GENERAL INTRODUCTION, AIMS AND OUTLINE OF THE THESIS

Delirium in hospitalised older adults with hip fracture

The clinical problem

Delirium has been discussed in the medical literature for more than two millennia, yet it is often under-recognised and not managed appropriately.[1, 2] Delirium is a complex neuropsychiatric syndrome characterized by acute and fluctuating onset, inattention, altered level of consciousness and evidence of disorganized thinking. [3] Delirium is very common in hospitalized older adults. Studies have identified delirium as the most frequent complication among the hospitalized elderly, particularly among those undergoing orthopedic surgical interventions following hip fracture.[4-6] Research reports that approximately 35% to 65% of patients experience delirium post-operatively.[7] Patients with delirium during the hospital stay have a worse prognosis, stay longer in the hospital, have higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge.[8-10] Delirium is reported to be preventable in almost 30 to 40% of cases. [11] Delirium has major significance for public health providers as a goal for interventions to prevent the associated burden of complications and costs. [12] Therefore, delirium is now routinely used as an indicator of health-care quality for older people. [13]

The exact mechanisms and causative factors of delirium are not well understood. A number of neurotransmitters have been postulated to lead to the development of delirium, including an elevation in dopamine level and deficiencies in acetylcholine, serotonin, and gamma-aminobutyric acid.[14] Some researchers proposed that impaired cholinergic transmission, inflammation and impaired oxidative metabolism could explain the pathogenesis of delirium.[15] There are also a variety of potential risk factors associated with this condition, many of which are avoidable or treatable.[16] Delirium is considered to be a result of the interactions between patient vulnerabilities and precipitating factors.[17] Advancing old age and cognitive impairment have been identified as the most consistent predictor of post-operative delirium.[18, 19] The amount of blood lost intra-operatively has been identified as another correlation with post-operative delirium. Greater intra-operative blood loss, more blood transfusions and a post-operative haematocrit <30% are associated with a higher incidence of delirium.[20] The physical hospital environment has also been identified as an aggravating factor for the onset of delirium.[21] These risk factors further intensify due to the presence of a fractured hip. Hip fracture is associated with considerable pain and undertreated pain is another significant risk factor to the development of delirium. [22 23] Hip fracture patients are also subject to emergency room

wait times and are therefore exposed to stressful factors often characterized by multiple staff encounters, disturbed sleep and discomfort.[24, 25]

The economic burden of delirium is significant. In Australia alone, there were an estimated 132 595 occurrences of delirium in the tax year 2016–2017. The total costs of delirium in Australia were estimated to be $8.8 billion in 2016–2017, ranging between $5.3 billion and 12.1 billion. [26] Patients who develop postoperative delirium have 2.5 times greater costs than those without, with additional costs ranging $16,000 to $64,000 per patient-year. [27]

Prevention and Management

Several studies have investigated various interventions to prevent delirium, which can be grouped into multicomponent therapies and single interventions. [28-31] The majority of single intervention studies focus on the impact of pharmacological interventions. [28-30] Effectiveness studies on the use of pharmacological interventions for delirium prevention show mixed results. [28-30] A randomized, placebo-controlled trial investigated the effectiveness of haloperidol prophylaxis on post-operative delirium in elderly hip fracture patients from a large general hospital.[28] Low dose haloperidol treatment (i.e. 1.5mg/d started pre-operatively and up to three days post-operatively) decreased hospital length of stay and improved delirium severity; however, it did not decrease the incidence of delirium.[28] Another multicentre, double-blind randomized controlled trial (RCT) examined the effectiveness of melatonin on the incidence of delirium among patients with hip fracture.[30] This study showed that treatment with 3mg of melatonin does not reduce the incidence of delirium.[30] On the other hand, studies exploring multicomponent therapies showed promising results. [31,] Multicomponent interventions/therapies refer to more than one strategy to address the range of risk factors associated with delirium which can include pharmacological as well as non-pharmacological interventions. A quasi-experimental study which included elderly patients with hip fracture showed a 35% reduction in the incidence of delirium following the implementation of a multi-factorial program which consisted of intense pre-hospital and peri-operative treatment and care. [31] The multi-factorial program comprised oxygen therapy, fluid intake management, pain relief management, delirium screening, avoidance of polypharmacy, and a select choice of peri-operative drugs and anesthetic interventions.[31] Similar results were described in a systematic review of RCTs and prospective studies which identified effective strategies for delirium prevention in critical care patients (e.g. critically ill, general medicine patients, post-surgical patients).[32] Multiple systematic reviews have been undertaken by researchers. [13 33 34, 35]

All the current literature suggests that multidisciplinary unified care by doctors, nurses, allied health and family members assists to prevent the complications and poorer outcomes frequently seen in patients with delirium related symptoms. Addressing the modifiable risk factors is crucial and multicomponent interventions can be of significant benefit. [1]

Various best practice guidelines provide healthcare professionals in the acute care setting with a set of evidence based recommendation statements regarding optimal care of older adults with delirium [36-38]. Both the Australian Delirium Clinical Care Standard and the Dutch Guidelines for Diagnosis and Treatment of Delirium are adapted from the guideline of the National Institute of Clinical Excellence (NICE), published in 2010 [39] and focusses on screening and non-pharmaceutical prevention and treatment.

How can we do better

The growing body of evidence suggests that delirium is a preventable syndrome. Although this condition is known to be associated with poor clinical outcomes, health service planners and practitioners have largely ignored its existence.[40] A number of multicomponent interventions to prevent delirium in hospitalised older patients with hip a fracture have been shown to be effective in randomised controlled trials but have not been translated into a real world setting. [41] It remains unclear if systematic early recognition of delirium improves patient outcomes. Additionally, it is also unclear if measurement of delirium severity and phenotype can improve outcomes of delirium. More data from trials is required to understand the impact of pharmacological agents on prevention and management of delirium. Furthermore, trials of multicomponent interventions are required (like those for prevention) for treatment of delirium. [41] This thesis uses implementation research methodology and seeks to understand the efficacy of a tailored delirium prevention intervention bundle within an existing orthopaedic speciality care system and resources. Many multicomponent interventions have proved to be effective but their usage in the real world have been limited. [41] Hence we aim to assess the feasibility of a tailored intervention bundle into our organisational and policy environment.

Aims and outline of the thesis

The ultimate goal of our research is to reduce incidence of delirium through implementation of a tailored intervention and increase adherence to delirium screening assessment (likewise through implementation of the tailored intervention). The thesis is divided into **two parts**.

Part One focusses on utilising the data collected from the Australia and New Zealand Hip fracture Registry (ANZHFR) to improve understanding of delirium and improve delirium care.

Chapter 1

Initially the data will be used to understand the association of Delirium with hospital length of stay, in-hospital mortality, long-term mortality, and institutionalisation in patients with hip fracture**.** A retrospective cohort study using data from the Australian & New Zealand Hip Fracture Registry (ANZHFR) will be performed. Length of hospital stay (after the date of surgery), in-hospital mortality and long-term mortality will be assessed using Kaplan-Meier curves and univariate and multivariate Cox regression. Discharge to a residential aged care facility will be assessed using multivariate logistic regression.

Chapter 2

Additionally, we will utilise the data to improve delirium recognition. A total of 6672 hip fracture patients with documented assessment for delirium will be analyzed from the Australia and New Zealand Hip Fracture Registry between June 2017 and December 2018. Thirty-six variables for the prediction of delirium using univariate and multivariate logistic regression will be assessed. The models will be assessed for diagnostic accuracy using C-statistic and calibration using Hosmer-Lemeshow goodness-of-fit test. A Delirium Risk Score will be developed based on the regression coefficients.

Chapter 3

Furthermore, we'll be utilising the Australia and New Zealand hip fracture data to externally validate a machine learning algorithm developed by our collaborators in *Massachusetts General Hospital, Harvard Medical School* The primary purpose of this study will be (1) to examine the performance of the SORG hip fracture delirium algorithm on an independent cohort of patients from a separate continent and (2) to examine the impact of predictor heterogeneity on the performance of machine learning algorithms

in orthopaedic surgery to offer recommendations for future studies seeking to build multinational and internationally valid algorithms. The baseline characteristics and variable definitions of the developmental cohort were compared to the validation cohort. Predictive performance on the validation cohort was assessed using discrimination, calibration, decision curve analysis, and Brier-score.

Part Two of this thesis would focus on development and implementation of the intervention bundle to reduce incidence of delirium through improved delirium recognition.

Implementation research is defined as the scientific study of methods to promote the systematic uptake of research findings and other evidence based practices into routine practice to improve the quality and effectiveness of health services and care. [42] The goal of implementation science is to understand how evidence based health interventions are made feasible and integrated into the organisational, social and policy environment. [43] This thesis will focus especially on improving delirium recognition and screening as improved delirium screening and recognition is a key component of delirium prevention.

Process models inform the process of translating research into practice; the Knowledge to Action framework (KTA) developed by Graham et al. provides the foundation for this project. [44], [45] The Knowledge to Action framework consists of a central knowledge creation cycle and a concurrent action cycle.

Chapter 4

A systematic review will be undertaken which will form the knowledge creation cycle. The aim of the systematic review will be to investigate the effect of multicomponent interventions on incidence of delirium. We hypothesise that multicomponent intervention strategies can have positive effects on preventing delirium in patients with a hip fracture. This will be a systematic review of experimental, non-experimental and observational studies. Electronic searches were conducted in MEDLINE, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials, Embase and Web of science.

Chapter 5

Implementation research begins with the phase of adapting the knowledge to the local context and identifying barriers to knowledge uptake. Hence, focus groups with multidisciplinary clinicians from orthopaedic surgical unit will be used to understand their perceptions in relation to recognition, diagnosis and management of delirium. This

will be a qualitative study using in-depth focus groups discussions with clinical staff of one orthopaedic unit within a level 1 trauma centre, south of Adelaide, South Australia.

Chapter 6

Despite the guidelines giving recommendations to clinicians on early detection, prevention and management of delirium the actual practices in the various clinical settings across the globe can be vastly different. Therefore, we aim to set out to evaluate three components of delirium care guidelines as performed in day to day practice, comparing an orthopaedic trauma unit in Australia with one in the Netherlands Data will be collected using a direct observation method. Direct observation has been identified as the most appropriate method as it allows for the regular nursing practices to be observed first-hand, without potential changes to normal responsibilities and setting.

Chapter 7

Implementation research then continues with selecting, tailoring and implementing knowledge translation intervention, monitoring and sustaining knowledge use and evaluating outcomes. We'll select specific intervention strategies informed by contemporary behaviour change techniques to address the barriers identified in the focus groups. This thesis seeks to assess whether the intervention bundle reduces the incidence of delirium in patients with hip fracture patients identified via the use of a validated tool in screening delirium. We will also examine the length of hospital stay, duration of delirium episode and the prevalence of the use of a validated tool to screen delirium.

Chapter 8

The three-step education intervention will be offered as part of the intervention strategies. Nurses will attend step 1 and step 2 before they could progress to step 3. The education will be based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality. A quasi-experimental (pre-intervention, post-intervention test) design will be used to test the effectiveness of an educational intervention on increasing knowledge. A self-administered structured survey will determine the delirium related knowledge. The specific objectives of the study will be to evaluate the effectiveness of the education intervention and assess if there was sustained knowledge at 6 months.

Chapter 9

Most delirium education programs assess nurse's knowledge of delirium using self-developed questionnaires or other pre-existing knowledge questionnaires that to our knowledge do not have established psychometric properties Therefore, we aim to develop and validate a delirium knowledge questionnaire. The construct validity of the survey will be assessed using Bayesian exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on responses obtained from the 35 knowledge-items of the knowledge survey.

Chapter 10

This implementation research project aims to understand the efficacy of a delirium prevention intervention within an existing orthopaedic speciality care system. This prospective cohort study will use interrupted time series design. Interrupted time series (ITS) analysis has been deemed as a preferred study design particularly when a randomized trial is unfeasible or unethical. In the pre-intervention phase patients will be monitored in between July 2017 to August 2018. The intervention will be implemented in between September 2018 to December 2018 and evaluated between October 2018 and December 2019. The primary outcome of interest is rate of delirium. Secondary outcome is compliance with the use of delirium 4AT screening tool, duration of delirium and hospital length of stay.

REFERENCES

1. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. Lancet. 2014;383(9920):911-22.
2. Irving K, Fick D, Foreman M. Delirium: a new appraisal of an old problem. Int J Older People Nurs. 2006;1(2):106-12.
3. Marcantonio ERJAoim. Delirium. 2011;154(11):ITC6-1.
4. Gustafson Y, Berggren D, Brannstrom B, Bucht G, Norberg A, Hansson LI, et al. Acute confusional states in elderly patients treated for femoral neck fracture. Journal of the American Geriatrics Society. 1988;36(6):525-30.
5. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. Arch Intern Med. 2000;160(12):1856-60.
6. Edlund A, Lundstrom M, Brannstrom B, Bucht G, Gustafson Y. Delirium before and after operation for femoral neck fracture. Journal of the American Geriatrics Society. 2001;49(10):1335-40.
7. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. Journal of the American Geriatrics Society. 2001;49(5):516-22.
8. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. Jama. 1990;263(8):1097-101.
9. Rockwood K, Cosway S, Carver D, Jarrett P, Stadnyk K, Fisk J. The risk of dementia and death after delirium. Age and ageing. 1999;28(6):551-6.
10. McCusker J, Cole M, Dendukuri N, Belzile E, Primeau F. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. CMAJ. 2001;165(5):575-83.
11. Gusmao-Flores D, Salluh JI, Chalhub RA, Quarantini LC. The confusion assessment method for the intensive care unit (CAM-ICU) and intensive care delirium screening checklist (ICDSC) for the diagnosis of delirium: a systematic review and meta-analysis of clinical studies. Crit Care. 2012;16(4):R115.
12. Lin Y, Chen J, Wang Z. Meta-analysis of factors which influence delirium following cardiac surgery. J Card Surg. 2012;27(4):481-92.
13. Siddiqi N, Stockdale R, Britton AM, Holmes J. Interventions for preventing delirium in hospitalised patients. Cochrane Database Syst Rev. 2007(2):CD005563.
14. Gunther ML, Morandi A, Ely EW. Pathophysiology of delirium in the intensive care unit. Crit Care Clin. 2008;24(1):45-65, viii.
15. Ali S, Patel M, Jabeen S, Bailey RK, Patel T, Shahid M, et al. Insight into delirium. Innovations in clinical neuroscience. 2011;8(10):25-34.
16. Ahmed S, Leurent B, Sampson EL. Risk factors for incident delirium among older people in acute hospital medical units: a systematic review and meta-analysis. Age and ageing. 2014;43(3):326-33.
17. Inouye SK, Charpentier PA. Precipitating factors for delirium in hospitalized elderly persons. Predictive model and interrelationship with baseline vulnerability. Jama. 1996;275(11):852-7.
18. Rudolph JL, Marcantonio ER. Review articles: postoperative delirium: acute change with long-term implications. Anesthesia and analgesia. 2011;112(5):1202-11.
19. Robinson TN, Wu DS, Pointer LF, Dunn CL, Moss M. Preoperative cognitive dysfunction is related to adverse postoperative outcomes in the elderly. Journal of the American College of Surgeons. 2012;215(1):12-7; discussion 7-8.

20. Marcantonio ER, Goldman L, Orav EJ, Cook EF, Lee TH. The association of intraoperative factors with the development of postoperative delirium. The American journal of medicine. 1998;105(5):380-4.

21. McCusker J, Cole MG, Dendukuri N, Belzile E. Does delirium increase hospital stay? Journal of the American Geriatrics Society. 2003;51(11):1539-46.

22. Morrison RS, Siu AL. A comparison of pain and its treatment in advanced dementia and cognitively intact patients with hip fracture. Journal of pain and symptom management. 2000;19(4):240-8.

23. Morrison RS, Magaziner J, Gilbert M, Koval KJ, McLaughlin MA, Orosz G, et al. Relationship between pain and opioid analgesics on the development of delirium following hip fracture. J Gerontol A Biol Sci Med Sci. 2003;58(1):76-81.

24. Jacobson SA, Dwyer PC, Machan JT, Carskadon MA. Quantitative analysis of rest-activity patterns in elderly postoperative patients with delirium: support for a theory of pathologic wakefulness. Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine. 2008;4(2):137-42.

25. Lynch EP, Lazor MA, Gellis JE, Orav J, Goldman L, Marcantonio ER. The impact of postoperative pain on the development of postoperative delirium. Anesthesia and analgesia. 1998;86(4):781-5.

26. Pezzullo L, Streatfeild J, Hickson J, Teodorczuk A, Agar MR, Caplan GAJBo. Economic impact of delirium in Australia: a cost of illness study. 2019;9(9):e027514.

27. Leslie DL, Marcantonio ER, Zhang Y, Leo-Summers L, Inouye SK. One-year health care costs associated with delirium in the elderly population. Arch Intern Med. 2008;168(1):27-32.

28. Kalisvaart KJ, de Jonghe JF, Bogaards MJ, Vreeswijk R, Egberts TC, Burger BJ, et al. Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study. Journal of the American Geriatrics Society. 2005;53(10):1658-66.

29. Overshott R, Karim S, Burns A. Cholinesterase inhibitors for delirium. The Cochrane database of systematic reviews. 2008(1):CD005317.

30. de Jonghe A, van Munster BC, Goslings JC, Kloen P, van Rees C, Wolvius R, et al. Effect of melatonin on incidence of delirium among patients with hip fracture: a multicentre, double-blind randomized controlled trial. CMAJ. 2014;186(14):E547-56.

31. Bjorkelund KB, Hommel A, Thorngren KG, Gustafson L, Larsson S, Lundberg D. Reducing delirium in elderly patients with hip fracture: a multi-factorial intervention study. Acta anaesthesiologica Scandinavica. 2010;54(6):678-88.

32. Kalisvaart CJ, Vreeswijk R, de Jonghe JF, Milisen K. [A systematic review of multifactorial interventions for primary prevention of delirium in the elderly]. Tijdschrift voor gerontologie en geriatrie. 2005;36(6):224-31.

33. Thomas E, Smith JE, Forrester DA, Heider G, Jadotte YT, Holly C. The effectiveness of non-pharmacological multi-component interventions for the prevention of delirium in non-intensive care unit older adult hospitalized patients: a systematic review. 2014. [non-pharmacological; delirium; prevention; multi-component; effect; hospitalised; adult patient]. 2014;12(4 <!-- jbi edits -->):53 <!-- jbi edits -->.

34. Martinez F, Tobar C, Hill N. Preventing delirium: should non-pharmacological, multicomponent interventions be used? A systematic review and meta-analysis of the literature. Age and ageing. 2015;44(2):196-204.

35. Hshieh TT, Yue J, Oh E, Puelle M, Dowal S, Travison T, et al. Effectiveness of multicomponent nonpharmacological delirium interventions: a meta-analysis. JAMA internal medicine. 2015;175(4):512-20.

36. Postoperative delirium in older adults: best practice statement from the American Geriatrics Society. J Am Coll Surg. 2015;220(2):136-48.e1.

37. Leentjens AF, Molag ML, Van Munster BC, De Rooij SE, Luijendijk HJ, Vochteloo AJ, et al. Changing perspectives on delirium care: the new Dutch guideline on delirium. J Psychosom Res. 2014;77(3):240-1.

38. Delirium Clinical Care Standard. Sydney: ACSQHC; 2016. p. 1-36.

39. Young J, Murthy L, Westby M, Akunne A, O'Mahony R, Guideline Development G. Diagnosis, prevention, and management of delirium: summary of NICE guidance. BMJ. 2010;341:c3704.

40. Inouye SK, Schlesinger MJ, Lydon TJ. Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. The American journal of medicine. 1999;106(5):565-73.

41. Marcantonio ER. Delirium in hospitalized older adults. New England Journal of Medicine. [Article]. 2017;377(15):1456-66.

42. Eccles MP, Mittman BS. Welcome to implementation science. BioMed Central; 2006.

43. Hodgson NA, Gitlin LN. The role of implementation science in behavioral intervention research. Behavioral intervention research: designing, evaluating and implementing. New York: Springer Publishers. 2016.

44. Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, et al. Lost in knowledge translation: Time for a map? Journal of Continuing Education in the Health Professions. 2006;26(1):13-24.

45. Wilson KM, Brady TJ, Lesesne C, Translation NWGo. An organizing framework for translation in public health: the Knowledge to Action Framework. Prev Chronic Dis. 2011;8(2):A46.

CHAPTER 1

Is delirium associated with negative outcomes in older patients with hip fracture: analysis of the 4904 patients 2017-2018 from the Australian and New Zealand Hip Fracture Registry

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ABSTRACT

Aim

To determine associations between delirium and health outcomes using the Australia and New Zealand population-based hip fracture patient registry (ANZHFR).

Methods

We performed a retrospective cohort study using data from the ANZHFR amongst hip-fracture surgery patients admitted to and discharged from hospital between 01st January 2017 and 31st December 2018.

Results

Of the 4,904 patients with complete data and included in the analysis, 1,789 (36.5%) experienced delirium during their hospital stay. Patients with delirium also had a higher rate of in-hospital mortality (adjusted HR=1.76; 95% CI=1.24, 2.49; p<0.001), a higher rate of long-term mortality (adjusted HR=1.30; 95% CI=1.15, 1.48; p<0.001) and a higher odds of discharge to an aged care facility (adjusted OR=1.24; 95% CI=1.04, 1.48; p=0.019).

Conclusion

A high rate of postoperative delirium exists amongst Australian and New Zealand hip fracture patients. Rates of hospital mortality, length of hospital stay and discharge to residential aged care are considerably worse in these patients.

BACKGROUND

Hip fracture is a serious and common injury experienced by older adults .[1] In Australia alone, 50,900 hip fracture episodes were managed in the 2015-2016 financial year resulting in 579,000 bed days and 206,300 procedures. Once hospitalized, these patients are at risk of developing complications including functional, physical, and mental impairments.[2] One of the most frequently experienced complication amongst individuals with hip fracture is delirium; with an incidence rate varying from 13% to 70%. [3, 4] In 2016-2017 alone within Australia, delirium has been associated with the total costs of $A 8.8 billion with nearly 35% of those costs related to direct costs and 65% to the value of healthy life lost. [5] Patients presenting with delirium during the hospital stay have a worse prognosis, higher costs, stay longer in the hospital, and have higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge.[2, 6-10] Mosk et al. found that postoperative delirium in patients' hip fracture was related with an increased median length of stay (LOS) of 6 days postoperatively. [11] Patients with delirium were more regularly admitted to a nursing home within 6 months (91.8%) and had higher rates mortality (30.1%) within 6-months. [11] One- year mortality was 12.4% in a cohort of 1050 hip fracture patients who experienced delirium.[12]Additionally a recent large meta-analysis of hip fractures by Liu et al also supported that patients with postoperative delirium had more than twice the risk of death than those without. [13]

Rationale

Despite many published studies on consequences of postoperative delirium, outcomes are likely to vary somewhat in different countries depending on demographics and health systems. There is currently little data reported from Australia and New Zealand however the establishment of a hip fracture registry in 2016 affords the opportunity to examine outcomes in this population. The purpose of this study was to extend the previous knowledge on consequences of delirium using the large Australia and New Zealand population-based hip fracture patient registry particularly focusing on hospital length of stay, in-hospital mortality, long-term mortality and institutionalization.

Methods

Study Design

We performed a retrospective cohort study using data from the Australian & New Zealand Hip Fracture Registry (ANZHFR). This is the second study we performed using this data; the first study was published in early 2021 and focussed on risk factors of delirium. [14] The following text on the study design has overlap with the previous study. The ANZHFR is a prospective multi-institutional program that collects preoperative, perioperative and postoperative data on over 50 independent variables from over 67 participating public hospitals in Australia (49) and New Zealand (18). Reported data is acquired from medical records as well as operative notes using a standard data collection form. The data items collected by the ANZHFR are specified in the ANZHFR Data Dictionary v12.1_October 2019 [15]. The extracted data set for this study included 36 variables under the following five categories: patient information, admission, assessment, treatment and discharge. ANZHFR defined the diagnostic criteria of delirium for clinicians. ANZHFR *suggests "Delirium is defined as an acute change in mental status that is common among older patients in hospital. It is characterised by a disturbance of consciousness, attention, cognition and perception that develops over a short period of time (usually hours to a few days). Patients with delirium may be agitated and restless (hyperactive delirium), quiet and withdrawn (hypoactive delirium), or move between these two subtypes (mixed delirium)".* [15] The registry recommended that assessment of delirium requires the use of a validated tool and should be completed within 7 days of the surgery. A range of validated diagnostic tools for delirium have been deemed acceptable including; Confusion Assessment Method (CAM), Confusion Assessment Method (CAM-ICU), 3D-CAM and The 4AT. [16-18] Dementia was documented as part of variable pre-admission cognitive state. Registry suggests that some validated tools for assessing cognitive function include; Abbreviated Mental Test Score (AMTS) Standardised Mini-Mental State Examination (SMMSE), Modified Mini Mental State Exam (3MS), General Practitioner's Assessment of Cognition (GPCOG) and The 4AT. [17, 19-22] The ANZHFR has started linkage of its Australian record data with the Australian Institute of Health and Welfare's (AIHW) National Death Index (NDI) to accurately understand patient survival after hip fracture. This allows a more comprehensive and accurate reporting of mortality.

Cohort definition

We included patients with a date of admission and a date of discharge between 01st January 2017 and 31st December 2018. The final date of follow-up for the purpose of assessing long-term mortality was 31st December 2019. Patients were censored at their date to death or on 31st December 2019 whichever occurred earlier. Patients were also

excluded if they did not have a date of surgery, or had no date for ward or hospital discharge, or had a date of death prior to 1st Jan 2017. Details of the numbers excluded are in **Figure 1**.

Statistical analysis

Patient characteristics were described according to their status for delirium using the mean and standard deviation for normally distributed continuous variables and median (inter-quartile range) for non-normally distributed variables. Categorical variables were described using frequency counts and percentages. Differences in patient characteristics and unadjusted outcomes were assess using independent t-tests and chi-squared tests of association. Length of hospital stay (after the date of surgery), in-hospital mortality and long-term mortality were assessed using Kaplan-Meier curves and univariate and multivariate Cox regression. In the multivariate regression we adjusted for age, gender, ASA grade, type of fracture, dementia and usual place of residence. ASA (American Society of Anaesthesiologists) grade is a marker of disease severity and operative risk and used for case-mix adjustment. [15] Proportional hazards were assessed using the log-log plot and the scaled Schoenfeld residuals for both individual covariates and globally. Discharge to a residential aged care facility was assessed using multivariate logistic regression with the same adjustment used as for the Cox regression. Analysis was performed using Stata version 17.0 (StataCorp, USA). A 2-sided Type 1 error rate of alpha=0.05 was used for significance testing.

Ethics, funding and conflicts of interest

Ethics approval was granted on 28th November 2019 by our local ethics Committee. No funding for this study was received and there are no potential conflicts of interest.

RESULTS

Patient characteristics and their unadjusted outcomes are described in **Table 1**. Of the 4,904 patients included in the study, 1,789 (36.5%) experienced delirium during their hospital stay. There were significant differences between patients with and without delirium for age ($p<0.001$), gender ($p=0.01$), ASA grade ($p<0.001$), usual care residence (<0.001), discharge residence ($p<0.001$), discharge to a residential aged-care facility ($p<0.001$) , dementia ($p<0.001$), acute length of stay ($p<0.001$), in-hospital mortality ($p<0.001$) and long-term mortality ($p<0.001$). However, there were no differences between

those with and without delirium in the number of atypical fractures and the length of stay after surgery.

Kaplan-Meier curves for length of stay and in-hospital and long-term mortality are described in Figure 2,3,4 and table 2 also describes the results from multivariate Cox and logistic regression. In Cox regression, all models met the assumptions of proportionality according to the log-log-plots. The test for proportional hazards was also met for each covariate for each outcome except for the global test of all parameters in the full model for long-term mortality (p=0.004). However, the log-log plot for delirium was approximately parallel and the test of proportional hazards for delirium was also non-significant (χ^2=0.17, 1df; p=0.68) indicating that the hazard ratio for delirium was approximately similar throughout the follow-up period.

Delirium was not associated with hospital length of stay when controlling only for age and gender but was associated with length of hospital stay after surgery in the fully adjusted model. Patients with delirium had a 15% longer length of stay (HR=0.85; 95% CI=0.80-0.91; p<0.001).

In both model 1 (adjustment for age and gender alone) and model 2 (additional adjustment for ASA grade, fracture type, usual care residence and dementia), patients with delirium had a higher rate of in-hospital mortality (fully adjusted HR=1.76; 95% CI=1.24, 2.49; p<0.001), a higher rate of long-term mortality (fully adjusted HR=1.30; 95% CI=1.15, 1.48; p<0.001) and a higher odds of discharge to an aged care facility (fully adjusted OR=1.24; 95% CI=1.04, 1.48; p=0.019).

DISCUSSION

Delirium is one of the highest post-operative complications for this surgical population and in this study the incidence of delirium was 39% amongst a large and representative sample of hospital patients in Australian and New Zealand who underwent hip fracture surgery. [14] Delirium within this population was associated with higher rates of discharge to residential care, higher rates of in-hospital mortality and higher rates of longer-term mortality as well as increased length of hospital stay. Previous studies that have examined these associations have all utilised populations from outside of Australia and New Zealand, have not all used representative hip-fracture populations, have varied in sample size, and have used varying exclusion and inclusion criteria based on regional definitions.

Our findings are consistent with several studies that report mortality rates for patients that develop delirium during their hospital stay for hip-fracture surgery. In our study, patients with postoperative delirium had had a 76% increased risk of in-hospital mortality and a 30 % increased risk of longer-term mortality. Similarly, a recent meta-analysis also observed higher rates of 30-day mortality, 6 month, 1 year and longer-term 1 mortality amongst patients with delirium. [23] Individual studies have observed comparable increases in mortality rates for 6 months of between 17% and 30% [11, 24] and for of 65% for 1-year mortality (32% in delirium group versus 19.3% in non-delirium group). [25]

Besides mortality, our study found that postoperative delirium after hip fracture was independently associated with increased rates of discharge to an aged care facility. Approximately forty-seven percent of the patients who experienced post-operative delirium were institutionalised in comparison to 24% of patients who did not experience post-operative delirium. This means that the odds for a change in residence is 24 percent for people with delirium after controlling for previous usual care residence. Mosk et al and Marcantonio et al both found delirious hip fracture patients had higher rates of institutionalisation. [11, 26] Marcantonio et al observed that patients with post-operative delirium were 3 times more likely to be placed in an aged care facility however the results were not adjusted for usual residence. [26]

Placement in long-term aged care facility alone is an independent driver of patient outcomes. Keshawn et al suggested that rates of post discharge adverse events are higher in patients discharged to an aged care facility and concluded that modifiable risk factors such as morbid obesity, smoking, diabetes, pulmonary disease, and hypertension for these patients should be addressed preoperatively to improve patient outcomes across discharge settings. [27]. Inouye et al suggest that 30 to 40% of the delirium episodes are preventable during hospitalisations by addressing modifiable risk factors. [2] A systematic review focussing on multicomponent interventions to prevent delirium in hospitalised hip fracture patients also suggested that addressing the risk factors related to delirium remains the most effective way of prevention. [28]

There were some limitations to our study. Particularly, our data was observational, and we cannot therefore infer causality. In addition, data were obtained retrospectively which may increase the risk of classification bias. However, the potential for this is limited given that all outcomes were objective in nature. Our data were also obtained from an administrative registry used for quality assurance rather than research and may therefore be less accurate than a registry developed for research purposes. However, the accuracy for length of stay and vital status have previously been established in a validation study. [29] Our results may also be at risk of bias due to confounding. However, we were able

to control for several important potential confounders including the type of fracture, the ASA grade which represented the patient's physical condition and the presence of dementia. In addition, the observed associations were all large and therefore unlikely to be entirely due to unobserved confounding. For example, the estimated e-value, which provides the strength of association between both the exposure and outcome in order for the observed association to disappear, would need to be at least 2.92 for the observed odds-ratio of 1.76 for in-hospital mortality. [30] It is therefore unlikely that any of the observed associations were due entirely to unobserved confounding since single or combined associations of this magnitude are unlikely. In addition, there was a large amount of missing data, with approximately forty-five percent of patients not assessed for delirium. However, the assessment for delirium is likely to have been positively associated with delirium and if the observed associations are real, then the omission of other patients with delirium will have biased the observed association towards the null leading to an underestimate of the true strength of the associations. Finally, the data were derived from the Australia and New Zealand Hip Fracture registry which records data on a voluntary basis only and the results may therefore not be fully generalizable to the whole of the Australian and New Zealand population or other countries. However, representativeness of the population is likely due to wide range of participating hospitals. Beyond these limitations, our study had several important strengths including the large and well described sample of patents collected from a representative collection of institutions that have demonstrated reliability in their data collection.[29] Our inclusion and exclusion criteria were also well-defined, thereby reducing the possibility of selection bias.

Conclusion

In conclusion, we observed a high rate of postoperative delirium in a representative sample of hospitalized hip-fracture patients in Australia and New Zealand. Rates of hospital mortality, longer hospital stay and discharge to residential aged care were considerably higher in patients with delirium than in those without confirming that higher post-surgery surveillance is required in this population and that wherever possible, strategies for the prevention of delirium should be employed. Delirium results in poorer outcomes and this study extents this in Australian and New Zealand population.

Impact statement

A high rate of postoperative delirium exists amongst Australian and New Zealand hip fracture patients. Rates of hospital mortality, long-term mortality, length of hospital

stay and discharge to residential aged care are considerably worse in these patients. The findings from this data can be used for future benchmarking and as part of quality improvement initiatives.

Data Availability Statement

The data that support the findings of this study are available from Australian and New Zealand Hip Fracture Registry. Restrictions apply to the availability of these data, which were used under license for this study. Data are available [from the authors / at URL] with the permission of Australia and New Zealand Hip Fracture Registry.

Tables

Table 1: Patient characteristics and outcomes according to development of delirium

	No delirium (n=3115)	Delirium (n=1789)	p-value
Age (years), mean (±SD)	82.4±8.3	85.8±7.3	<0.001
Gender, n (%)			
Male	936 (30.05)	606 (33.87)	0.011
Female	2,178 (69.92)	1,181 (66.01)	
Unknown	1 (0.03)	2 (0.11)	
ASA Grade, n (%)			
Healthy individual with no systemic disease	29 (0.93)	16 (0.89)	<0.001
Mild systemic disease not limiting activity	39 (1.25)	4 (0.22)	
Severe systemic disease that limits activity	547 (17.56)	117 (6.54)	
Incapacitating systemic disease	1,717 (55.12)	977 (54.56)	
Moribund not expected to survive 24 hours	532 (17.08)	496 (27.72)	
Not known	2 (0.06)	2 (0.11)	
Missing	249 (7.99)	178 (9.95)	
Atypical Fracture, n (%)			
Not a pathological or atypical fracture	2,899 (93.03)	1,696 (94.75)	0.107
Pathological fracture	58 (1.86)	28 (1.57)	
Atypical fracture	141 (4.53)	60 (3.35)	
Missing	18 (0.58)	6 (0.34)	
Usual Care residence			
Private residence (including retirement village)	2476 (79.5)	1001 (56.0)	<0.001
Residential aged care facility	622 (20.0)	770 (43.0)	
Other	11 (0.35)	16 (0.89)	
Not known	1 (0.03)	0 (0.00)	
Missing	6 (0.16)	2 (0.11)	
Discharge destination, n (%)			
Private residence	425 (13.64)	82 (4.58)	<0.001
Residential aged care facility	518 (16.63)	638 (35.66)	
Rehabilitation unit public	1450 (46.55)	661 (36.95)	
Rehabilitation unit private	393 (12.62)	104 (5.81)	
Other hospital / ward / specialty	264 (8.48)	213 (11.91)	
Deceased	41 (1.32)	67 (3.75)	
Short term care in residential care facility	3 (0.10)	2 (0.11)	
Missing	21 (0.67)	22 (1.23)	
Dementia	786 (25.2)	1158 (64.7)	<0.001
Acute Length of stay, (days), median (IQR)	7.0 (5.0-11.0)	8.0 (6.0-12.0)	<0.001
Length of stay after surgery, (days), median (IQR)	13.0 (5.0-27.0)	12.0 (6.0-29.0)	0.088
In-hospital mortality, n (%)	67 (2.15)	100 (5.59)	<0.001
Long-term mortality, n (%)	681 (21.86)	661 (36.95)	<0.001

Table 2: Association of Delirium with hospital length of stay, in-hospital mortality, long-term mortality, and aged care discharge destination

			Unadjusted		Adjusted[1]	
Length of hospital stay	**N**	**Discharged (%)**	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
Without Delirium	3112	3112 (100.0)	1.00		1.00	
With Delirium	1787	1787 (100.0)	0.95 (0.90-1.06)	0.077	0.85 (0.80-0.91)	<0.001
In-hospital mortality	N	Died (%)				
Without Delirium	3099	65 (2.09)	1.00		1.00	
With Delirium	1780	99 (5.54)	2.56 (1.87, 3.51)	<0.001	1.76 (1.24, 2.49)	0.002
[2] Long term mortality	N	Died (%)				
Without Delirium	3,113	616 (19.8)	1.00		1.00	
With Delirium	1,788	619 (34.6)	1.95 (1.74, 2.18)	<0.001	1.30 (1.15, 1.48)	<0.001
Discharge to Aged Care	N	Aged care (%)	OR (95 % CI)	p-value	OR (95 % CI)	p-value
Without Delirium	3,116	755 (24.2)	1.00		1.00	
With Delirium	1,790	849 (47.5)	2.82	<0.001	1.24 (1.04, 1.48)	0.019

[1]**Adjusted for** age, gender, ASA grade, type of fracture, place of usual residence and dementia. HR=Hazard ratio, OR=Odds ratio. CI=confidence interval.
[2] **Long** term mortality- out of hospital mortality

Figures

Figure 1: Flowchart of exclusions

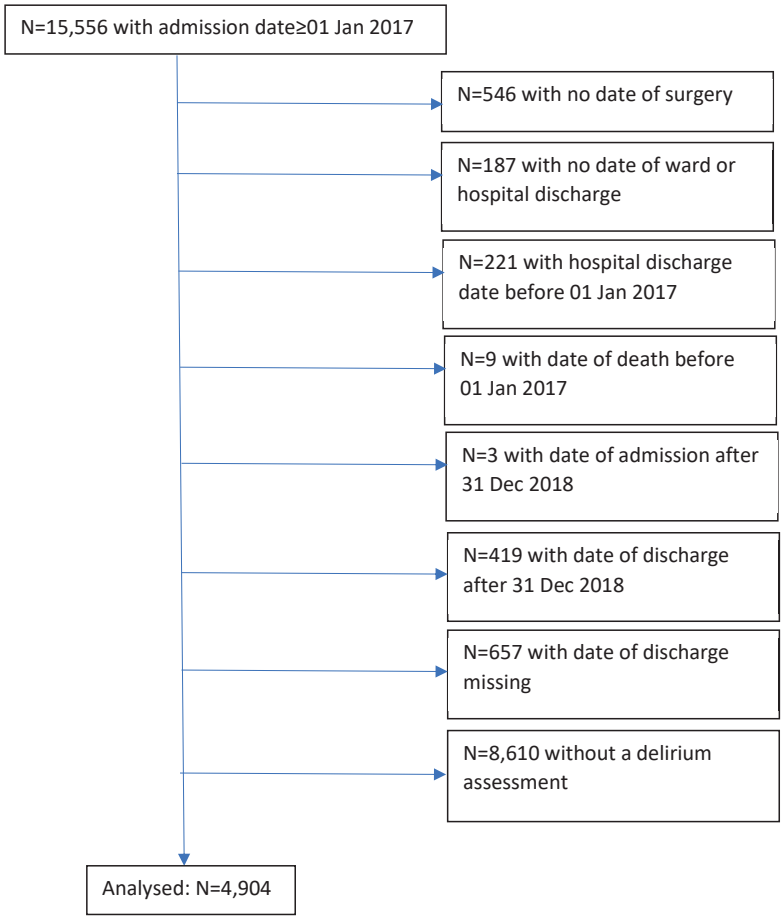


Figure 2: Kaplan Meier plot for hospital length of stay (n=4,891)

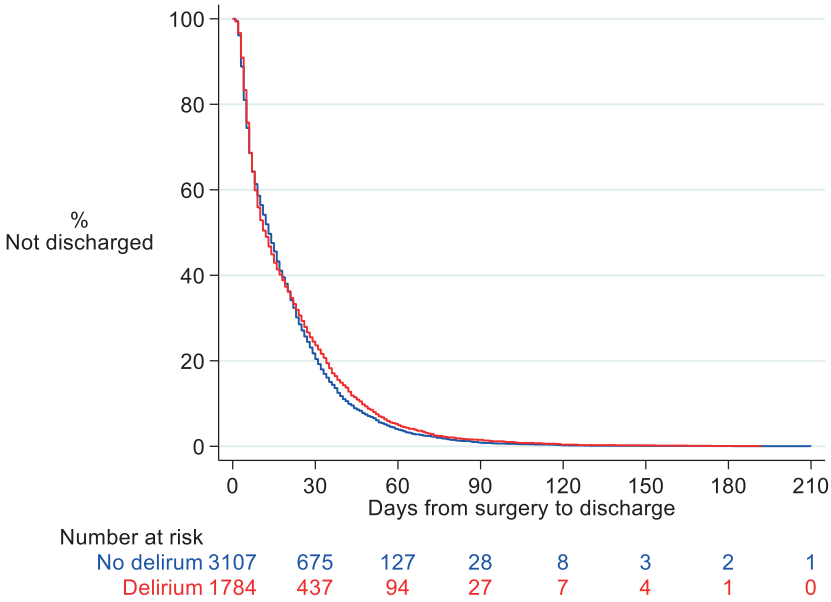


Figure 3: Kaplan Meier plot for in-hospital mortality (n=4,890)

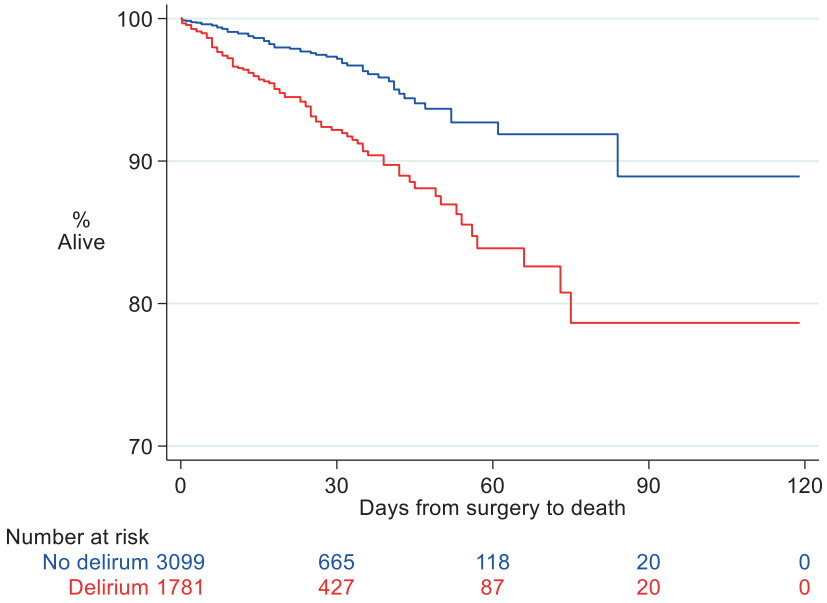
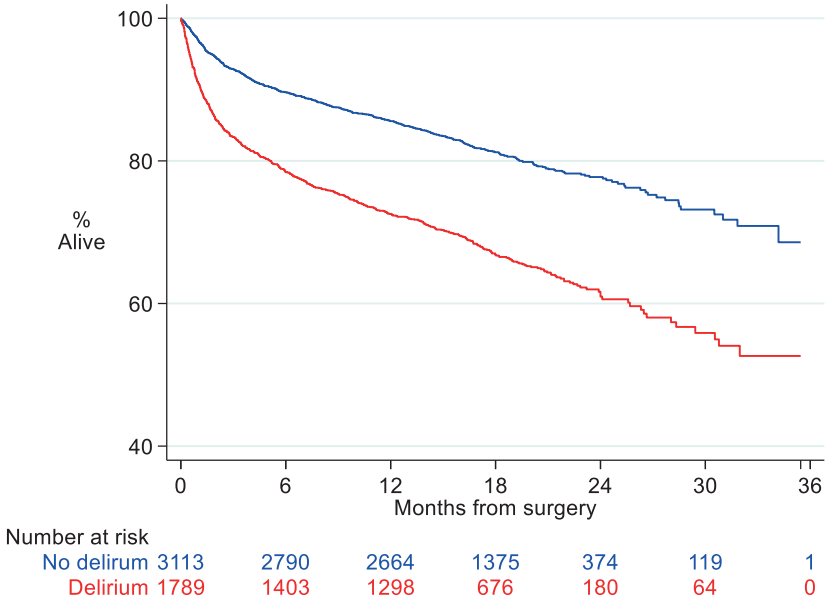


Figure 4: Kaplan Meier plot for long-term mortality (n=4,892)



REFERENCES

1. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. Ageing Res Rev. 2003; 2: 57-93.DOI:10.1016/s1568-1637(02)00045-4.
2. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. Lancet. 2014; 383: 911-22. DOI:10.1016/S0140-6736(13)60688-1.
3. Krogseth M, Watne LO, Juliebo V, et al. Delirium is a risk factor for further cognitive decline in cognitively impaired hip fracture patients. Arch Gerontol Geriatr. 2016; 64: 38-44.DOI:10.1016/j.archger.2015.12.004.
4. Krogseth M, Wyller TB, Engedal K, Juliebo V. Delirium is a risk factor for institutionalization and functional decline in older hip fracture patients. J Psychosom Res. 2014; 76: 68-74.DOI:10.1016/j.jpsychores.2013.10.006.
5. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.
6. Rockwood K, Cosway S, Carver D, et al. The risk of dementia and death after delirium. Age and ageing. 1999; 28: 551-6
7. McCusker J, Cole M, Dendukuri N, et al. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. CMAJ. 2001; 165: 575-83
8. Dolan MM, Hawkes WG, Zimmerman SI, et al. Delirium on hospital admission in aged hip fracture patients: prediction of mortality and 2-year functional outcomes. J Gerontol A Biol Sci Med Sci. 2000; 55: M527-34.DOI:10.1093/gerona/55.9.m527.
9. Gleason LJ, Schmitt EM, Kosar CM, et al. Effect of Delirium and Other Major Complications on Outcomes After Elective Surgery in Older Adults. JAMA Surg. 2015; 150: 1134-40.DOI:10.1001/jamasurg.2015.2606.
10. Zywiel MG, Hurley RT, Perruccio AV, et al. Health economic implications of perioperative delirium in older patients after surgery for a fragility hip fracture. J Bone Joint Surg Am. 2015; 97: 829-36. DOI:10.2106/JBJS.N.00724.
11. Mosk CA, Mus M, Vroemen JP, et al. Dementia and delirium, the outcomes in elderly hip fracture patients. Clin Interv Aging. 2017; 12: 421-30.DOI:10.2147/CIA.S115945.
12. Chow SK, Qin JH, Wong RM, et al. One-year mortality in displaced intracapsular hip fractures and associated risk: a report of Chinese-based fragility fracture registry. J Orthop Surg Res. 2018; 13: 235.DOI:10.1186/s13018-018-0936-5.
13. Liu Y, Wang Z, Xiao W. Risk factors for mortality in elderly patients with hip fractures: a meta-analysis of 18 studies. Aging clinical and experimental research. 2018; 30: 323-30.DOI:10.1007/s40520-017-0789-5.
14. Oberai T, Oosterhoff JHF, Woodman R, et al. Development of a postoperative delirium risk scoring tool using data from the Australian and New Zealand Hip Fracture Registry: an analysis of 6672 patients 2017-2018. Arch Gerontol Geriatr. 2021; 94: 104368.DOI:10.1016/j.archger.2021.104368.
15. ANZHFR. Data Dictionary Version 12. Sydney, Australia: Australian and New Zealand Hip Fracture Registry, 2019
16. Ely EW, Margolin R, Francis J, et al. Evaluation of delirium in critically ill patients: validation of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU). 2001; 29: 1370-9

17. Bellelli G, Morandi A, Davis DH, et al. Validation of the 4AT, a new instrument for rapid delirium screening: a study in 234 hospitalised older people. Age Ageing. 2014; 43: 496-502.DOI:10.1093/ageing/afu021.

18. Inouye SK, Kosar CM, Tommet D, et al. The CAM-S: development and validation of a new scoring system for delirium severity in 2 cohorts. Ann Intern Med. 2014; 160: 526-33.DOI:10.7326/M13-1927.

19. Hodkinson HJA, ageing. Evaluation of a mental test score for assessment of mental impairment in the elderly. 1972; 1: 233-8

20. Molloy DW, Standish TIJIP. A guide to the standardized Mini-Mental State Examination. 1997; 9: 87-94

21. Teng E, Chui HJCJP. The modified mini-mental state examination (3MS). 1987; 41: 114-21

22. Brodaty H, Pond D, Kemp NM, et al. The GPCOG: a new screening test for dementia designed for general practice. 2002; 50: 530-4

23. Bai J, Liang Y, Zhang P, et al. Association between postoperative delirium and mortality in elderly patients undergoing hip fractures surgery: a meta-analysis. 2020; 31: 317-26

24. Bellelli G, Carnevali L, Corsi M, et al. The impact of psychomotor subtypes and duration of delirium on 6-month mortality in hip-fractured elderly patients. Int J Geriatr Psychiatry. 2018.DOI:10.1002/gps.4914.

25. Lee HB, Oldham MA, Sieber FE, Oh ES. Impact of Delirium After Hip Fracture Surgery on One-Year Mortality in Patients With or Without Dementia: A Case of Effect Modification. Am J Geriatr Psychiatry. 2017; 25: 308-15.DOI:10.1016/j.jagp.2016.10.008.

26. Marcantonio ER, Flacker JM, Michaels M, Resnick NM. Delirium is independently associated with poor functional recovery after hip fracture. Journal of the American Geriatrics Society. 2000; 48: 618-24

27. Keswani A, Tasi MC, Fields A, et al. Discharge Destination After Total Joint Arthroplasty: An Analysis of Postdischarge Outcomes, Placement Risk Factors, and Recent Trends. The Journal of Arthroplasty. 2016; 31: 1155-62.DOI:https://doi.org/10.1016/j.arth.2015.11.044.

28. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. Int Psychogeriatr. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

29. Registry AaNZHF. ANZHFR Annual Report of Hip Fracture Care 2019. August, 2019

30. Mathur MB, Ding P, Riddell CA, VanderWeele TJJE. Website and R package for computing E-values. 2018; 29: e45

CHAPTER 2

Development of a postoperative delirium risk scoring tool using data from the Australian and New Zealand Hip Fracture Registry: an analysis of 6672 patients 2017-2018

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ABSTRACT

Background and purpose

This study aimed to determine the incidence, predictors of postoperative delirium and develop a post-surgery delirium risk scoring tool.

Patients and Methods

A total of 6672 hip fracture patients with documented assessment for delirium were analyzed from the Australia and New Zealand Hip Fracture Registry between June 2017 and December 2018.Thirty-six variables for the prediction of delirium using univariate and multivariate logistic regression were assessed. The models were assessed for diagnostic accuracy using C-statistic and calibration using Hosmer-Lemeshow goodness-of-fit test. A Delirium Risk Score was developed based on the regression coefficients.

Results

Delirium developed in 2599/6672 (39.0%) hip fracture patients. Seven independent predictors of delirium were identified; age above 80 years (OR=1.6 CI 1.4-1.9; p=0.001), male (OR=1.3 CI 1.1-1.5; p=0.007), absent pre-operative cognitive assessment (OR=1.5 CI 1.3-1.9; p=0.001), impaired pre-operative cognitive state (OR=1.7 CI 1.3 -2.1; p=0.001), surgery delay (OR=1.7 CI 1.2-2.5; p=0.002) and mobilisation day 1 post-surgery (OR=1.9 CI 1.4-2.6; p=0.001). The C-statistics for the training and validation datasets were 0.74 and 0.75, respectively. Calibration was good ($\chi 2=35.72$ (9); $p<0.001$). The Delirium Risk Score for patients ranged from 0 to 42 in the validation data and when used alone as a risk predictor, had similar levels of diagnostic accuracy (C-statistic=0.742) indicating its potential for use as a stand-alone risk scoring tool.

Conclusion

We have designed and validated a delirium risk score for predicting delirium following surgery for a hip fracture using seven predicting factors. This could assist clinicians in identifying high risk patients requiring higher levels of observation and post-surgical care.

BACKGROUND

Fractures of the proximal femur (hip) are serious injuries commonly experienced by older individuals.[1] In 2015-2016, 50,900 episodes of hospital care for hip fractures, both new and revisions were managed in Australia. These hospitalisations equate to more than 579,000 bed days, and involved more than 206,300 procedures or interventions.[2]

Delirium has been identified as the most common complication in hospitalized older people, particularly in those undergoing orthopedic surgical interventions following hip fracture.[3] Patients experiencing delirium during the hospital stay have a worse prognosis, stay longer in the hospital, have higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge.[4] There were an estimated 132,595 occurrences of delirium in Australia in 2016–2017, with more than 900 deaths attributed to delirium. Delirium causes an estimated 10.6% of the dementia cases within Australia and the total costs of care for delirium in Australia is estimated to be around $A8.8 billion in 2016–2017. [5]

Delirium is considered to be a result of interactions between patient vulnerabilities and precipitating factors.[6] Early engagement of multidisciplinary staff, including geriatricians, who address the risk factors of delirium is a key element of a successful delirium prevention program. [7].

Rationale

Despite many published studies on potential risk factors for postoperative delirium, the majority of studies are usually limited to cohorts from outside of Australia and New Zealand. The purpose of this study was to determine the incidence and predictors of postoperative delirium using the large Australia and New Zealand population-based hip fracture patient database. The study also aims to establish and test a risk prediction scoring algorithm for delirium following hip fracture surgery using independent predictors of delirium.

Patients and Methods

This study included all data from the Australian & New Zealand Hip Fracture Registry (ANZHFR) in the period between 1st June 2017 and 31st December, 2018. The ANZHFR is a prospective multi-institutional program that collects preoperative, perioperative and

postoperative data on over 50 independent variables from over 67 participating public hospitals in Australia (49) and New Zealand (18). The registry collects data which has a major geriatric care focus instead of surgical technique or surgical intervention focus. Reported data are acquired from medical records as well as operative notes using a standard data collection form (A.1). The data items collected by the ANZHFR are specified in the ANZHFR Data Dictionary v12.1_October 2019 (A.2). The data set included 36 variables under the following five categories: patient information, admission, assessment, treatment and discharge.

Patients

All patients aged 65 years and older who sustained proximal femur fracture (e.g. femoral head or neck, intertrochanteric, subtrochanteric and Intracapsular- displaced/impacted or displaced) in Australia and New Zealand and were admitted to one of the participating hospitals are included in ANZHFR.

Primary Outcome

ANZHFR defined the diagnostic criteria of delirium for clinicians. ANZHFR suggested "Delirium is defined as an acute change in mental status that is common among older patients in hospital. It is characterised by a disturbance of consciousness, attention, cognition and perception that develops over a short period of time (usually hours to a few days). Patients with delirium may be agitated and restless (hyperactive delirium), quiet and withdrawn (hypoactive delirium), or move between these two subtypes (mixed delirium)". [8] The registry recommended that assessment of delirium requires the use of a validated tool and should be completed within 7 days of the surgery. A range of validated diagnostic tools for delirium have been deemed acceptable including; Confusion Assessment Method (CAM), Confusion Assessment Method (CAM-ICU), 3D-CAM and The 4AT. [9-11] The authors acknowledge that different scales have different sensitivities. However, due to the nature of the data collected by the registry we are not able to provide breakdown of the various scales used for assessing each patient included in the study.

Statistical Analysis

Data analysis was performed using Stata version 16.0 (Statacorp, Texas, USA). Descriptive statistics are presented as mean (with standard deviation, SD) for continuous normally distributed variables, median (interquartile range, IQR) for continuous non-normally distributed data and frequency (percentage) for categorical data. In the development of the prediction model, a stratified split was carried out on the combined records from

Australia and New Zealand. Evaluation of a model's accuracy on the same dataset that is used for its development would result in a biased (overly optimistic) assessment of the model's accuracy. It is common practice to therefore randomly divide the dataset into two separate datasets, namely a "training" dataset and a "validation" dataset. The model is developed using the training dataset and evaluated for accuracy using the held-out test sample. [12] The balance of samples for the training: validation is commonly either a 50:50 ratio split or a 70:30 ratio split depending on the size of the dataset, with larger datasets using a 70:30 split. Two equal sized sets using 50:50 split of data were used for training and validation purposes in this study. Each of the resulting datasets consisted of 3,336 patients undergoing surgery. Differences in variables between the validation and training datasets were assessed using independent t-tests, the Mann-Whitney U test or the Chi-squared test as appropriate. Associations with a p-value of <0.05 were considered significant.

Multivariate Logistic Regression Analysis

We developed a multivariate logistic regression model for predicting the risk of delirium using the available clinical patient characteristics. Age was included as a binary variable (less than 80 years versus 80+ years old) and each of the predictors listed in A.3 were assessed as categorical variables i.e. ASA grade, anaesthesia, analgesia, atypical fracture, bone medication, bone medication on discharge, pre-operative cognitive assessment, pre-admission cognitive state, discharge destination, discharge residence, falls assessment, mobilisation, operation type, pain assessment, pre-admission walking status, pre operation medical assessment, pressure ulcers, gender, surgery delay, usual residence and ward type. Registry suggests that some validated tools for assessing cognitive function include; Abbreviated Mental Test Score (AMTS) Standardised Mini-Mental State Examination (SMMSE), Modified Mini Mental State Exam (3MS), General Practitioner's Assessment of Cognition (GPCOG) and The 4AT. [10, 13-16]

In univariate analysis, variables that were significant at p<0.20 using a Wald test were considered as predictors for the multivariate model. Individual categories of each variable that were significant at p<0.05 when included in the multivariate model were entered as binary indicator variables. Any subjects with missing data for any of the variables that were included in the final model were excluded from analysis in both the training of validation cohorts.

Performance of the multivariate logistic regression model was assessed according the discrimination using the c-statistic and calibration using the Hosmer-Lemeshow goodness-of-fit test.

Development of the Delirium Risk Score

Following validation of the prediction model we created a delirium risk score (DRS). The score weights were based on the β coefficients of the separate independent variables with each β-coefficient multiplied by 10 and rounded to the nearest integer to provide a weight. Since all variables in the final model were binary, the coefficients could be considered to have the same scale and we therefore summed the weights to provide an overall risk score for each patient. We then compared the C-statistic of the independent variable risk prediction model with that of a model that used delirium risk score alone in order to confirm that the weights created for the delirium score provided a similar level of discrimination. A cut point for the risk score that provided maximum sensitivity and specificity was also calculated.

To assess the independent impact of each clinical characteristic in improving risk prediction we calculated the C-statistic in both univariate and multivariate analysis and the category-less Net Reclassification Index (NRI). [17] The latter statistic is the proportion of subjects whose predicted probability of delirium moves in the correct direction when a specific variable is added to the model. Individuals who did not develop delirium should ideally have a lower predicted probability of delirium when the new variable is added and patients who did develop delirium should have a higher predicted probability of delirium

Ethics, funding and conflicts of interest

Ethics approval was granted on 28th November, 2019 by our institutional Clinical Human Research Ethics Committee (OFR: 262.19). No funding for this study was received and there are no potential conflicts of interest.

Guidelines

The study set-up has been performed following the Transparent Reporting of Multivariate Prediction Models for Individual Prognosis or Diagnosis Guideline (TRIPOD-Statement). [18]

Results

Patients

We identified 6672 patients aged 65 and older, who had sustained a fracture of proximal femur and had documented delirium screening in the ANZHFR data base. A total of 2599 (39.0%) individuals experienced post-operative delirium. For the development of the prediction model the combined records from Australia and New Zealand were randomly

divided into two equal sized sets (3336 patients each) of data for training and validation purposes. The clinicopathological features from patients with and without delirium both in the training and validation cohort have been described in Table 1.
The mean age in both cohorts was 82.7 years (SD 8.2) for patients without and 85.8 years (SD 7.1) for patients with postoperative delirium. The ratio of females was approximately 70% in the cohort with no delirium and 65% in patients with delirium, both in the training and validation cohort. Compared to patients without post-operative delirium, those with delirium showed a higher rate of preoperative cognitive impairment (26.5% vs. 65.3%, p<0.001). Fewer individuals without postoperative delirium were discharged to residential aged care facility in comparison to individuals with postoperative delirium (16.6% vs. 32.6%, p<0.001).

Multivariate Logistic Regression Analysis

Multivariate logistic regression analysis showed that age above 80 years, male gender, cognition not assessed, impaired pre-operative cognitive state, surgery delay due to being medically unfit and not being given the opportunity to start mobilisation day 1 post surgery were independently associated with a higher risk of developing postoperative delirium. The diagnostic accuracy was C-statistic=0.74 for the training model and 0.75 for the validation model.

Treatment in a non-orthopaedic ward, hip fracture pattern, type of anaesthesia, type of analgesia, bone medication, falls assessment and type of operation performed were not independent risk factors for postoperative delirium.

Delirium risk prediction

Table 2 describes the results of the multivariate binary logistic regression using the training data. Each of the 7 clinical characteristic variables were significant independent predictors (p<0.01 for each). Table 2 also describes the discriminatory value of each variable alone as well as the added contribution to the C-statistic when variables were added to the model. For age above 80 years alone the C-statistic was 0.6 and this eventually increased to 0.7 when the factors; male gender, mobilisation opportunity, surgery delay, lack of cognition assessment, impaired cognition and prior impaired cognition or known dementia were added to the model. The variable that contributed the most to the strength of the C-statistic, was impaired cognition (ΔC-statistic=0.07; p<0.001).

The estimated independent risk of delirium according to each of the 7 independent variables was 42.8% versus 33.0% (Δ=9.85%, p<0.001) for age over 80 years, 43.3%

versus 38.1% (Δ=5.2%, p=0.002) male gender versus female gender, 51.6% versus 38.8% (Δ=12.7%, p<0.001) for those not given the opportunity to mobilise 1 day post-surgery versus those patients that were, 51.6% versus 39.1% (Δ=12.5%, p=0.001) for those with delayed surgery due to being medically unfit versus those without delayed surgery, 44.5% versus 37.5% for those without a cognitive assessment compared to those with a cognitive assessment performed (Δ=7.0%, p<0.001), 45.9% versus 37.6% for those with a cognitive assessment performed and impaired compared to those with a cognitive assessment performed and unimpaired cognition(Δ=8.2%, p=0.001) and 57.9% versus 25.5% for those with prior impaired cognition or known dementia versus those without prior impaired cognition or known dementia ((Δ=32.4%, p<0.001).

The weighting for the delirium risk score based on the coefficients of the regression model with separate independent variables are shown in Table 2. The distribution of the risk scores according to delirium is shown in Figure 1. When the continuous delirium risk score was used alone in a univariate logistic regression model the C-statistic was 0.7419 for the training data which was not significantly different to the C-statistic based on the independent factors themselves (p=0.109). The optimal cut-point for sensitivity and specificity was a delirium risk score of 11 which provided a sensitivity of 70.6% and a specificity of 69.3%.

Figure 2 shows the predicted proportion of patients with delirium according to increasing delirium risk score. The mean predicted risk of delirium for patients in the delirium risk score categories of <10, 10-19, 20-29, 30-39, 40+ were 14.2%, 30.6%, 53.8%, 75.5% and 89.1% respectively. The odds ratios of delirium for those with scores of 10-15, 16-19, 20-24, 25-29, 30-34, 35+ compared to those with risk scores of less than 10 were 1.9 (CI 1.5-2.5; p<0.001), 4.3 (3.1-6.1; p<0.001), 7.5 (CI 5.4-10.2; p<0.001), 9.7 (CI 7.4 -12.7; p<0.001), 10.2 (CI 7.3 - 14.2; p<0.001), 26.7 (CI 15.1- 47.4; p<0.001) and 30.7 (CI 3.5 - 265.7; p=0.002) respectively.

Model validation

The C-statistic for the risk transfusion score model in the validation dataset was 0.7463 and the H-L goodness of fit statistic was χ^2=35.72 (9), p<0.001. Figure 3 shows the predicted probability of delirium according to the delirium risk score based on the training and validation datasets.

Net reclassification Index

Table 2 shows the NRI with the addition of each independent variable to the risk prediction model beyond age alone. There was a significant increase in the proportion of

patients whose probability for delirium moved in the correct direction (i.e. the probability decreased for those without delirium and increased for those with delirium) with the addition of mobilisation opportunity (4.9%, p=0.033), cognition being impaired (15.6%, p<0.001), and prior impaired cognition (38.2%, p<0.001).

DISCUSSION

Hip Fractures in older adults pose a significant socio-economic burden associated with reduced life expectancy as well as being at increased risk of developing functional, physical, and mental impairments.[19] Delirium is one of the highest post-operative complications for this surgical population and in this study; the incidence of delirium was 39% amongst a large and representative sample of hospital patients in Australian and New Zealand who underwent hip fracture surgery. This study not only provides an unbiased estimate of the incidence of postoperative delirium after hip fracture surgery, it also provides insight into the strongest predictors of delirium as well as provides a delirium risk score.

There were several on-admission patient characteristics including advanced age, male gender, cognition not assessed and pre-operative cognitive impairment that indicated a higher likelihood for development of delirium following hip fracture surgery. Cognition not assessed is the scoring system within the variable pre-operative cognition assessment. The registry recommends cognitive status is assessed prior to surgery using a validated tool and recorded in the medical record. Cognition not assessed was independently associated with a higher risk of developing postoperative delirium in the multivariate analysis of our study. We believe that cognition not assessed showed significant relationship because these patients were possibly difficult to be assessed due to severe cognitive impairment. In addition, surgery delay due to patients being deemed medically unfit and not being mobilised on day 1 post-operatively were separate post admission factors that contributed to a higher risk of developing delirium. Together these risk factors provided a normally distributed risk score for the development of delirium suggesting that the risk varied in a linear fashion rather than at a clearly defined cut-point. Our analysis using the net reclassification index also showed that together several of these factors provided large and meaningful improvements in the successful prediction of patient's classification for the development of delirium. Knowledge of whether a patient had a previous diagnosis of impaired cognition or delirium contributes to a 38% improvement in correctly classifying patients for delirium. While impaired cognition at the time of assessment, meant 16% improvement in correctly classifying the patient.

Seven separate independent risk factors were included in the final model for delirium risk prediction. This delirium risk prediction scoring tool could aid clinicians in gauging each individual patient's risk and assisting with their clinical decision making.

The incidence of delirium in this ANZHFR data base was 39%, which is in the middle of the range of 4% to 65% reported in a meta-analysis. [20] The wide range of reported incidences can be partly explained by the wide variety of screening tools available for diagnosing delirium. Tools used within the meta-analysis include the DSM-IV (±OBS), DSM-III (±OBS), CAM, DRS, NEECHAM, and ICD-10 criteria. [20]

Findings of our study are consistent with several other studies that report advanced age as an important risk factor for the development of postoperative delirium. In a systematic review of 32 studies, patients older than 80, were almost twice as likely to develop postoperative delirium after hip surgery. [21] The 2011 Australian Burden of Disease study reported that hip fracture burden increased with age. Almost 30,000 disability-adjusted life years (DALYs) attributed to hip fractures among those aged 65 and over, with those aged 80 to 89 carrying the majority of this disease burden (18,000 DALYs). [22]

Pre-operative cognitive status (known dementia/ cognitive impairment) was one of the strongest independent predictors for the development of postoperative delirium, a finding in line with those from previous systematic reviews. [21] . Our finding that males were more likely to develop delirium after hip fracture surgery is also in line with other studies. [23] This might be due to a higher underlying preoperative disease severity or rate of postoperative complications, which we were unable to verify in this study. Surgery delay to being deemed as medically unfit was also a risk factor for postoperative delirium; in line with those of Pioli et al. [24] The effect of preoperative timing on patient-important outcomes across various age groups remains controversial. [25] Advocates of early treatment argue that this approach minimizes the length of time a patient is confined to bed rest, thus reducing the risk of associated postoperative complications. [26] However, those supporting a delay in surgery believe that it provides adequate chance to medically optimize patients, consequently decreasing the risk for perioperative complications.

Our analysis also suggested that patients not given the opportunity to mobilise on the first postoperative day were at a higher risk of developing delirium. Malik et al concluded that inability to bear weight on the first postoperative day was associated with delirium.[27] It is therefore quite possible that this finding relates to other patient factors such as a pre-existing cognitive impairment and preoperative walking ability.

In addition to observing important predictors of delirium, our study also indicated a number of factors that did not influence delirium risk. The type or anaesthetic used as well as other intra-operative factors like type of nerve block used or type of operation performed did not influence the development of delirium. This finding is similar to those of a systematic review conducted by Mason et al. who concluded that there was no effect of the type of anaesthesia on the risk of developing postoperative delirium. [28] Our study furthermore indicated no association between treatment in a non-orthopaedic ward, hip fracture pattern, type of anaesthesia, type of analgesia, bone medication, preoperative medical assessment, geriatric assessment, or exposure to a falls assessment and the development of postoperative delirium.

Worldwide, about 1.5 million hip fractures occur each year and this places a considerable burden upon healthcare systems as a result of patient's associated increases in morbidity. [29] According to The REFReSH study group total annual hospital costs associated with incident hip fractures in UK were estimated at £ 1.1 billion. [30] Inouye et al found that 30% to 40% of the delirium during geriatric hospitalizations could be prevented by treatment of the risk factors. [31] An accurate knowledge of delirium risk within 1-day post-surgery may thereby assist multi-disciplinary teams in reducing both the incidence of delirium and with that reduce a major determinant of national healthcare costs. Another study by Zhang et al designed a predictive nomogram for the prevention of delirium. [32] According to their results, preoperative cognitive impairment, multiple medical comorbidities, ASA classification, transfusion exceeding 2 units of red blood cell, and intensive care were identified to be the independent predictors of the development of postoperative delirium. Similar to our study, the risk of postoperative delirium increased with the increasing risk score of predictive nomogram. However, this study was based on small population of 825 patients. We believe the larger sample size (6672 patients) of our study gives a better accuracy to the delirium risk score. Furthermore, most of the identified risk factors in our study like age, gender, pre-existing cognitive impairment are non-modifiable. Therefore, using delirium risk score to identify at-risk patients becomes even more valuable. This will allow early recognition of at-risk patients and will encourage clinicians to start preventive strategies as soon as the patient arrives to hospital.

There were several limitations to our study. Most notably, our data was observational and collected retrospectively from an administrative registry that collected data for quality assurance rather than research. However, researchers were blinded to the outcome of delirium when performing the analysis and we were able to control for a large number of potential confounders. Given the observational nature of the study we can also not conclude causality for any of the observed associations. However, our main objective was to determine risk prediction. In addition, the data were derived from the Australia and

New Zealand Hip Fracture registry which records data from a large number of institutions, but on a voluntary basis and the results may therefore not be fully generalizable to the whole of the Australian and New Zealand population, or to other countries. However, the data collected are likely to be representative of the population across Australia due to wide range of participating hospitals. No data on 30-day postoperative delirium was collected in the registry, which may have led to an underestimation of the incidence of delirium as well as, some bias in the prediction of risk. Nevertheless, our estimate for the incidence of delirium was in line with previously published estimates.[20] Finally, given the administrative nature of the ANZHFR database we were unable to adjust for other potentially predictive factors, such as preoperative use of medication, the type of cognitive screening instruments used and/or pre-treatment interventions employed. Despite these limitations, our study had several important strengths including the large and well described sample of patents collected from a representative collection of institutions that have demonstrated reliability in their data collection.[33]

Implications for practice

The greater strength of this study is the delirium risk score which has potential to be used as a stand-alone risk scoring tool. Most studies stop after identifying risk factors however our study provides a risk score analysis. The delirium risk score poses to be an "easy to use tool" by clinicians to improve the delirium recognition. Delirium risk score should be applied to all hip fracture patients admitted to an acute care setting. Recognising delirium is the first step towards prevention of delirium before its onset.

Implications for research

Future research should focus on externally validating the Delirium Risk Score for predicting postoperative delirium. In addition, we are exploring the concept of Machine Learning. Promising collaboration has been established to further develop a machine learning algorithm for preoperative prediction of postoperative delirium in elderly hip fracture patients. [34] The data used for developing this algorithm was derived from The National Surgical Quality Improvement Program (NSQIP), United States. In the future, we will use ANZHFR data to externally validate the above mentioned machine learning algorithm. We are planning to also use the NSQIP data to externally validate the logistic regression prediction score presented in this paper.

Conclusion

This study demonstrates the importance of seven commonly reported demographic and clinical factors that together can be combined into a delirium risk prediction score for hip fracture patients and use amongst multidisciplinary clinicians. More accurately identifying high risk patients can be used to assist in planning for higher levels of observation and post-surgical care with the aim of reducing the incidence of delirium and associated burgeoning healthcare costs.

TABLES

Table 1: Clinical characteristics of patients with and without delirium in the training and validation dataset (n=3,336).

	Training dataset (n=3,336)			Validation dataset		
	No delirium (N=2,010)	Delirium (N=1,326)	p-value for difference	No delirium (N=2,063)	Delirium (N=1,273)	p-value for difference
Age (years), mean (SD)	82.7 (8.2)	85.8 (7.1)	<0.001	82.7 (8.3)	85.7 (7.4)	<0.001
Gender, n (%)						
Male	615 (30.6)	462 (34.8)	0.035	592(28.7)	442(34.7)	0.00
Female	1,394 (69.4)	863 (65.1)		1,471(71.3)	829 (65.1)	
Missing	1 (0.05)	1 (0.08)		0 (0.00)	2 (0.2)	
ASA Grade, n (%)						
Unknown	18(0.9)	11 (0.8)	<0.001	25(1.2)	11 (0.9)	<0.001
Healthy Individual	17(0.8)	0(0.00)		19(0.9)	3(0.2)	
Mild Systemic disease	280(13.9)	62(4.7)		269(13.0)	64(5.0)	
Severe systemic disease	914(45.5)	533(40.2)		942(45.6)	535(42.0)	
Incapacitating system	295 (14.7)	288(21.7)		292 (14.1)	535(42.0)	
Moribund not expected to survive 24	1 (0.05)	2 (0.15)		2 (0.10)	1(0.08)	
hours with or without surgery	485(24.13)	430(32.4)		514(25.0)	390(30.6)	
Missing						
Anaesthesia, n (%)						
General Anaesthesia	963(47.9)	688 (51.9)	0.014	965(46.8)	689 (54.1)	<0.001
Spinal/ regional Anaesthesia	666(33.1)	370(27.9)		699(33.8)	333(26.1)	
General and Spinal	348(17.3)	248(18.7)		367(17.8)	226(17.7)	
Missing	33(1.6)	20(1.5)		32(1.5)	25(2.0)	
Analgesia, n (%)						
Nerve Block administered before arriving	872(43.4)	563(42.5)	0.015	875(42.4)	550(42.5)	0.380
in OT	270(13.4)	208(15.7)		291(14.1)	184(14.4)	
Nerve block administered in OT	642(31.9)	373(28.1)		641(31.0)	359(28.2)	
Both	180(9.0)	136(10.3)		190(9.2)	132(10.4)	
Neither	46 (2.3)	46 (3.5)		66(3.2)	48(3.8)	
Missing						

	Training dataset (n=3,336)			Validation dataset		
	No delirium (N=2,010)	Delirium (N=1,326)	p-value for difference	No delirium (N=2,063)	Delirium (N=1,273)	p-value for difference
Bone Medication, n (%)						
No bone protection medication	1278(63.6)	778(58.7)	0.006	1343(65.1)	733(57.5)	<0.001
Yes- Calcium and/or Vit D only	508(25.3)	409(30.8)		491(23.8)	414(32.5)	
Yes- Bisphosphonates	189(9.4)	116(8.7)		208(10.1)	101(8.0)	
Missing	35(1.7)	23(1.7)		21(1.0)	25(2.0)	
Bone Medication on Discharge, n (%)						
No bone protection medication	308(15.3)	258(19.4)	<0.001	309(15.3)	246(19.32)	<0.001
Yes- calcium and/or Vit D only	1113 (55.4)	713(53.8)		1130 (54.8)	702(55.1)	
Yes- Bisphosphonates	519(25.8)	289(21.8)		561(27.1)	289(21.8)	
Missing	70(3.5)	66(4.9)		63(3.05)	48(3.7)	
Cognitive Assessment, n (%)						
Cognition assessed and normal	1018(50.6)	325(24.5)	<0.001	1061(51.4)	328(25.8)	<0.001
Cognition not assessed	637(31.6)	472(35.6)		631(30.6)	429(33.7)	
Cognition assessed and impaired	291(14.5)	462(34.8)		294(14.2)	459(36.1)	
Missing	64(3.2)	67(5.0)		77(3.7)	57(4.5)	
Cognitive state, n (%)						
Normal cognition	1429(71.09)	424(31.9)	<0.001	1475(71.5)	399(31.3)	<0.001
Impaired cognition	533(26.5)	866(65.3)		518(25.1)	829(65.1)	
Missing	48(2.4)	36(2.7)		70(3.4)	45(3.5)	
Discharge destination from acute ortho episode n (%)	261(13.0)	66(4.9)	<0.001	282(13.7)	48(3.8)	<0.001
Private residence (including unit in retirement village)	333(16.6)	433(32.6)		318(15.4)	429(33.7)	
Residential aged care facility	980(48.7)	551(41.5)		1028(49.8)	538(42.3)	
Rehabilitation unit public	215(10.7)	70(5.3)		216(10.4)	53(4.2)	
Rehabilitation unit private	160(8.0)	132(10.0)		169(8.2)	128(10.0)	
Other hospital / ward / specialty	39(2.0)	54(4.0)		31(1.5)	56(4.4)	
Deceased	0(0.0)	1(0.1)		3(0.1)	1(0.1)	
Short term care in residential care facility (New Zealand)	22(1.1)	19(1.4)		16(0.8)	20(1.5)	
Other/Missing						

	Training dataset (n=3,336)			Validation dataset		
	No delirium (N=2,010)	Delirium (N=1,326)	p-value for difference	No delirium (N=2,063)	Delirium (N=1,273)	p-value for difference
Discharge place of residence, n (%)						
Private residence (including unit in retirement village)	962(47.9)	358(27.0)	<0.001	1025(49.7)	325(25.5)	<0.001
Residential aged care facility	498(24.8)	619(46.7)		488(23.6)	592(46.5)	
Deceased	55(2.7)	76(5.7)		70(3.4)	104(8.2)	
Other	257(12.8)	117(8.8)		256(12.4)	121(9.5)	
Missing	238(11.8)	156(11.8)		224(10.9)	131(10.3)	
Mobilisation n (%)						
Patient given opportunity to start mobilising day 1 post surgery	1871(93.1)	1169(88.2)	<0.001	1912(92.7)	1113(87.4)	<0.001
Patient not given opportunity to start mobilising day 1 post surgery	100(5.0)	138(10.4)		115(5.6)	129(10.1)	
Not known	39(2.0)	19(1.4)		36(1.7)	31(2.4)	
Pain assessment n (%)						
Assessment of pain within 30 mins of ED presentation	1379(68.6)	855(64.5)	<0.001	1395(67.6)	844(66.3)	0.020
Assessment of pain greater than 30 min of ED presentation	363(18.1)	247(18.6)		392(1901)	212(16.6)	
Pain assessment not documented or not done	152(7.7)	147(11.1)		166(8.0)	133(10.4)	
Not known	116(5.8)	77(5.8)		110(5.3)	84(6.6)	
Pre-admission walking ability n (%)						
Usually walks without walking aids	968(48.1)	434(32.8)	<0.001	1022(49.5)	392(30.8)	<0.001
Usually walks with either a stick or crutch	260(13.0)	176(13.3)		297(14.4)	173(13.6)	
Usually walks with two aids or frame (with or without assistance of a person)	713(35.5)	635(47.9)		670(32.5)	625(49.1)	
Usually uses a wheelchair / bed bound	47(2.3)	60(4.5)		54(2.6)	55(4.3)	
Missing	22(1.1)	21(1.6)		20(1.0)	28(2.2)	

	Training dataset (n=3,336)			Validation dataset		
	No delirium (N=2,010)	Delirium (N=1,326)	p-value for difference	No delirium (N=2,063)	Delirium (N=1,273)	p-value for difference
Pressure ulcers						
No	1903(94.7)	1903(94.7)	<0.001	1933(93.7)	1156(90.8)	<0.001
Yes	46(2.3)	46(2.3)		62(3.0)	48(3.7)	
Missing	61(3.0)	61(3.0)		68(3.3)	69(5.4)	
Surgery delay						
No delay, surgery completed <48 hours	1583(78.8)	1009(76.0)	<0.001	1626(78.8)	958(75.3)	<0.001
Delay due to patient deemed medically unfit	75(3.7)	89(6.7)		82(3.8)	83(6.5)	
Delay due to issues with anticoagulation	71(3.5)	60(4.5)		66(3.2)	59(4.6)	
Delay due to theatre availability	159(7.8)	95(7.1)		162(7.8)	110(8.6)	
Delay due to surgeon availability	24(1.2)	4 (0.3)		16(0.8)	4 (0.3)	
Delay due to delayed diagnosis of hip fracture	25(1.2)	23(1.7)		6(1.3)	13 (1.0)	
Other type of delay	31(1.5)	21(16)		41(2.0)	20(1.6)	
Missing	42(2.1)	25(1.9)		44(2.1)	26(2.0)	

Table 2: Multivariable binary logistic regression analysis using the training dataset (n=3,336). β-coefficients, odds ratios, delirium risk score weights, C-statistics and Net reclassification index (NRI).

	β coefficient	Odds ratio (95% CI)	p-value	Delirium risk score weight	Univariate C-statistic	Multivariate C-statistic	Δ C-statistic	NRI (p-value)
Age (>80 years)	**0.49**	**1.6 (1.4, 1.9)**	**<0.001**	**5**	**0.5799**	**0.5799**	**-**	**-**
Male gender	**0.23**	**1.3 (1.1, 1.5)**	**0.007**	**2**	**0.5212**	**0.5936**	**0.0132 (p=0.006)**	**0.042 (0.053)**
Mobilisation opportunity[1]	**0.64**	**1.9 (1.4, 2.6)**	**<0.001**	**6**	**0.5274**	**0.6078**	**0.0142 (p=0.002)**	**0.049 (0.033)**
Surgery delay[2]	**0.56**	**1.7 (1.2, 2.5)**	**0.002**	**6**	**0.5149**	**0.6125**	**0.0047 (p=0.1165)**	**0.025 (0.303)**
Cognition not assessed	**0.44**	**1.5 (1.3, 1.9)**	**<0.001**	**4**	**0.5195**	**0.6176**	**0.0051 (p=0.068)**	**0.034 (0.118)**
Cognition impaired	**0.52**	**1.7 (1.3, 2.1)**	**<0.001**	**5**	**0.6018**	**0.6881**	**0.0705 (p<0.001)**	**0.156 (<0.001)**
Prior impaired cognition or known dementia	**1.36**	**3.90 (3.2, 4.7)**	**<0.001**	**14**	**0.6998**	**0.7421**	**0.054 (p<0.001)**	**0.382 (<0.001)**

[1] Patient not given opportunity to start mobilising day 1 post surgery. [2] Due to patient deemed medically unfit

FIGURES

Figure1: Distribution of delirium risk scores amongst patients with and without delirium (n=3,336)

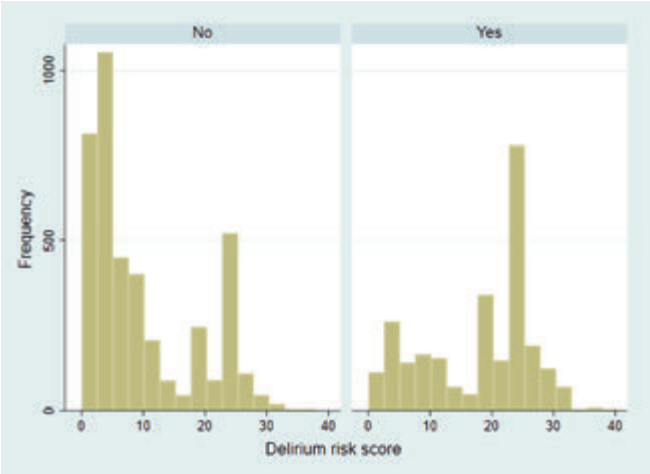


Figure 2: Proportion of patients that were diagnosed with delirium according to their Delirium risk score (n=3,336).

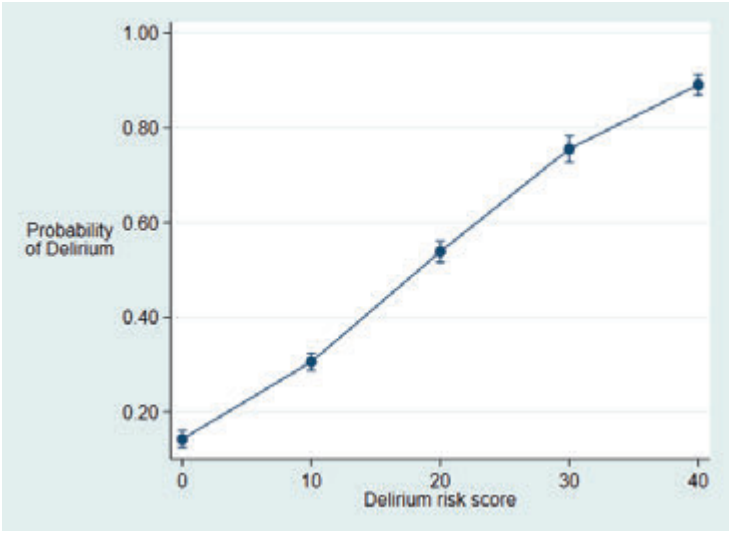
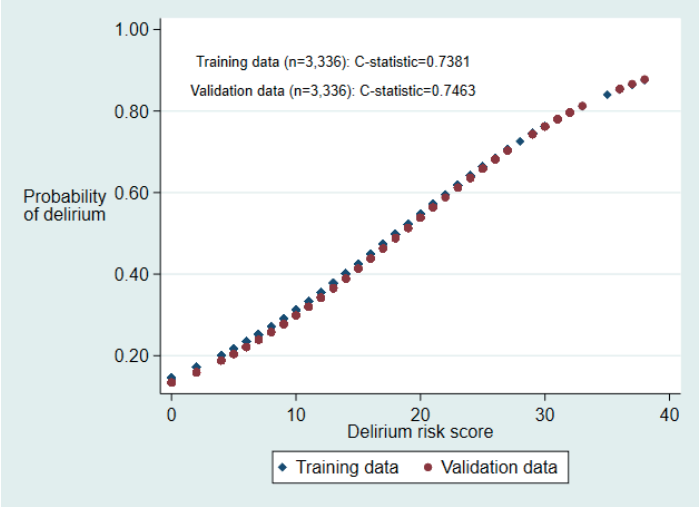


Figure3: Agreement in prediction model for delirium risk score between training and validation data.



A.1: ANZHFR Patient Level Data Collection form

Hospital:

State / Territory: Australia

ANZHFR
Australian & New Zealand Hip Fracture Registry

First Name	Surname	Patient's postcode
Date of Birth (dd/mm/yyyy)	**Sex**	**Contact telephone number**
__ __/__ __/__ __ __ __	¯ Male Female Other	
Hospital MRN	**Patient type**	**Indigenous Status**
	ı Public ı Private Γ Overseas Ł Not known	_ Aboriginal Torres Strait Islander Both Aboriginal and Torres Strait Islander _ Neither Aboriginal nor Torres Strait Islander Not known
Medicare number		

Admission via ED of operating hospital	If transferred from another hospital
ı Yes ℑ No, transferred from another hospital ı No, in-patient fall ı Other/not known	Name of transferring hospital: ED/Hospital arrival date/time (transferring hospital) __ __/__ __/__ __ __ __ __ __:__ __hrs Record time using 24hr clock
ED/Hospital Admission (operating hospital)	**If an in-patient fracture (time using 24hr clock)**
Admission __ __/__ __/__ __ __ __ __ __:__ __hrs Departure (from ED) __ __/__ __/__ __ __ __ __ __:__ __hrs Record time using 24hr clock	Date / time of diagnosis __ __/__ __/__ __ __ __ __ __:__ __hrs Record time using 24hr clock
Usual Place of Residence	**Type of ward admitted to**
ı Private residence including retirement village ר Residential care facility ـ Other ı Not known Note: If holiday residence/respite care, document usual place of residence	ı Hip fracture unit /Orthopaedic ward / preferred ward ℑ Outlying ward ℑ HDU / CCU / ICU ı Other / not known

Walking ability pre-admission	Preadmission cognitive status	Preoperative cognitive assessment
ı Usually walks without walking aids ı Usually walks with a stick or crutch ı Usually walks with two aids or frame ı Usually uses a wheel chair/ bed bound ℑ Not known Note: If a person has different levels of mobility on different surfaces then record the level of most assistance	ı Normal cognition ı Impaired cognition or known dementia ı Not known or recorded	Cognition not assessed Cognition assessed and normal Cognition assessed and impaired Not known Note: cognitive assessment requires use of a validated tool

Pain Assessment	Pain Management
ℑ Documented assessment of pain within 30 minutes of ED presentation ı Documented assessment of pain greater than 30 minutes of ED presentation ı Pain assessment not documented or not done ℑ Not known or recorded	ℑ Analgesia given within 30 minutes of ED presentation ı Analgesia given more than 30 minutes after ED presentation ı Analgesia provided by paramedics ı Analgesia not required ı Not known

Bone protection medication at admission
ı No bone protection medication ı Yes, calcium and/or vitamin D only ı Yes, bisphosphonate (oral or IV) denosumab or teriparatide (with or without calcium and/or vitamin D) ℑ Not known

Pre-operative medical assessment	Side of fracture
ı No assessment conducted ı Geriatrician / geriatric team ℑ Physician / physician team ℑ GP ı Specialist nurse ı Not known This is in addition to preoperative anaesthetic and orthopaedic review	ı Left ℑ Right If bilateral – complete a separate record for each fracture
Atypical fracture	**Type of fracture**
ℑ Not a pathological or atypical fracture ı Pathological fracture ı Atypical fracture See data dictionary if uncertain of definitions	ℑ Intracapsular – undisplaced / impacted ı Intracapsular - displaced ı Per / intertrochanteric ı Subtrochanteric Note: Basal/basicervical #s are to be classed as per/intertrochanteric

A.2: ANZHFR Data Dictionary

Data Dictionary
Version 12

October 2019

APPENDIX 3

Categories of patient characteristics in the assessment of predictors of delirium

- ASA grade (Healthy individual with no systemic disease/Mild systemic disease not limiting activity/Severe systemic disease that limits activity but not incapacitating/ Incapacitating systemic disease which is constantly life threatening/Moribund not expected to survive 24 hours with or without surgery)
- Anaesthesia (General anaesthesia/Spinal or regional anaesthesia/General and spinal/regional anaesthesia)
- Analgesia (Nerve block administered before arriving in OT/Nerve block administered in OT/Both/Neither)
- Atypical fracture (Not a pathological or atypical fracture/Pathological fracture/ Atypical fracture)
- Bone medication (No bone protection medication, Calcium and/or vitamin D only/ Bisphosphonates, strontium, denosumab or teriparitide with or without calcium and/or vitamin D)
- Bone medication at discharge (No bone protection medication/Calcium and/or vitamin D only/Bisphosphonates, strontium, denosumab or teriparitide (with or without calcium and/or vitamin D)
- Cognitive assessment (Cognition assessed and normal/Cognition not assessed/ Cognition assessed and impaired)
- Cognitive state (Normal cognition/Impaired cognition or known dementia/Not known)
- Discharge destination from acute orthopaedic episode (Private residence including unit in retirement village/Residential aged care facility/Public rehabilitation unit public/Private rehabilitation unit/Other hospital ward or specialty/Deceased/Short term care in residential care facility (New Zealand only)
- Discharge place of residence (Private residence (including unit in retirement village)/Residential aged care / rest home/Deceased/Other)
- Falls assessment (No/Performed during admission/Awaiting falls clinic assessment/ Further intervention not appropriate/Not relevant, e.g. patient died)
- Geriatric assessment (No/Yes/No geriatric medicine service available)
- Mobilisation (Patient given opportunity to start mobilising day 1 post surgery/ Patient not given opportunity to start mobilising day 1 post surgery).
- Operation (Cannulated screws (e.g. multiple screws)/Sliding hip screw/ Intramedullary nail short/Intramedullary nail long/Hemiarthroplasty stem

cemented/Hemiarthroplasty stem Uncemented/Total hip replacement stem cemented/Total hip replacement stem uncemented/Other)

- Pain assessment (Documented assessment of pain within 30 minutes of ED presentation/Documented assessment of pain greater than 30 minutes of ED presentation/Pain assessment not documented or not done)
- Pre admission walking ability (Usually walks without walking aids/Usually walks with either a stick or crutch/Usually walks with two aids or frame (with or without assistance of a person)/Usually uses a wheelchair or bed bound)
- Pressure ulcers (No/Yes)
- Sex (Male/Female/Intersex or indeterminate)
- Surgery delay (No delay, surgery completed <48 hours/Delay due to patient deemed medically unfit/Delay due to issues with anticoagulation/Delay due to theatre availability/Delay due to surgeon availability/Delay due to delayed diagnosis of hip fracture/Other type of delay)
- Usual Residence (Private residence (including unit in retirement village)/Residential aged care facility/Other)
- Ward type (Hip fracture unit or Orthopaedic ward or Preferred ward/Outlying ward/HDU or ICU or CCU/Other)

REFERENCES

1. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. Ageing Res Rev. 2003; 2: 57-93.DOI:10.1016/s1568-1637(02)00045-4.

2. AIHW. Hip fracture incidence and hospitalisations in Australia 2015-16. Canberra: AIHW, 2018

3. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. Journal of the American Geriatrics Society. 2001; 49: 1335-40

4. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. Jama. 1990; 263: 1097-101

5. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.

6. Inouye SK, Charpentier PA. Precipitating factors for delirium in hospitalized elderly persons. Predictive model and interrelationship with baseline vulnerability. Jama. 1996; 275: 852-7

7. Tarandeep O, Laver K, Crotty M, Killington M. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. 2018:

8. ANZHFR. Data Dictionary Version 12. Sydney, Australia: Australian and New Zealand Hip Fracture Registry, 2019

9. Ely EW, Margolin R, Francis J, et al. Evaluation of delirium in critically ill patients: validation of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU). 2001; 29: 1370-9

10. Bellelli G, Morandi A, Davis DH, et al. Validation of the 4AT, a new instrument for rapid delirium screening: a study in 234 hospitalised older people. Age Ageing. 2014; 43: 496-502.DOI:10.1093/ageing/afu021.

11. Inouye SK, Kosar CM, Tommet D, et al. The CAM-S: development and validation of a new scoring system for delirium severity in 2 cohorts. Ann Intern Med. 2014; 160: 526-33.DOI:10.7326/M13-1927.

12. Gareth James DW, Trevor Hastie RT. An introduction to statistical learning. Springer Science+ Business Media New York; 2013.

13. Hodkinson HJA, ageing. Evaluation of a mental test score for assessment of mental impairment in the elderly. 1972; 1: 233-8

14. Molloy DW, Standish TIJIP. A guide to the standardized Mini-Mental State Examination. 1997; 9: 87-94

15. Teng E, Chui HJCJP. The modified mini-mental state examination (3MS). 1987; 41: 114-21

16. Brodaty H, Pond D, Kemp NM, et al. The GPCOG: a new screening test for dementia designed for general practice. 2002; 50: 530-4

17. RB Sr PMDAJEonrictmuonbSM. andSteyerberg EW. 2011; 30: 11-21

18. Khan YA, Spring J, Morales-Castro D, et al. Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): the TRIPOD statement. 2019; 199: 1148-50

19. Hirsch CH, Sommers L, Olsen A, et al. The natural history of functional morbidity in hospitalized older patients. J Am Geriatr Soc. 1990; 38: 1296-303.DOI:10.1111/j.1532-5415.1990.tb03451.x.

20. Bruce AJ, Ritchie CW, Blizard R, et al. The incidence of delirium associated with orthopedic surgery: a meta-analytic review. 2007; 19: 197-214

21. Smith TO, Cooper A, Peryer G, et al. Factors predicting incidence of post-operative delirium in older people following hip fracture surgery: a systematic review and meta-analysis. Int J Geriatr Psychiatry. 2017; 32: 386-96.DOI:10.1002/gps.4655.

22. AIHW. Australian Burden of Disease Study: Impact and causes of illness and death in Australia 2011. In: Welfare AIoHa, ed. Canberra: Australian Institute of Health and Welfare, 2016

23. Oh ES, Sieber FE, Leoutsakos JM, et al. Sex Differences in Hip Fracture Surgery: Preoperative Risk Factors for Delirium and Postoperative Outcomes. J Am Geriatr Soc. 2016; 64: 1616-21.DOI:10.1111/jgs.14243.

24. Pioli G, Bendini C, Giusti A, et al. Surgical delay is a risk factor of delirium in hip fracture patients with mild-moderate cognitive impairment. Aging clinical and experimental research. 2019; 31: 41-7.DOI:10.1007/s40520-018-0985-y.

25. Simunovic N, Devereaux PJ, Bhandari M. Surgery for hip fractures: Does surgical delay affect outcomes? Indian journal of orthopaedics. 2011; 45: 27-32.DOI:10.4103/0019-5413.73660.

26. Orosz GM, Magaziner J, Hannan EL, et al. Association of timing of surgery for hip fracture and patient outcomes. 2004; 291: 1738-43

27. Malik AT, Quatman-Yates C, Phieffer LS, et al. Factors Associated With Inability to Bear Weight Following Hip Fracture Surgery: An Analysis of the ACS-NSQIP Hip Fracture Procedure Targeted Database. Geriatr Orthop Surg Rehabil. 2019; 10: 2151459319837481.DOI:10.1177/2151459319837481.

28. Mason SE, Noel-Storr A, Ritchie CW. The impact of general and regional anesthesia on the incidence of post-operative cognitive dysfunction and post-operative delirium: a systematic review with meta-analysis. J Alzheimers Dis. 2010; 22 Suppl 3: 67-79.DOI:10.3233/JAD-2010-101086.

29. Hernlund E, Svedbom A, Ivergard M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos. 2013; 8: 136.DOI:10.1007/s11657-013-0136-1.

30. Leal J, Gray AM, Prieto-Alhambra D, et al. Impact of hip fracture on hospital care costs: a population-based study. Osteoporos Int. 2016; 27: 549-58.DOI:10.1007/s00198-015-3277-9.

31. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. Lancet. 2014; 383: 911-22. DOI:10.1016/S0140-6736(13)60688-1.

32. Zhang X, Tong D-k, Ji F, et al. Predictive nomogram for postoperative delirium in elderly patients with a hip fracture. 2019; 50: 392-7

33. Registry AaNZHF. ANZHFR Annual Report of Hip Fracture Care 2019. August, 2019

34. Oosterhoff J, Aditya V. Karhade, Tarandeep Oberai, et al. Development of machine learning algorithms for prediction of postoperative delirium in 2 elderly hip fracture patients. Journal of the American Academy of Orthopaedic Surgeons (JAAOS). 2020:

CHAPTER 3

Does the SORG Orthopaedic Research Group Hip Fracture Delirium Algorithm Perform Well on an Independent Intercontinental Cohort of Patients With Hip Fractures Who Are 60 Years or Older?

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ABSTRACT

Background

Postoperative delirium in patients aged 60 years or older with hip fractures adversely affects clinical and functional outcomes. The economic cost of delirium is estimated to be as high as USD 25,000 per patient, with a total budgetary impact between USD 6.6 to USD 82.4 billion annually in the United States alone. Forty percent of delirium episodes are preventable, and accurate risk stratification can decrease the incidence and improve clinical outcomes in patients. A previously developed clinical prediction model (the SORG Orthopaedic Research Group hip fracture delirium machine-learning algorithm) is highly accurate on internal validation (in 28,207 patients with hip fractures aged 60 years or older in a US cohort) in identifying at-risk patients, and it can facilitate the best use of preventive interventions; however, it has not been tested in an independent population. For an algorithm to be useful in real life, it must be valid externally, meaning that it must perform well in a patient cohort different from the cohort used to "train" it. With many promising machine-learning prediction models and many promising delirium models, only few have also been externally validated, and even fewer are international validation studies.

Question/purpose

Does the SORG hip fracture delirium algorithm, initially trained on a database from the United States, perform well on external validation in patients aged 60 years or older in Australia and New Zealand?

Methods

We previously developed a model in 2021 for assessing risk of delirium in hip fracture patients using records of 28,207 patients obtained from the American College of Surgeons National Surgical Quality Improvement Program. Variables included in the original model included age, American Society of Anesthesiologists (ASA) class, functional status (independent or partially or totally dependent for any activities of daily living), preoperative dementia, preoperative delirium, and preoperative need for a mobility aid. To assess whether this model could be applied elsewhere, we used records from an international hip fracture registry. Between June 2017 and December 2018, 6672 patients older than 60 years of age in Australia and New Zealand were treated surgically for a femoral neck, intertrochanteric hip, or subtrochanteric hip fracture and entered into the Australian & New Zealand Hip Fracture Registry. Patients were excluded if they had a pathological hip fracture or septic shock. Of all patients, 6% (402 of 6672) did not meet the inclusion criteria, leaving 94% (6270 of 6672) of patients available for inclusion in this retrospective analysis. Seventy-one percent (4249 of 5986) of patients were aged 80 years

or older, after accounting for 5% (284 of 6270) of missing values; 68% (4292 of 6266) were female, after accounting for 0.06% (4 of 6270) of missing values, and 83% (4690 of 5661) of patients were classified as ASA III/IV, after accounting for 10% (609 of 6270) of missing values. Missing data were imputed using the missForest methodology. In total, 39% (2467 of 6270) of patients developed postoperative delirium. The performance of the SORG hip fracture delirium algorithm on the validation cohort was assessed by discrimination, calibration, Brier score, and a decision curve analysis. Discrimination, known as the area under the receiver operating characteristic curves (c-statistic), measures the model's ability to distinguish patients who achieved the outcomes from those who did not and ranges from 0.5 to 1.0, with 1.0 indicating the highest discrimination score and 0.50 the lowest. Calibration plots the predicted versus the observed probabilities, a perfect plot has an intercept of 0 and a slope of 1. The Brier score calculates a composite of discrimination and calibration, with 0 indicating perfect prediction and 1 the poorest.

Results

The SORG hip fracture algorithm, when applied to an external patient cohort, distinguished between patients at low risk and patients at moderate to high risk of developing postoperative delirium. The SORG hip fracture algorithm performed with a c-statistic of 0.74 (95% confidence interval 0.73 to 0.76). The calibration plot showed high accuracy in the lower predicted probabilities (intercept -0.28, slope 0.52) and a Brier score of 0.22 (the null model Brier score was 0.24). The decision curve analysis showed that the model can be beneficial compared with no model or compared with characterizing all patients as at risk for developing delirium.

Conclusion

Algorithms developed with machine learning are a potential tool for refining treatment of at-risk patients. If high-risk patients can be reliably identified, resources can be appropriately directed toward their care. Although the current iteration of SORG should not be relied on for patient care, it suggests potential utility in assessing risk. Further assessment in different populations, made easier by international collaborations and standardization of registries, would be useful in the development of universally valid prediction models. The model can be freely accessed at: https://sorg-apps.shinyapps.io/hipfxdelirium/.

INTRODUCTION

Hip fractures are one of the most serious and costly fall-related injuries experienced by people, most of whom are treated operatively [10, 14]. The number of hip fractures continues to rise worldwide and is predicted to rise to an incidence of 6.26 million fractures annually in 2050 [1]. Delirium is the most common complication in patients with hip fractures, occurring in 28% to 50% [5], and it is characterized by an acute and fluctuating course, inattention, altered level of consciousness, and evidence of disorganized thinking [28]. Although potentially reversible and by definition transient, delirium is one of the most frequent reasons for a patient referral to a geriatrician [26]. A patient with delirium may be disoriented to place and time, may not understand the severity of the injury, and may not adhere to therapy. This will lead to a longer in-hospital stay, higher risk of complications, and higher economic costs. Substantial additional costs occur after surgery because of the longer in-hospital stay, increased hospitalization, and rehabilitation after discharge [15]. According to estimates, the healthcare costs attributable to postoperative delirium can be as high as USD 25,000 per patient, with a total budgetary impact between USD 6.6 to USD 82.4 billion annually in the United States alone [12, 23]. Forty percent of delirium episodes are preventable, and accurate risk stratification can decrease the incidence, improve clinical outcomes in patients, and reduce economic costs [15].

Many delirium prevention strategies have been described, with accurate (internally validated) tools in the intensive care unit population [6] and in the hip fracture population [22, 46]. However, only a few of the promising prediction models have been externally validated—a necessary step before clinical implementation [42]—with few external validation studies specific for the hip fracture population [11, 29]. External validation is required to assess the performance of the clinical prediction model and validate the promise in an independent population with similar injury and patient characteristics to confirm that the model is generalizable. Recently, a clinical prediction model using machine-learning algorithms was developed, showing promise in estimating the risk of postoperative delirium in 28,207 hip fracture patients aged 60 years or older in a North American cohort [31]. This clinical prediction model is available in a freely available internet application at https://sorg-apps.shinyapps.io/hipfxdelirium/. However, while many promising machine-learning prediction models have been developed in orthopaedic surgery, only few have also been externally validated, and even fewer are international validation studies [13]. International collaborations and standardization of international registries may allow for universally valid prediction models, which is the next step for moving prediction modeling from a single-country task to a coordinated global effort [17].

Therefore, we asked: Does the SORG hip fracture delirium algorithm, initially trained on a database from the United States, perform well on external validation in patients aged 60 years or older in Australia and New Zealand?

Patients and Methods

This study followed the Transparent Reporting of Multivariable Prediction Models for Individual Prognosis or Diagnosis Guideline [7] and the Strengthening the Reporting of Observational Studies in Epidemiology [44] guidelines.

Study Design and Setting

We developed a model in 2021 for assessing delirium risk in patients with hip fractures, using the records of 28,207 patients obtained from the American College of Surgeons National Surgical Quality Improvement Program. In this developmental cohort of 28,207 patients, 28% (8030) developed a postoperative delirium [31].

The clinical prediction model reached good discrimination (c-statistic = 0.79 [95% CI 0.77 to 0.80]), almost perfect calibration (intercept = -0.01, slope = 1.02), and excellent overall model performance (Brier score = 0.15). The following variables were included in the primary developed clinical prediction model: age, American Society of Anesthesiologists (ASA) classification, functional status (independent or partially or totally dependent for any activities of daily living), preoperative dementia, preoperative delirium, and preoperative need for a mobility aid. Further details of the original clinical prediction model can be found in the developmental study's report [31].

To assess whether this model could be applied elsewhere, we used records from an international hip fracture registry. The validation cohort originated from the Australian and New Zealand Hip Fracture Registry (ANZHFR), which was queried from June 2017 to December 2018. The ANZHFR is a prospective, multiinstitution database that collects preoperative, perioperative, and postoperative data on more than 50 independent variables from more than 67 participating hospitals in Australia and New Zealand. Data are acquired from medical records and operative notes. The data items collected by the ANZHFR are specified in the Australian and New Zealand Hip Fracture Registry Data Dictionary version 12.1_October 2019. A range of validated diagnostic tools for delirium have been deemed acceptable in the ANZHFR, including confusion assessment method (CAM), the CAM for the Intensive Care Unit (CAM-ICU), the 3-Minute CAM (3D-CAM), and the 4 As test (4AT) [3, 9, 16]. The selection criteria used in the developmental study [31] were

applied; we included patients older than 60 years who underwent operative fixation of a femoral neck, intertrochanteric hip, or subtrochanteric hip fracture. Patients were excluded if they sustained a pathologic hip fracture or septic shock. The primary outcome of interest was postoperative delirium after surgical treatment of a hip fracture.

Participants' Baseline Characteristics

Between June 2017 to December 2018, 6672 patients older than 60 years of age in Australia and New Zealand were treated surgically for a femoral neck, intertrochanteric hip, or subtrochanteric hip fracture and entered into the ANZHFR. Patients were excluded if they had sustained a pathological hip fracture or developed septic shock. Of all patients, 6% (402 of 6672) did not meet the inclusion criteria, leaving 94% (6270 of 6672) available for inclusion in this retrospective analysis, of whom 39% (2467 of 6270) had postoperative delirium. Seventy-one percent (4249 of 5986) of patients were aged 80 years or older, 68% were female (4292 of 6266), and 83% of patients were classified as ASA III/IV (4690 of 5661) (Table 1).

Baseline characteristics in the validation cohort differed from those in the original developmental cohort [31] in several regards (Table 1). The cohort from Australia and New Zealand were more likely to be older, men, and healthier (as evidenced by a lower ASA score). However, they were less likely to live independently, and more likely to experience preoperative delirium and preoperative dementia. They were more likely to use bone protective medication (calcium and/or vitamin D only AND/OR bisphosphonates, denosumab, or teriparatide) prior to injury, and their hospital care was more likely to include medical co-management by a geriatrician or specialized nurse conducting preoperative medical assessment (in addition to an anesthetic review and orthopaedic assessment) (all $p < 0.05$). The proportion of postoperative delirium was higher in the validation cohort (39% [2467 of 6270]) than in the developmental cohort (29% [8030 of 28,207]; $p < 0.05$).

Missing Data

Preprocessing of the validation cohort was performed by imputing missing values, using the missForest methodology [35] as previously applied by our group [4, 18–20, 39]. We imputed missing values for age (5% [284 of 6270]), gender (0.06% [4 of 6270]), American Society of Anesthesiologists (ASA) class (10% [609 of 6270]), functional status (0.2% [13 of 6270]), preoperative need for a mobility aid (1% [86 of 6270]), preoperative delirium (44% [2767 of 6270]), and preoperative dementia (3% [187 of 6270]). In addition, a complete case analysis was carried out to evaluate the effect when a variable has > 30% missing data [33].

Ethical Approval

The study was approved by the Southern Adelaide Clinical Human Research Ethics Committee (OFR: 262.19).

Assessment of Model Performance and Statistical Analysis

Model performance was evaluated according to a proposed framework for the evaluation of a clinical prediction model [38] that includes discrimination with the c-statistic, calibration with a calibration slope and intercept, and the overall performance, assessed with the Brier score.

The c-statistic (area under the curve of a receiver operating characteristic curve) ranges from 0.50 to 1.0, with 1.0 indicating the highest discrimination score and 0.50 indicating the lowest. The receiver operating curve (ROC) plots the false positive rate (x-axis) and true positive rate (y-axis). In risk stratification, ideally there is a high true positive rate and a low false positive rate. The higher the discrimination score, the better the model's ability to distinguish between patients with the outcome and those who did not have the outcome [37]. In general, we used the following rule, depending on the context: a c-statistic of 0.5 suggests no discrimination (that is, the ability to predict patients with and without a postoperative delirium based on the model), 0.6 to 0.7 was considered poor, 0.7 to 0.8 was considered acceptable, 0.8 to 0.9 was considered excellent, and more than 0.9 was considered outstanding [27].

A calibration plot charts the predicted (x-axis) versus the true observed probabilities (y-axis, labeled outcomes) for the primary outcome. The concept is to evaluate the average predicted probability that corresponds with the true predicted probability for binned predictions (that is, a probability of 0.80 to 0.89 is one bin) and gives a certain confidence on the prediction (or the reliability of the algorithm) [32]. A perfect calibration plot has an intercept of 0 (< 0 reflects overestimation and > 0 reflects underestimating the probability of the outcome) and a slope of 1 (model is performing similarly in training and test sets) [38, 40]. In a small dataset, the slope is often < 1, reflecting model overfitting; probabilities are too extreme (low probability too low; high probability too high) [37].

The Brier score calculates a composite of discrimination and calibration, with 0 indicating perfect prediction and a Brier score of 1 representing the poorest prediction. The null-model Brier score (a score that equals the probability of delirium in the dataset) was used to benchmark the algorithm's Brier score. A Brier score lower than the null-model Brier score indicates superior performance of the model to this null benchmark. Perfect models would have a Brier score of 0 [38].

In addition, we undertook a decision curve analysis to investigate the net benefit (weighted average of true positives and false positives, formula = sensitivity x prevalence – (1 – specificity) x (1 – prevalence) x odds at the threshold probability) of the conducted algorithms over the range of risk thresholds for clinical decision-making [43]. With threshold probability we refer to the probability that an algorithm ranks a positive outcome over a negative outcome. If the threshold is set at 0.5, then patients with a probability > 0.5 are classified as positive and < 0.5 are classified as negative. If the threshold is set at 0.8, then patients with a probability > 0.8 are classified as positive and < 0.8 are classified as negative. The decision curve of the model is compared with decision curves of treating everyone as being at risk for postoperative delirium and treating no one as being at risk for postoperative delirium.

Baseline characteristics are presented as percentages and frequencies for dichotomous and categorical variables and median with interquartile range for continuous variables. Baseline characteristics in the developmental and validation cohort were compared using a bivariate analysis, where a p value of < 0.05 was considered significant. Data preprocessing and analysis were performed using R Version 4.0 ("R: A Language and Environment for Statistical Computing" The R Foundation) and R-studio Version 1.2.1335 (R-Studio).

Internet Application

This clinical prediction model is available in a freely available internet application at https://sorg-apps.shinyapps.io/hipfxdelirium/.

RESULTS

External Validation of SORG Hip Fracture Delirium Algorithm in Australia and New Zealand

The SORG hip fracture delirium algorithm achieved good discrimination in predicting postoperative delirium in hip fracture patients aged 60 years or older in the Australian and New Zealand cohorts. The c-statistic was 0.74 (95% confidence interval [CI] 0.73 to 0.76) (Table 2) and the ROC curve shows the graph of the model performance by plotting the false positive and true negative rates with an area under the curve (AUC) corresponding to the c-statistic with 0.74 (Figure 1). The calibration plot of the algorithm in the validation cohort showed calibration metrics with an intercept of -0.28 (95% CI -0.35 to -0.21) and

a calibration slope of 0.52 (95% CI 0.49 to 0.56) (Figure 2). The calibration plot was highly accurate in the range of lower predicted probabilities. The Brier score was lower than the respective null-model Brier score (0.22 versus 0.24), indicating good overall performance of the SORG hip fracture delirium algorithm. According to the decision curve analysis, the SORG hip fracture delirium algorithm provided a positive net benefit compared with a strategy of treating all patients or no patients as being at risk of postoperative delirium (Figure 3). The net benefit can be interpreted as reflecting the balance between a true positive prediction and the harm of a false positive prediction. Seeing no patients as being at risk is always 0 because the model will not predict anyone as being positive. Seeing all patients as being at risk of postoperative delirium will cross y = 0 at the prevalence of the validation cohort (39% in our study) [41]. A risk threshold can be interpreted as follows: with a risk threshold of 20% (1 to 5), each false positive should be weighed by the odds of 5 (the harm-to-benefit ratio). A model is only clinically useful if the net benefit at a certain risk threshold T is higher than treat all or treat no patients. However, there is no single risk threshold that is universally acceptable, and the choice of a clinically appropriate threshold should not depend on the result of a decision curve analysis [21].

Data pre-processing and analysis were performed using R Version 5.3 (“R: A Language and Environment for Statistical Computing" The R Foundation, Vienna, Austria 2013) and R-studio Version 1.2.1335 (R-Studio, Boston, MA, USA).

DISCUSSION

Patients aged 60 years or older undergoing hip fracture surgery have a high risk of developing postoperative delirium, leading to higher complications, longer in-hospital stays, and increased economic costs. Many delirium-preventive strategies exist, including prediction models that assess delirium risk. However, only a few delirium prediction models have been validated in an independent cohort, a necessary step before clinical implementation, and even fewer tools are externally validated specific for the hip fracture population. Previously, we developed a clinical prediction model (SORG hip fracture delirium algorithm) in a large North American cohort, and the purpose of this study was to externally validate the prediction model in an independent cohort. On external validation, the prediction model retained good discriminative ability and was shown to be accurate in distinguishing between low-risk patients (< 25%) and moderate to high-risk patients (> 25%) to make preventive interventions a priority. The internet-based tool suggests potential utility over treating everyone as being at risk.

Limitations

The results of this study should be viewed considering several limitations. First, although machine learning can work well at deriving associations and correlations, it cannot determine causation or assess whether those associations make physiologic sense. Second, as with any algorithm, the quality of machine learning is highly dependent on data quality; if available data are poor, subjective, or incomplete, no algorithm can be expected to work well. Here, data on preoperative delirium were missing for almost half of the patient group, and we cannot be sure that our algorithm would not have performed differently if these data had been available. Further, generalizability of a prediction model cannot be assessed after a single external validation study, but it should be examined after thorough independent external validation for each population if the population differs considerably in setting, in patient demographics, or outcome incidence. This was a validation study in an Australian and New Zealand cohort. This might limit the reference value for other countries, for patients from other racially distinct regions, or patients with different background in terms of social determinants of health (such as, socioeconomic status, income level, or education). In addition, statistical models using machine learning are hypothesized to have the potential to provide more accurate estimates for the prediction of binary events compared with more traditional logistic regression algorithms. Our prediction model uses a penalized logistic regression algorithm, which is basically a logistic regression algorithm with more flexibility in the hyperparameters. This finding is in line with previous research, which has shown that the benefit of more complex machine-learning methods may be limited in this context for the prediction of binary outcome in orthopaedic trauma [30]. Moreover, the study designs of the development and validation cohort were country-wide registries, meaning the data were collected for quality outcome purposes rather than research. However, researchers can gain data-driven insights from these registry-based patient cohorts to better understand expected outcomes. Predictive analytics on registry-based data may play a significant role in the future with advances in computation to improve the prediction model's accuracy when, for example, combined with medical imaging or free-text notes leading to artificial intelligence–based registries [34]. In addition, the cohorts originated from different continents, which could lead to variation in treatment protocols and diversity in training programs for orthopaedic surgeons between countries. A previous study assessing a cross-cultural comparison of treatment outcomes in hip fracture patients found that although there were possible differences in clinical practices in two different countries, that did not influence the clinical outcomes [24], and we did not expect the differences from our cohort to influence treatment outcomes. Furthermore, the variable definition differed between both cohorts, including the assessment of postoperative delirium, which was defined as occurring within 7 days of surgery in the validation cohort compared with 30 days in the developmental cohort. Because the start of delirium is usually rapid

(appearing within hours [2] and peaking between 1 and 3 days postoperatively [45]), we assumed all postoperative delirium events were captured within the 7-day period, and that we did not miss cases of postoperative delirium (Supplementary Table 1; https://links.lww.com/CORR/A803). Lastly, a high proportion of missing values was seen in our assessment of preoperative delirium. Therefore, we performed a complete case analysis, and the results were in line with model performance metrics for the total validation cohort with a c-statistic of 0.75 (95% CI 0.74 to 0.77) (Supplementary Table 2; https://links.lww.com/CORR/A804), comparable ROC curve (Supplementary Fig. 1; https://links.lww.com/CORR/A805), calibration plot (Supplementary Fig. 2; https://links.lww.com/CORR/A806), and decision curve analysis (Supplementary Fig. 3; https://links.lww.com/CORR/A807).

Discussion of Key Findings

We found that the SORG hip fracture delirium algorithm, initially trained on a dataset from North America, performed equally well on a dataset from Australia and New Zealand.

However, in its current iteration, we did not find that the SORG hip fracture delirium algorithm performed better than other existing and validated instruments for assessing postoperative delirium risk. The current study is an external validation of a single prediction model, although many successful delirium prediction models have been described [6, 25]. Our study emphasizes the importance of externally validating a well-developed algorithm in an independent cohort, with similar patient and injury characteristics (patients with hip fractures who were 60 years or older). We believe international validation studies with transparent reporting is an important step for moving prediction modeling from a single-country to a coordinated global effort [13]. More than 15 delirium prediction models are reported in the evidence [6], and only two studies externally validated a delirium prediction model specific to the hip fracture population [11, 29]. One of these two studies externally validated the Risk Model for Delirium score and reported a c-statistic of 0.73 (95% CI 0.68 to 77) but did not report calibration, Brier scores, or decision curve metrics, which is recommended in evaluating prediction models [29, 36]. Another study assessed the performance of the Delirium Elderly at Risk in hip fracture patients, reporting a positive predictive value ranging between 54% to 65% (that a positive prediction turns out to be a postoperative delirium) and a negative predictive value ranging between 76% to 90%. Discrimination, calibration, Brier scores, and decision curves were not reported [11].
The model in the current specific population has been shown to be highly accurate for distinguishing between low-risk patients (< 25%) and moderate to high-risk patients

(> 25%). We recommend preventive measures be made a priority in patients who have a more than 25% probability of developing postoperative delirium after hip fracture surgery. Delirium is common, costly, and associated with complications; however, effective, multidisciplinary strategies can prevent it. Interventions in hospitalized older adults include regular orientation, therapeutic activities, frequent mobilization and exercise, and avoidance of psychoactive medications in favor of nonpharmacologic approaches for anxiety and sleep [8]. The prediction model should not be used as a standalone tool, and it does not replace clinical judgment nor screening measures. The prediction model may support assigning patients to a delirium prevention program when delirium prevention strategies are not standard practice, especially in smaller, nonacademic hospital and rural areas.

Conclusion

Algorithms developed with machine learning are a potential tool for refining treatment of at-risk patients. If high-risk patients can be reliably identified, resources can be appropriately directed toward their care. Although the current iteration of SORG should not be relied on for patient care, it suggests potential utility in assessing risk. However, the current machine-learning algorithm did not perform any better than other existing and validated instruments for assessing postoperative delirium risk. Further assessment in different populations, made easier by international collaborations and standardization of registries, would be useful in the development of universally valid prediction models. The model can be freely accessed at: https://sorg-apps.shinyapps.io/hipfxdelirium/.

Table 1. Baseline characteristics of validation cohort, n = 6,270

Variable	n (%) | median (IQR)		
	Validation cohort (n=6,270)	Developmental cohort (n=28,207)	p-value
Age, years			<0.001
60+	340 (5.7)	3151 (11.2)	
70+	1397 (23.3)	6247 (22.1)	
80+	2838 (47.4)	11691 (41.4)	
90+	1411 (23.6)	7118 (25.2)	
Gender, female	4292 (68.4)	19845 (70.4)	<0.01
ASA class			<0.001
I	60 (1.1)	126 (0.4)	
II	848 (15.1)	4162 (14.8)	
III	3373 (60.3)	17631 (62.5)	
IV	1317 (23.5)	6288 (22.3)	
Preoperative functional status			<0.001
Independent	4389 (70.5)	21672 (76.8)	
Partially/totally dependent	1840 (29.5)	6535 (23.2)	
Preoperative need for mobility-aid	3527 (57.0)	16239 (57.6)	0.55
Preoperative delirium	1406 (35.6)	3714 (13.2)	<0.001
Preoperative dementia	2597 (42.7)	8668 (30.7)	<0.001
Preoperative bone protective medication	2317 (37.0)	9047 (32.1)	<0.001
Medical co-management by geriatric medicine	6086 (97.1)	25136 (89.1)	<0.001
Postoperative delirium	2467 (39.2)	8030 (28.5)	<0.001

IQR= interquartile range; ASA=American Society of Anaesthesiologist class

Table 2. Variable definition of validation (ANZ) and developmental (NSQIP) cohort

Variable	Validation cohort	Developmental cohort
Age	Complete years at admission	Complete years at admission
Gender	Male Female	Male Female
ASA class	I/II/III/IV	I/II/III/IV
Preoperative functional status	Private residence (including unit in retirement village) Residential aged care facility	Independent Partially or Totally Dependent
Preoperative need for mobility-aid	Usually walks with either a stick or crutch Usually walks with two aids or frame Usually uses a wheelchair / bed bound Usually walks without walking aids	Yes No
Preoperative delirium	Cognition assessed and impaired Cognition assessed an normal	Yes No
Preoperative dementia	Impaired cognition or known dementia Normal cognition	Yes No
Preoperative bone protective medication	Yes - Calcium and/or vitamin D only Yes - Bisphosphonates, denosumab or teriparitide (with or without calcium and/or vitamin D) No bone protection medication	Yes No
Medical co-management by geriatric medicine	Yes No No geriatric medicine service available	Yes – co-management during stay Yes – partial co-management during stay No
Postoperative delirium	Assessed and identified (7 days) Assessed and not identified	Yes (30 days) No

ASA class = American Society of Anaesthesiologist class

Table 3. Model performance assessment on external validation in Australia-New Zealand Hip Fracture Registry (95% confidence interval), n = 6,270

Metric	Elastic-Net Penalized Logistic Regression
AUC	0.75 (0.73, 0.76)
Intercept	-0.28 (-0.35, -0.21)
Slope	0.52 (0.49, 0.56)
Brier	0.22 (0.21-0.23)

AUC: area under the receiver operating curve. Null model Brier score = 0.24

Figure 1. Discrimination of elastic-net penalized logistic regression model on external validation in the institutional population, n = 6270

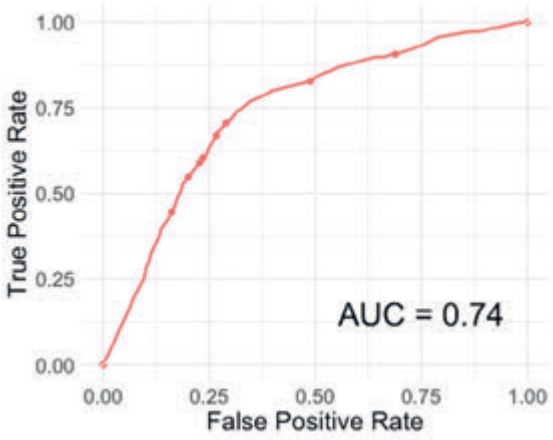


Figure 2. Calibration of elastic-net penalized logistic regression model on external validation in the institutional population, n = 6270

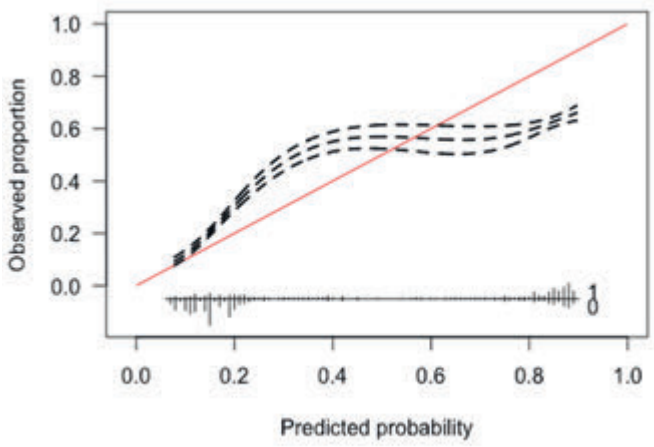
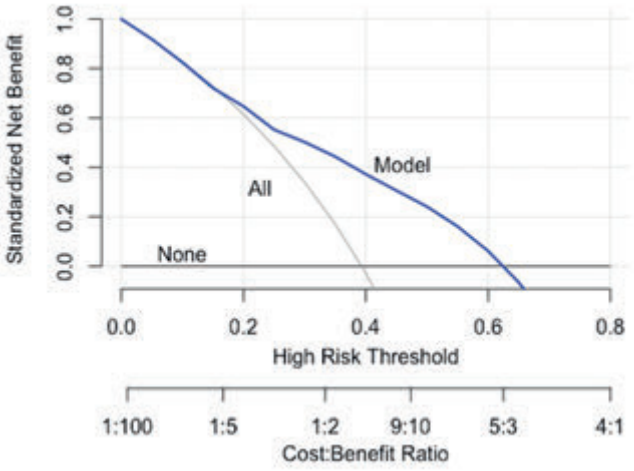


Figure 3. Decision curve analysis for the PLR for prediction of postoperative delirium in the validation set, n=6,270. Decision curve analysis with net benefit achieve by management changes based on the PLR algorithm relative to default strategies.



SUPPLEMENTARY MATERIAL

Supplement 1

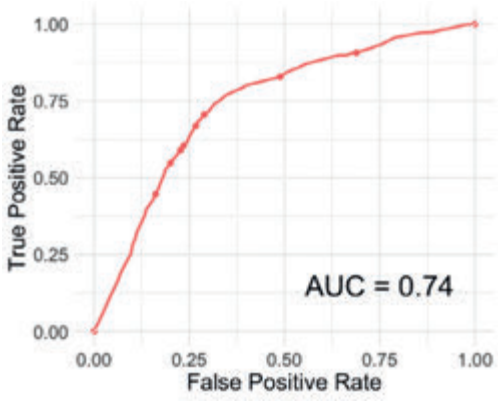
Table. Model performance assessment on external validation in Australia-New Zealand database (95% confidence interval), n = 3321 (complete case analysis)

Metric	Elastic-Net Penalized Logistic Regression
AUC	0.75 (xx, xx)
Intercept	-0.31 (-0.40, -0.22)
Slope	0.55 (0.51, 0.60)
Brier	0.21 (0.20, 0.22)

(AUC): area under the receiver operating curve. Null model Brier score = 0.23

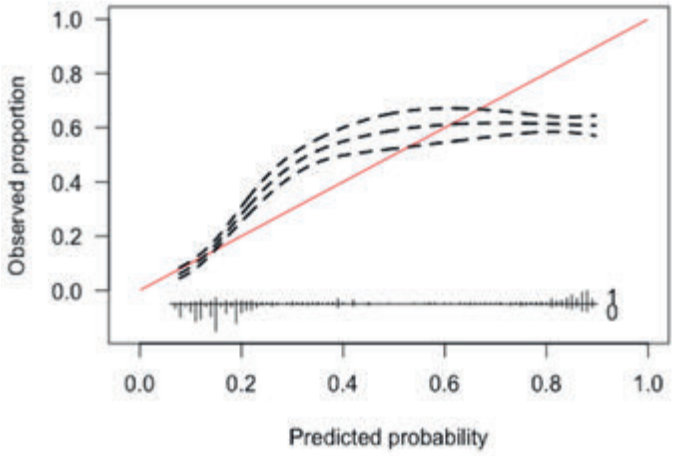
Supplement 2

Figure. Discrimination of elastic-net penalized logistic regression model on external validation in the Australian-New Zealand database, n = 3321 (complete case analysis)



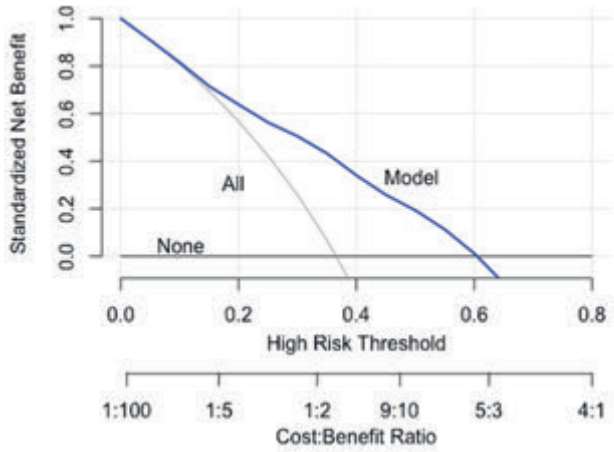
Supplement 3

Figure. Calibration of elastic-net penalized logistic regression model on external validation in the institutional population, n = 3321 (complete case analysis)



Supplement 4

Figure. Decision-curve analysis of elastic-net penalized logistic regression model on external validation in the institutional population, n = 3321 (complete case analysis)



REFERENCES

1. American Academy Orthopaedic Surgeons. Management of hip fractures in the elderly: evidence-based clinical practice guideline. Available at: https://www.aaos.org/globalassets/qualityand-practice-resources/hip-fractures-in-theelderly/management_of_hip_fractures_in_the_elderly-7-24-19. pdf. Accessed June 26, 2020.

2. Bellelli G, Mazzola P, Morandi A, et al. Duration of postoperative delirium is an independent predictor of 6-month mortality in older adults after hip fracture. J Am Geriatr Soc. 2014;62: 1335-1340.

3. Bellelli G, Morandi A, Davis DHJ, et al. Validation of the 4AT, a new instrument for rapid delirium screening: a study in 234 hospitalised older people. Age Ageing. 2014;43:496-502.

4. Bongers MER, Thio QCBS, Karhade AV, et al. Does the SORG

algorithm predict 5-year survival in patients with chondrosarcoma? An external validation. Clin Orthop Relat Res. 2019;477:2296-2303.

5. Brauer C, Morrison RS, Silberzweig SB, et al. The cause of delirium in patients with hip fracture. Arch Intern Med. 2000; 160:1856-1860.

6. Chen X, Lao Y, Zhang Y, et al. Risk predictive models for delirium in the intensive care unit: a systematic review and metaanalysis. Ann Palliat Med. 2021;10:1467.

7. Collins GS, Reitsma JB, Altman DG, et al. Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): the TRIPOD statement. BMJ. 2015;350: g7594.

8. Deeken F, Sanchez A, Rapp MA, et al. Outcomes of a delirium prevention program in older persons after elective surgery: a stepped-wedge cluster randomized clinical trial. JAMA Surg. 2022;157:e216370-e216370.

9. Ely EW, Margolin R, Francis J, et al. Evaluation of delirium in critically ill patients: validation of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU). Crit Care Med.2001;29:1370-1379.

10. Fixation using Alternative Implants for the Treatment of Hip fractures (FAITH) Investigators. Fracture fixation in the operative management of hip fractures (FAITH): an international, multicentre, randomised controlled trial. Lancet. 2017;389: 1519-1527.

11. Freter S, Dunbar M, Koller K, et al. Risk of pre- and postoperative delirium and the Delirium Elderly At Risk (DEAR) tool in hip fracture patients. Can Geriatr J. 2015;18:212-216.

12. Gou RY, Hshieh TT, Marcantonio ER, et al. One-year Medicare costs associated with delirium in older patients undergoing major elective surgery. JAMA Surg. 2021;156:430-442.

13. Groot OQ, BJJ Bindels, Ogink PT, et al. Availability and reporting quality of external validations of machine-learning prediction models with orthopedic surgical outcomes: a systematic review. Acta Orthop. 2021;92:385-393.

14. HEALTH Investigators, Bhandari M, Einhorn T, et al. Total hip arthroplasty or hemiarthroplasty for hip fracture. N Engl J Med. 2019;381:2199-2208.

15. Inouye SK, Bogardus ST, Charpentier PA, et al. A multicomponent intervention to prevent delirium in hospitalized older patients. N Engl J Med. 1999;340:669-676.

16. Inouye SK, Charpentier PA. Precipitating factors for delirium in hospitalized elderly persons: predictive model and interrelationship with baseline vulnerability. JAMA. 1996;275: 852-857.

17. Johansen A, Golding D, Brent L, et al. Using national hip fracture registries and audit databases to develop an international perspective. Injury. 2017;48:2174-2179. 1-year mortality in spinal metastatic disease: development and internal validation. Clin Neurosurg. 2019;85:E671-E681.

19. Karhade AV, Thio QCBS, Ogink PT, et al. Development of machine learning algorithms for prediction of 30-day mortality after surgery for spinal metastasis. Clin Neurosurg. 2019;85: E83-E91.

20. Karhade A V, Ogink PT, Thio QCBS, et al. Development ofmachine learning algorithms for prediction of prolonged opioid prescription after surgery for lumbar disc herniation. Spine J.

2019;19:1764-1771.

21. Kerr KF, Brown MD, Zhu K, et al. Assessing the clinical impact of risk prediction models with decision curves: guidance for correct interpretation and appropriate use. J Clin Oncol. 2016;34:2534-2540.

22. Kim EM, Li G, Kim M. Development of a risk score to predict postoperative delirium in patients with hip fracture. Anesth Analg. 2020;130:79-86.

23. Kinchin I, Mitchell E, Agar M, et al. The economic cost of delirium: a systematic review and quality assessment. Alzheimers Dement. 2021;17:1026-1041.

24. Kusen JQ, van der Vet PCR, Wijdicks FJG, et al. Efficacy of two integrated geriatric care pathways for the treatment of hip fractures: a cross-cultural comparison. Eur J Trauma Emerg Surg. Published online March 10, 2021. DOI: 10.1007/s00068-021-01626-y.

25. Lindroth H, Bratzke L, Purvis S, et al. Systematic review of prediction models for delirium in the older adult inpatient. BMJ Open. 2018;8:e019223.

26. Lipowski ZJ. Transient cognitive disorders (delirium, acute confusional states) in the elderly. Am J Psychiatry. 1983;140: 1426-1436.

27. Mandrekar JN. Receiver operating characteristic curve in diagnostic test assessment. J Thorac Oncol. 2010;5:1315-1316.

28. Marcantonio ER. In the clinic. Delirium. Ann Intern Med. 2011; 154:6-16.

29. Moerman S, Tuinebreijer WE, de Boo M, et al. Validation of the risk model for delirium in hip fracture patients. Gen Hosp Psychiatry. 2012;34:153-159.

30. Oosterhoff JHF, Gravesteijn BY, Karhade AV, et al. Feasibility of machine learning and logistic regression algorithms to predict outcome in orthopaedic trauma surgery. J Bone Joint Surg Am. 2022;104:544-551.

31. Oosterhoff JHF, Karhade AV, Oberai T, et al. Prediction of postoperative delirium in geriatric hip fracture patients: a clinical prediction model using machine learning algorithms. Geriatr Orthop Surg Rehabil. Published online December 12, 2021. DOI: 10.1177/21514593211062277.

32. Pedregosa F, Varoquaux G, Gramfort A, et al. Scikit-learn: machine learning in Python. J Mach Learn Res. 2011;12: 2825-2830.

33. Pigott TD. A review of methods for missing data. Educ Res Eval. 2001;7:353-383.

34. Rajpurkar P, Chen E, Banerjee O, et al. AI in health and medicine. Nat Med. 2022;28:31-38.

35. Stekhoven DJ, Buhlmann P. MissForest–non-parametric missing value imputation for mixed-type data. Bioinformatics. 2012;28: 112-118.

36. Steyerberg E. Validation of prediction models. In: Gail M, Samet J, Singer B, eds. Clinical Prediction Models. A Practical Approach to Development, Validation, and Updating. 2nd ed. Springer; 2019:309-323.

37. Steyerberg EW, Vergouwe Y. Towards better clinical prediction models: seven steps for development and an ABCD for validation. Eur Heart J. 2014;35:1925-1931.

38. Steyerberg EW, Vickers AJ, Cook NR, et al. Assessing the performance of prediction models: a framework for traditional and novel measures. Epidemiology. 2010;21:128-138.

39. Thio QCBS, Karhade AV, Ogink PT, et al. Development and internal validation of machine learning algorithms for preoperative survival prediction of extremity metastatic disease. Clin Orthop Relat Res. 2020;478:322-333.

40. van Calster B, Vickers AJ. Calibration of risk prediction models: impact on decision-analytic performance. Med Decis Making. 2015;35:162-169.

41. van Calster B, Wynants L, Verbeek JFM, et al. Reporting and interpreting decision curve analysis: a guide for investigators.Eur Urol. 2018;74:796-804.

42. van Meenen LCC, van Meenen DMP, de Rooij SE, et al. Risk prediction models for postoperative delirium: a systematic review and meta-analysis. J Am Geriatr Soc. 2014;62:2383-2390.

43. Vickers AJ, Elkin EB. Decision curve analysis: a novel method for evaluating prediction models. Med Decis Making. 2006;26: 565-574.

44. von Elm E, Altman D, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370:1453-1457.

45. Whitlock EL, Vannucci A, Avidan MS. Postoperative delirium. Minerva Anestesiol. 2011;77:448-456.

46. Zhao H, You J, Peng Y, et al. Machine learning algorithm usingelectronic chart-derived data to predict delirium after elderly hip fracture surgeries: a retrospective case-control study. Front Surg. 2021;8:634629.

CHAPTER 4

Effectiveness of multicomponent interventions on incidence of delirium in hospitalised older patients with hip fracture: a systematic review

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International Psychogeriatrics- April 2018

INTRODUCTION

Delirium is the most frequent complication among the hospitalized elderly with hip fracture. Although, delirium is associated with longer hospital stay, higher mortality rates, worse functional outcomes and higher institutionalization rates yet health service planners have hugely ignored its existence. This review aims to identify the effectiveness of multicomponent interventions to prevent delirium in hospitalized elderly patients with hip fracture.

Methods

This is a systematic review of experimental, non-experimental and observational studies. Electronic searches were conducted in MEDLINE, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials, Embase and Web of science.

Results

After inclusion and exclusion criteria were applied, 9 full text articles were included in the review. The studies reported the following effect on delirium:

We pooled data regarding incidence of delirium from the three randomised controlled trials. The effect was in favour of the intervention group (odds ratio 0.64, 95% CI 0.46 to 0.87). All three RCT's reported that duration of delirium was shorter in the intervention group than in the usual care group (mean 2.9 vs 3.1 days, median 3 vs 4 days, median 5.0 vs 10.2 days). Four other studies reported on the duration of delirium with Milisen and colleagues reported shorter duration of delirium within the intervention group. Four studies reported on severity of delirium with two research groups reporting significant results.

Conclusion

In summary, early engagement of multidisciplinary staff who address the risk factors of delirium as soon as the patient presents to the acute care environment is the key element of a successful delirium prevention program.

BACKGROUND

Hip fractures, which are often a result of low energy trauma, are serious injuries commonly experienced by older people.[1, 2] Worldwide, about 1.5 million hip fractures occur each year [3].These injuries have a major impact not only on the person's long-term health, but also on informal carers, health services and the community.[4] Globally, the 30-day mortality after a neck of femur fracture is between 7% and 9% and the one-year mortality ranges from 22% to 30%.[5, 6] Hip fractures also place a considerable burden upon the healthcare system because of the associated increase in morbidity. According to The REFReSH study group total annual hospital costs associated with incident hip fractures in UK were estimated at £ 1.1 billion [7].

During hospital admissions, these people are at risk of developing complications including functional, physical, and cognitive impairments.[4] Poor general health, older age, cognitive impairment and decreased activity level increase the risk of complications associated with hip fractures.[8, 9] Studies have identified delirium as the most frequent complication among hospitalized older people and delirium is particularly common following a hip fracture.[10-12] Delirium is a complex neuropsychiatric syndrome characterized by acute and fluctuating onset, inattention, altered level of consciousness and evidence of disorganized thinking.[13] Marcantonio and colleagues reported that 35% to 65% of patients who have undergone surgery for a neck of femur fracture repair suffered delirium post-operatively.[14] A systematic review published in 2016 reported on risk factors for post-operative delirium following hip fracture repair. The results of a recent meta-analysis examining risk factors for delirium showed that patients with existing cognitive impairment, advancing age, living in an institution, heart failure, total hip arthroplasty, multiple comorbidities and morphine use were more likely to experience delirium after hip surgery. [15] Several studies have observed that patients presenting with delirium during the hospital stay have a worse prognosis, stay longer in the hospital, and have higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge.[16-18] Although delirium is known to be associated with poor clinical outcomes, health service planners and practitioners have largely accepted delirium as a common presentation.[19]

A number of studies have investigated interventions to prevent delirium, which can be grouped into multicomponent therapies and single interventions. [20-23] The majority of single intervention studies focus on the impact of pharmacological interventions. [20-22] Effectiveness studies on the use of pharmacological interventions for delirium prevention show mixed results. [20-22] Randomized, controlled trials investigating the effectiveness of drugs such as haloperidol and melatonin for prevention of delirium in hip fracture patients have been conducted[20] but so far have failed to change the incidence of delirium.[20 22]

On the other hand, studies exploring the effect of multicomponent interventions have shown promising results. [23] Multicomponent interventions refer to more than one strategy to address the range of risk factors associated with delirium which can include pharmacological as well as non-pharmacological interventions; a number of studies suggest this approach is effective.[23] [24]

A Cochrane review published in 2007 examined interventions for preventing delirium in various older patients. Only one of the included studies involved people following hip fracture repair; in this study it was suggested that proactive geriatric consultation can reduce incidence and severity of delirium.[25] In 2013, Thomas et al. published a systematic review regarding the effectiveness of non-pharmacological multicomponent interventions for delirium prevention; participants in the study comprised any elderly patient admitted to a non-intensive care unit. The findings of this review suggested that multicomponent interventions have a potential to reduce risk of delirium.[26] More recently, two systematic reviews were undertaken on the same interventions but this time involving elderly patients with various medical conditions [42, 43]. As none of the reviews are specific to hip fracture population, a systematic review investigating effect of multicomponent interventions on incidence of delirium is warranted.

METHODS

Inclusion criteria

Types of participants

This review considered studies that included hospitalized patients aged 65 years and over, who sustained a hip fracture, irrespective of the mechanism of injury or method of treatment.

Types of intervention

Studies were included if they evaluated the effect of multicomponent interventions on incidence of delirium. A multicomponent intervention refers to the use of more than one strategy which can include but is not limited to: the use of specialized clinical staff/volunteers, geriatric/psychiatric consultation, staff education, patient orientation, addressing visual and hearing needs, sleep enhancement, medication review, hydration and nutrition, early mobilization, pain management, addressing bowel and bladder functions and prevention and treatment of medical complications.. This review did

not exclude studies based on the dose of (e.g. intensity, frequency, duration), or who delivered, the intervention.

Types of comparators

This review considered studies where multicomponent interventions had been compared to single interventions or usual care or no intervention.

Types of outcomes

Studies were eligible for inclusion if they measured incidence of delirium as a primary outcome. Only studies which determined the presence of delirium using standardized criteria or a validated tool (such as but not limited to Confusion Assessment Method (CAM), Mental Status Questionnaires, and Mini Mental State Examination (MMSE)) were included. Where reported, data regarding other outcomes such as discharge destination, length of stay, cognitive function, functional ability and readmission were also extracted and presented in this review.

Types of studies

This review considered experimental studies which presented information on an intervention group and information from a control group. This included randomized controlled trials, non-randomized controlled trials, and before and after intervention studies. This review also included observational studies such as prospective and retrospective cohort studies and case control studies as long as there was a control group.

Search strategy

The search strategy was designed to find both published and unpublished studies. A three-step search strategy was utilized in this review. An initial limited search of MEDLINE and CINAHL was undertaken followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms was then undertaken across all included databases. Thirdly, the reference list of all identified articles was searched for additional studies. Only studies published in the English language were considered for inclusion in this review. The search was limited to studies published between 1999 to the present as multicomponent intervention strategies for the prevention of delirium began to appear in the published literature during this time.[27-31]

The databases searched via EBSCO and OVID platforms included MEDLINE, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials, Embase and Web of science. Please refer to Supplemental File 1 for complete results and search terms used.

Data Collection and analysis

Selection of studies

The initial search yielded 2247 titles and abstracts from electronic searches (Figure 1). After duplicates were removed, 1176 articles were reviewed for initial screening and 176 for next stage of screening. After inclusion and exclusion criteria were applied, nine full text articles were included in the review.

Assessment of quality

The methodological quality of the studies was assessed by two independent reviewers (TO and LL) using standardized critical appraisal instruments from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI). Any disagreements that arose between the reviewers were resolved through discussion.

Data extraction

Data was extracted from papers included in the review using the standardized data extraction tool from JBI-MAStARI. The data extracted included specific details about the populations, interventions (e.g. type, intensity, and duration), outcomes and study methods. Data extraction was carried out by one reviewer with verification by another reviewer to minimize bias and potential errors in data extraction. Pooling of results was not possible due to methodological differences hence the findings have been presented in narrative form.

RESULTS

Description of the studies

Nine studies met the inclusion and exclusion criteria. Out of the nine studies, three were randomised controlled trials [32-34]. The total number of participants in the nine included studies were 1889; 874 in the intervention group and 1015 in the control groups.

Participants in the studies comprised of 75% females and 25% males. The average age of the participants in all the included studies ranged from 78 to 85 years. All the patients sustained various forms of proximal hip fracture. The studies originated from different parts of the world including North America, Europe and Australia. The patients included in the studies were mostly treated in orthopaedic or geriatric ward settings. Bjorkelund, 2010 [35] did not include patients who had prevalent delirium on admission. Characteristics of included studies are described in more detail in Table 1.

The multicomponent interventions in the studies included common themes (Table 2) and four studies implemented consultation/assessment by a geriatrician. Marcantonio et al. [32] implemented multicomponent interventions following proactive geriatric consultation of individuals in intervention group which began pre-operatively or within 24 hours of surgery. Wong et al. [36], Watne et al. [34] and Deschodt et al [37] used the same model where recommendations were based on work done by Marcantonio et al following a consultation by a geriatric registrar which formed a basis of treatment planning. The team consisted of geriatrician, nurse, physiotherapist and occupational therapist. Milisen et al. [38] and Lundstrom et al. [33] focussed their interventions not only on team work but also on staff education. Milisen et al. [38] implemented a nurse-led interdisciplinary intervention program where nurses were educated on early recognition and diagnosing delirium as they considered it essential for proper treatment. Consultative services were provided by a delirium resource nurse, a geriatric nurse specialist or a psychogeratrician and the model of care was based on work done by Inouye and colleagues. [39] Bjorkelund et al. [35] implemented a new program including pre-hospital, perioperative treatment and care. Lundstrom and colleagues [40] conducted another study which also focussed on staff education in caring, rehabilitation, teamwork, knowledge about delirium, risk factors prevention and treatment. Holroyd-Leduc et al. [41] studied the application of a clinical decision support system that included an enhanced version of the hip fracture order set. The order set included elements of the multicomponent interventions followed in the studies by Marcantonio et al. [32] and Lundstrom et al. [33]

Outcomes examined included incidence of delirium, duration and severity of delirium, cognitive function, activities of daily living, length of hospital stay, institutionalisation at discharge and mortality. Although, all studies examined incidence of delirium, there was heterogeneity in both the statistical measures of frequency and diagnostic methods used.

Risk of bias in included studies

Studies varied in their methodological quality. Randomised controlled trials (RCT's) were considered high quality for all items although participants and personnel weren't blinded. All three RCT's [32 33, 34] included blinded assessment of outcomes. The three non-randomised trials [35 37 38] were also considered high quality as all the items were reported on with the exception of multiple measurements pre and post exposure. It wasn't possible to comment on the quality of the two studies [36 41] as the methodology used in these studies has been poorly described.

Effect of interventions

We only considered randomised controlled studies for inclusion in a meta-analysis. We were able to conduct meta-analysis for one outcome (incidence of delirium) as other outcomes were not reported in a way that is appropriate for pooling. The impact of multicomponent interventions on outcomes is described in Table 3.

Primary outcome

Incidence of delirium

We pooled data regarding incidence of delirium from the three randomised controlled trials [32-34]. The effect was in favour of the intervention group (odds ratio 0.64, 95% CI 0.46 to 0.87) (see Figure 2). The remaining six studies all reported that incidence of delirium was reduced in the intervention group ; the difference in incidence of delirium between groups ranged from only 2% in one study [41] to 31 % in another [40].

Duration of delirium

Six studies reported on duration of delirium[32-34, 37, 38, 40]. All three randomised trials reported that the duration of delirium was shorter in the intervention group than in the usual care group (mean 2.9 vs mean 3.1 days[32]; median 3 vs 4 days[34]; median 5.0 vs 10.2 days)[33]. Data from these three studies could not be pooled due to the way in which they were reported. The other three/four studies reported on the duration of delirium with Milisen and colleagues[38] reporting statistically significantly shorter duration of delirium within the intervention group (median=1 day, IQR=1) compared with the non-intervention cohort) median=4 days, IQR=5.5). Two other studies (Bjorkelund et al and Lundstrom et all 1999) reported that participants in the control group had longer lasting delirium than those in

the intervention group however the differences between groups were not found to be statistically significant. Deschodt and colleagues found no differences between groups.

Severity of delirium

Four studies reported on severity of delirium [32, 34, 37, 38]. Marcantonio and colleagues reported that a smaller proportion of participants within their intervention group experienced severe delirium (12% vs 29%) whereas Watne et al[34] did not find a statistically significant difference between groups. Milisen and colleagues [38] reported less severe symptoms of delirium were experienced by participants within the intervention group (ranges from 3.82 to 1.91 vs 6.92 to 5.0) and Bjorkelund et al[35] failed to detect a statistically significant difference between groups.

Secondary outcomes

Discharge destination

Participant discharge destination was reported in five studies. [32, 34, 36, 40, 41]. Methods of reporting on this outcome varied across the studies. Four studies reported whether or not the person was discharged to a care institution whilst Lundstrom and colleagues [40] reported on the patients who were discharged to independent living. The difference between intervention and control group participants who were discharged to institutionalised care ranged from only 1% in one study [34] to 7% in another study[41], however none of the studies suggested any significant difference in the change of discharge destination.

Length of hospital stay

Length of hospital stay was reported in seven studies[32-34, 36, 38, 41]. Two[32, 34] of the randomised trials reported no significant differences between groups whereas Lundstrom and colleagues[33] found significantly shorter length of stay in the intervention group (mean 28 (SD 17.9) vs mean 38 (40.6) days). Of the remaining studies, three reported no significant differences whereas Lundstrom et al. [40] found significant shorter post-operative hospitalisation was experienced by the patients in the intervention group (12.5 days including rehabilitation time vs length of stay excluding the rehabilitation time in patients ' of control group 1 and control group 2 was 17.4 and 11.6 days[40]. Interestingly, Watne et al. [34] reported that the patients in the intervention group within their RCT had longer length of stay by three days however, this was not statistically significant.

Cognitive function

Cognitive function was reported in three studies [37] [34, 38] with only one (non-randomised) study [37] demonstrating significantly higher proportion of participants experiencing cognitive decline at discharge within the control group than those allocated to intervention group (38.7% vs 22.6%).

Functional and mobility status

Only three studies[34, 38, 40] reported on functional or mobility status of the patients. Only Lundstrom and colleagues[40] suggested that a significantly higher number of participants were walking independently with walking aids on discharge (83.8% within the intervention group and 58.3% & 60.2% within Control group 1 and control group 2 respectively).

DISCUSSION

This review included nine studies with evidence that multicomponent intervention strategies have positive effects on delirium in patients with hip fracture. Benefits appear to be predominantly in reduced incidence. Only two studies[33, 38] suggested shorter duration of delirium and one study suggested less severe symptoms of delirium. One study [40] demonstrated reduced length of hospital stay and a larger proportion of the participants returning to their previous living conditions. The same study also reported a higher proportion of patients were walking independently with a walking aid on discharge. Only one study [37] demonstrated a significant difference in cognitive decline at discharge in between the intervention and control group.

All included studies initiated assessment/consultation within 24 hours of admission which then formed the basis for early care planning. Once delirium had developed, the multicomponent interventions did not appear to make a significant difference to the duration or severity of delirium

All of the studies provided information about the multidisciplinary teamwork or clinical leadership in implementing the interventions. The common theme appears to be of early diagnosis and early management by specialist geriatric clinical staff. In general early assessment by geriatricians is associated with better outcomes and many national guidelines now include this as best practice (city Australian guideline and UK NICE guideline [42, 43]. Besides this, clinical staff consistently implemented targeted protocols/

guidelines/electronic care pathways that addressed cognition, mobility, sleep/rest, hydration, nutrition, pain management, bowel and bladder function, along with prevention and management of any post-operative complications. The multicomponent interventions were varied and involved multiple strategies and disciplines but all the strategies addressed the significant risk factors in development of delirium in hip fracture population. A variety of clinical staff were involved including doctors, nurses, physiotherapists, occupational therapist and social workers. All studies included components such as proactive consultation with a geriatrician and individual care planning.

The limited number of studies (including only three randomised trials) means that it is difficult to draw conclusions about which participant group may benefit most from multicomponent intervention. In the subgroup analyses conducted by Marcantonio and colleagues, interventions were more effective in reducing delirium among patients without prefracture dementia or activities of daily living impairment. Due to the relatively small sample size within these subgroups, these effects were not statistically significant. Another study[33] demonstrated significant difference in duration of post-operative delirium in patients with dementia in the intervention group patients.

None of the studies assessed the economic impact of shorter length of hospital stay. We believe that if economic evaluations were performed in the studies which reported on shorter length of hospital stay this could have added up to significant figure as acute care hospital environment is highly expensive. Study conducted by REFReSH group reported that the hospitalisation costs associated with each admission for hip fracture were £ 8663. Only one study [36] reported that expense of the intervention as the registrars (of geriatric specialty) spent considerably more time (estimated at an extra of 3 hours per day) with the patients than they had before the project started.

This review supports the findings of other reviews that multicomponent interventions are effective in reducing incidence of delirium. However, none of these reviews are specific to hip fracture patients and given that this patient group has a higher level of risk and a different set of precipitating risk factors for delirium and may therefore require a distinct set of interventions compared to other older patient groups, this systematic review will add value to the existing literature.

Within this review, most of the included studies were at risk of bias due to lack of randomization and blinding. Although most studies reported the benefits of multicomponent intervention, it is difficult to make assumptions about which particular approach is most beneficial. For example, which components are most likely to be

beneficial or whether one particular multicomponent approach is superior to others. Additionally, the variability in the components of the programs means that there is a limitation for accurate replication.

Implications for practice

Early diagnosis and primary prevention is the most effective strategy to prevent delirium. To decrease the incidence of delirium, all hip fracture patients admitted to acute care setting should have preventative interventions including review by geriatricians initiated as soon as soon as possible. Once delirium develops the multicomponent intervention strategies have limited efficacy in minimising duration and severity of delirium. Prevention of delirium before its onset is of high importance in order to keep patients with hip fracture physically, functionally, cognitively independent as well as safely discharge them to their pre-injury place of residence. Educating staff on the importance of early screening for delirium is a valuable exercise as screening will prompt early management of risk factors.

Implications for research

More translational evidence on the best way to implement use of delirium prevention protocols is needed to assist clinicians. In addition, economic evaluations conducted alongside randomised trials would provide useful information which may convince clinical staff and policy makers to invest more in delirium prevention.

Conclusion

In summary, early engagement of multidisciplinary staff particularly geriatricians who address the risk factors of delirium as soon as the patient present to the acute care environment is the key element of a successful delirium prevention program. The studies do not address which components within a program provide the most benefit for delirium prevention or management yet this systematic review reveals that people with hip fracture who received multicomponent interventions had a significantly lower risk of developing delirium as compared to those who did not.

Table 1: Characteristics of the included studies

Authors	Year	Location	Setting	Metho-dology	Prevalent delirium excluded on admission	Control group
Holroyd-Leduc et al.	2010	Canada	Orthopaedic unit in two hospitals	Prospective cohort study	Unable to determine	Pre=implemen-tation control group
Lundstrom et al.	2007	Sweden	Specialised geriatric unit and conventional orthopaedic unit	Randomised control trial	No	Usual care
Lundstrom et al.	1999	Sweden	Geriatric rehabilitation unit	Prospective cohort	No	Historic control group
Bjorkelund et al.	2012	Sweden	Orthopaedic unit	Non-randomised control trial	Yes	Pre-intervention control group
Marcantonio et al.	2001	United states	Academic tertiary medical centre	Randomised control trial	No	Usual care
Milisen et al.	2001	Belgium	Two trauma units	Non-randomised control trial(prospective before/after design)	No	Usual care
Wong et al.	2005	Australia	Orthopaedic unit	Prospective cohort	No	Historic control group
Watne et al.	2014	Norway	Acute geriatric ward and orthopaedic ward	Randomised control trial	No	Usual care
Deschodt et al.	2012	Belgium	Two trauma units	Non-randomised control trial	No	Usual care

Table 2: Themes of Multicomponent interventions

Authors	Fluid/ electrolyte	Nutrition	Pain	Oxygen	Mobility	Bowel / bladder care	Avoidance of polypharmacy	Complication management	Environment stimuli	Treatment of agitated delirium	Discharge planning
Marcantonio et al, 2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
Watne et al, 2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lundstrom et al, 2007	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
Bjorkelund et al, 2012	✓	✓	✓	✓	×	×	✓	×	×	×	×
Deschodt et al, 2012	✓	✓	✓	✓	✓	✓	×	✓	×	✓	✓
Milisen et al, 2001	✓	✓	✓	×	✓	×	✓	✓	✓	×	×
Wong et al, 2005	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
Holroyd-Leduc et al, 2010	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
Lundstrom et al, 1999	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓

Table 3: Effect of Interventions

	Marcantonio 2001 N=126 I=62 U=64	**Watne 2014 N=329 I=163 U=166**	**Lundstrom 2007 N=199 I=102 U= 97**	**Deschodt 2012 N=171 I=94 U=77**
Incidence of delirium	CAM I=20/62=32% U=32/64=50%	CAM I=80/163-49% U=86/166-53%	MMSE I=56/102, 54.9% U= 73/97, 75.3%	CAM I=35-37.2% U=41-53.2%
Duration of delirium	Days Mean±SD I=2.9±2.0 U=3.1±2.3	Median, IQR I= 3(2 to7) U= 4 (2 to 6)	Median ± SD I=5.0±7.1 days U= 10.2±13.3 days	Days I= 1 day (IQR- 1-5)
Severity of delirium	MDAS I=7/60=12% U=18/62(29%)	MDAS Median, IQR I=21.5(15.3 to 25) U=20 (13.8 to 26)	-	Delirium index No significant difference, P= 0.51
Discharge destination	To NH or Rehab home I=92% U=88%	To NH at 4 months after surgery I= 19 (16%) U= 18 (15%)	-	
LOS	Median±IQR=5±2 days in both groups	Median IQR I= 11 (8 to 15) U= 8(4.8 to 11)	Mean±SD I=28±17.9 days U=38.0±40.6 days	
Cognitive function	-	4 months after surgery-I=121 U=121 mean (SD) I= 54.7(30.3) U=52.9(29.1)	-	
Function/walking Status	-	Mobility at 4 months after surgery-SPPB Median(IQR) I=4 (1 to 8) U=3 (1 to 6)	-	

Bjorkelund 2010 N=263 IG= 131 CG=132	**Holroyd 2010 N=134 I=64 C=70**	**Wong 2005 N=99 Baseline=28 Post-intervention=71**	**Milisen 2001- N=120 I=60 U=60**	**Lundstrom 1999 I=49 CG1=111 CG2=103**
OBS SCALE IG=29/131 (22.1%) CG=45/132(34.1%)	CAM I=20/64 (31%) U= 23/70(33%)	CAM I=9/71=12.7% U= 10/28(35.7%)	CAM I=12=20% U=14=23.3%	OBS scale I=30.6% CG1=61.3% CG2=47.6%
≤1/≥2 days IG=14(10.7%)/15(11.5%) CG=23(17.4%)/ 22(16.7%)	-	-	Days median(IQR) I= M=1day,IQR+1 U=M=4 days,IQR=5.5	Days≥7 days I=16.3% CG1= 39.6% CG2= 29.1%
OBS max score ≤6/≥7 IG=105(80.2%)/26(19.8%) CG=97(73.5%/35(26.5%)	-	-	Variant of CAM I=3.82 SD=2.8 to 1.92 SD=2.3 U= 6.92 SD=2.8 to 5.0 SD=3.1	-
-	To long-term care I=4/64(6%) U=9/70(13%)	To High care level I=17/71 (23.9%) U=7/28 (25.0%)		To independent living I=89.3% CG1=62.3% CG2=53.4%
-	Median days (range) I=12(10-21) U=14(9-21)	Median, range I=10(2-44) U=8(3-41)	Median±IQR I=13.5 IQR=3.75 U=14, IQR=5	I= 12.5 days(incl rehab time) CG1=17.4 DAYS(ortho ward) CG2= 11.6 days(ortho ward)
-	-	-	No significant difference	-
		-	No significant difference	Walking independent with walk aid on discharge I=83.8% CG1= 58.3% CG2= 60.2%

Figure 1: Schema of the stages of searching and inclusion/exclusion of studies for the review

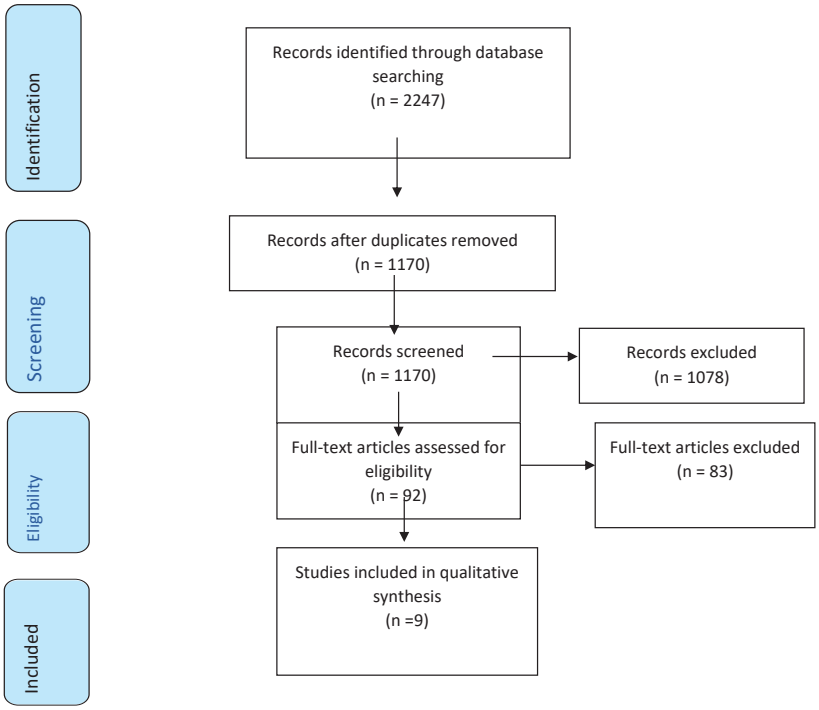
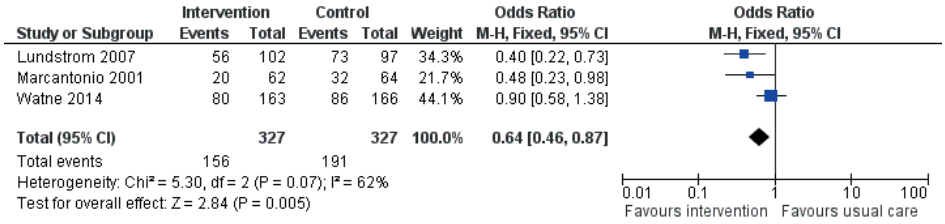


Figure 2: Multicomponent intervention to prevent delirium versus usual care: effect on incidence of delirium



REFERENCES

1. Magaziner J, Hawkes W, Hebel JR, et al. Recovery from hip fracture in eight areas of function. *J Gerontol A Biol Sci Med Sci*. 2000; 55: M498-507.DOI:10.1093/gerona/55.9.m498.

2. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. *Ageing Res Rev.* 2003; 2: 57-93

3. Hernlund E, Svedbom A, Ivergard M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos*. 2013; 8: 136.DOI:10.1007/s11657-013-0136-1.

4. Hirsch CH, Sommers L, Olsen A, et al. The natural history of functional morbidity in hospitalized older patients. *Journal of the American Geriatrics Society.* 1990; 38: 1296-303

5. Rae HC, Harris IA, McEvoy L, Todorova T. Delay to surgery and mortality after hip fracture. *ANZ J Surg*. 2007; 77: 889-91.DOI:10.1111/j.1445-2197.2007.04267.x.

6. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? *The Journal of bone and joint surgery American volume*. 2005; 87: 483-9.DOI:10.2106/JBJS.D.01796.

7. Leal J, Gray AM, Prieto-Alhambra D, et al. Impact of hip fracture on hospital care costs: a population-based study. *Osteoporos Int*. 2016; 27: 549-58.DOI:10.1007/s00198-015-3277-9.

8. Liu S, Zhu Y, Chen W, et al. Risk factors for the second contralateral hip fracture in elderly patients: a systematic review and meta-analysis. *Clinical rehabilitation*. 2015; 29: 285-94. DOI:10.1177/0269215514542358.

9. Svensson O, Stromberg L, Ohlen G, Lindgren U. Prediction of the outcome after hip fracture in elderly patients. *The Journal of bone and joint surgery British volume*. 1996; 78: 115-8

10. Gustafson Y, Berggren D, Brannstrom B, et al. Acute confusional states in elderly patients treated for femoral neck fracture. *Journal of the American Geriatrics Society.* 1988; 36: 525-30

11. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. *Arch Intern Med*. 2000; 160: 1856-60.DOI:10.1001/archinte.160.12.1856.

12. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *J Am Geriatr Soc*. 2001; 49: 1335-40

13. Marcantonio ER. In the clinic. Delirium. *Annals of internal medicine*. 2011; 154: ITC6-1, ITC6-2, ITC6-3, ITC6-4, ITC6-5, ITC6-, ITC-7, ITC6-8, ITC6-9, ITC6-10, ITC6-1, ITC6-2, ITC6-3, ITC6-4, ITC6-5; quiz ITC6-6.DOI:10.7326/0003-4819-154-11-201106070-01006.

14. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

15. Yang Y, Zhao X, Dong T, et al. Risk factors for postoperative delirium following hip fracture repair in elderly patients: a systematic review and meta-analysis. *Aging Clinical and Experimental Research*. 2017; 29: 115-26.DOI:10.1007/s40520-016-0541-6.

16. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. *JAMA*. 1990; 263: 1097-101

17. Rockwood K, Cosway S, Carver D, et al. The risk of dementia and death after delirium. *Age Ageing*. 1999; 28: 551-6

18. McCusker J, Cole M, Dendukuri N, et al. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. *CMAJ*. 2001; 165: 575-83

19. Inouye SK, Schlesinger MJ, Lydon TJ. Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. *Am J Med*. 1999; 106: 565-73

20. Kalisvaart KJ, de Jonghe JF, Bogaards MJ, et al. Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study. *Journal of the American Geriatrics Society*. 2005; 53: 1658-66.DOI:10.1111/j.1532-5415.2005.53503.x.

21. Overshott R, Karim S, Burns A. Cholinesterase inhibitors for delirium. *The Cochrane database of systematic reviews*. 2008: CD005317.DOI:10.1002/14651858.CD005317.pub2.

22. de Jonghe A, van Munster BC, Goslings JC, et al. Effect of melatonin on incidence of delirium among patients with hip fracture: a multicentre, double-blind randomized controlled trial. *CMAJ*. 2014; 186: E547-56.DOI:10.1503/cmaj.140495.

23. Bjorkelund KB, Hommel A, Thorngren KG, et al. Reducing delirium in elderly patients with hip fracture: a multi-factorial intervention study. *Acta anaesthesiologica Scandinavica*. 2010; 54: 678-88.DOI:10.1111/j.1399-6576.2010.02232.x.

24. Kalisvaart CJ, Vreeswijk R, de Jonghe JF, Milisen K. [A systematic review of multifactorial interventions for primary prevention of delirium in the elderly]. *Tijdschrift voor gerontologie en geriatrie*. 2005; 36: 224-31

25. Siddiqi N, Stockdale R, Britton AM, Holmes J. Interventions for preventing delirium in hospitalised patients. *Cochrane Database Syst Rev*. 2007: CD005563.DOI:10.1002/14651858.CD005563.pub2.

26. Thomas E, Smith JE, Forrester DA, et al. The effectiveness of non-pharmacological multi-component interventions for the prevention of delirium in non-intensive care unit older adult hospitalized patients: a systematic review. *2014*. 2014; 12: 53 <!-- jbi edits -->.DOI:10.11124/jbisrir-2014-1446.

27. Zimberg M, Berenson S. Delirium in patients with cancer: nursing assessment and intervention. *Oncology nursing forum*. 1990; 17: 529-38

28. Wanich CK, Sullivan-Marx EM, Gottlieb GL, Johnson JC. Functional status outcomes of a nursing intervention in hospitalized elderly. *Image--the journal of nursing scholarship*. 1992; 24: 201-7

29. Morency CR. Mental status change in the elderly: recognizing and treating delirium. *Journal of professional nursing : official journal of the American Association of Colleges of Nursing*. 1990; 6: 356-64; discussion 64-5

30. Holt J. How to help confused patients. *The American journal of nursing*. 1993; 93: 32-6

31. Bleasdale S, George J. Managing delirium in elderly people. *Elderly care*. 1996; 8: 13-4

32. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

33. Lundstrom M, Olofsson B, Stenvall M, et al. Postoperative delirium in old patients with femoral neck fracture: a randomized intervention study. *Aging Clin Exp Res*. 2007; 19: 178-86

34. Watne LO, Torbergsen AC, Conroy S, et al. The effect of a pre- and postoperative orthogeriatric service on cognitive function in patients with hip fracture: randomized controlled trial (Oslo Orthogeriatric Trial). *BMC Med*. 2014; 12: 63.DOI:http://dx.doi.org/10.1186/1741-7015-12-63.

35. Bjorkelund KB, Hommel A, Thorngren KG, et al. Reducing delirium in elderly patients with hip fracture: a multi-factorial intervention study. *Acta Anaesthesiol Scand*. 2010; 54: 678-88.DOI:http://dx.doi.org/10.1111/j.1399-6576.2010.02232.x.

36. Wong DM, Niam T, Bruce JJ, Bruce DG. Quality project to prevent delirium after hip fracture. *Australas J Ageing*. 2005; 24: 174-7.DOI:http://dx.doi.org/10.1111/j.1741-6612.2005.00108.x.

37. Deschodt M, Braes T, Flamaing J, et al. Preventing delirium in older adults with recent hip fracture through multidisciplinary geriatric consultation. *J Am Geriatr Soc*. 2012; 60: 733-9.DOI:http://dx.doi.org/10.1111/j.1532-5415.2012.03899.x.

38. Milisen K, Foreman MD, Abraham IL, et al. A nurse-led interdisciplinary intervention program for delirium in elderly hip-fracture patients. *J Am Geriatr Soc*. 2001; 49: 523-32

39. Inouye SK, Wagner DR, Acampora D, et al. A controlled trial of a nursing-centered intervention in hospitalized elderly medical patients: the Yale Geriatric Care Program. *J Am Geriatr Soc*. 1993; 41: 1353-60

40. Lundstrom M, Edlund A, Lundstrom G, Gustafson Y. Reorganization of nursing and medical care to reduce the incidence of postoperative delirium and improve rehabilitation outcome in elderly patients treated for femoral neck fractures. *Scand J Caring Sci*. 1999; 13: 193-200

41. Holroyd-Leduc JM, Abelseth GA, Khandwala F, et al. A pragmatic study exploring the prevention of delirium among hospitalized older hip fracture patients: Applying evidence to routine clinical practice using clinical decision support. *Implement Sci*. 2010; 5: 1-6.DOI:10.1186/1748-5908-5-81.

42. Chesser T, Handley R, Swift C. New NICE guideline to improve outcomes for hip fracture patients. *Injury*. 2011; 42: 727-9

43. Chehade M, Taylor A. Australian and New Zealand Guideline for Hip Fracture Care-improving outcomes in hip fracture management of adults. 2014:

CHAPTER 5

"Just another piece of paperwork": perceptions of clinicians on delirium screening following hip fracture repair elicited in focus groups

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ABSTRACT

Background

Delirium is a complex clinical syndrome characterised by disturbed consciousness, cognitive function, or perception and associated with serious adverse outcomes such as death, dementia, and the need for long term care. However recognition and management of delirium is poorly prioritised even though it is the most frequent complication among patients undergoing surgery following hip fracture. The aim of this study was to understand clinicians' from orthopaedic speciality perceptions in relation to recognition, diagnosis and management of delirium.

Methods

This was a qualitative study using in-depth focus groups discussions with clinical staff of one orthopaedic unit within a level 1 trauma centre, south of Adelaide, South Australia.

Results

A total number of 17 individuals (14 Nurses, 1 Geriatric Registrar, 1 Nursing Manager and 1 Speech Therapist) participated in the focus groups. Four major themes were identified: 1. Delirium is important but can be hard to recognize and validate 2. Ambiguity on the use of delirium screening tool 3. Need of designated delirium care pathway 4. Vital role of family. Despite the initial lack of agreement on use of the objective tool to screen delirium, nurses did propose a number of ways that formal delirium screening could be included in routine nursing duties and existing nursing documentation.

Conclusion

Although orthopedic nurses aim to provide effective care to patients experiencing delirium symptoms following hip fracture, they are doing so in the absence of structured screening, assessment and multidisciplinary team approach. This study emphasizes the various barriers which need to be considered before attempting to change practice in this important area.

BACKGROUND

Delirium is a complex clinical syndrome characterised by disturbed consciousness, cognitive function, or perception. [50]Also, known as acute confusional state, delirium has an acute onset, a fluctuating course, and is associated with serious adverse outcomes such as death, dementia, and the need for long term care.[50] [51] Delirium is the most frequent complication among patients undergoing surgery following a hip fracture [6] [8] with research suggesting that 35% to 65% of patients who have undergone surgery for a hip fracture repair experience delirium post-operatively. [9] Although delirium is associated with poor clinical outcomes, delirium continues to be under-recognised by health service planners and clinicians. [21, 52] Due to the high incidence and relationship with worse outcomes, delirium prevention should be a high priority for clinicians. [14]

Healthcare professionals like doctors and nurses are adequately placed to take the lead in delirium screening and identification as their role requires them to provide 24- hour monitoring of patients to observe fluctuation in health status which is characteristic of delirium. [52, 53] Clinicians are effective in identifying patients under their care who are confused however the identification is almost always without the use of an objective assessment tool. Most clinicians would admit that delirium is under-diagnosed and screening is inadequate. [54] [55, 56]

A retrospective case note audit (n=200) was conducted to determine the frequency of delirium screening in the same orthopaedic unit of a level 1 trauma centre in Australia (unpublished data). The results of this audit demonstrated that less than 1% of patients with hip fracture received pre-operative cognitive assessment on admission. Overall, 48% of patients had evidence of behaviour change during the post-operative period however only 9% of patients received formal cognitive assessment using a validated tool in this period. Similar difficulties of persuading health care professionals to adhere to best practice guidelines have been shown by many studies. [57-60] An understanding of barriers and enablers to best practice is needed to develop implementation interventions to increase the uptake of evidence into practice. [61] Such interventions are more likely to be effective if they target the factors influencing practice change. [62] Objective early diagnosis of delirium is particularly important because multidisciplinary interventions have been shown to effectively prevent delirium in older adults. [34, 40, 63]

The aim of this study was to explore the views of clinicians' from the orthopaedic speciality in the acute care hospital in South Australia in relation to recognition, diagnosis and management of delirium and to explore reasons regarding why their practice was not consistent with best practice recommendations. This study provided rich information

using qualitative techniques which will be used to design a 'Delirium Observation through Treatment Engagement' (DOTE) program by targeting the identified barriers and facilitators with inclusion of relevant behaviour change techniques. [64]

METHODS

Design

This was a qualitative study using in-depth focus groups discussions. The study is reported in accordance with the COREQ guidelines.[65]

Participants and setting

Clinical staff (geriatric and orthopaedic doctors, nurses, and allied health) managing patients with hip fracture in an acute care setting within a level 1 trauma centre, south of Adelaide, South Australia were invited to participate in focus groups. The clinical pathway for patients admitted following hip fracture to the hospital was to present at the emergency department before being admitted to the 28 bed orthopaedic ward. The service admits 400 people per year with hip fracture.

Recruitment

Focus groups were advertised at lunchtime presentations and ward meetings/handovers by one of the researchers (TO). Invitations with four pre-set focus group dates were extended to staff and information sheets were displayed at nursing stations, staff lounges and on the bulletin board of the orthopaedic department. Focus group sessions were timetabled at the most convenient times for clinicians which was advised to be at handover times for nursing staff when both early and late shift staff were present. Focus group participants completed a written consent form.

Procedure

Focus groups were considered to be an appropriate methodology to efficiently and effectively address the research questions. Focus groups are used to give a voice to participants and allow them to express their opinion in a guided environment. [66] Hence they were used to stimulate the dialogue regarding the factors hindering and enabling achievement of recommended practice related to screening and managing delirium in hip fracture patients. We were seeking information regarding clinicians' perception of using

a screening tool, and enablers and barriers to providing individualised care to patients to prevent and manage delirium in their acute orthopaedic setting. Four focus groups were conducted by two researchers. At the conclusion of the four focus groups no new issues arose i.e. the point of 'saturation' had been reached. [67] Saturation is the point at which after a number of interviews has been performed, it is unlikely that performing further focus group discussions will reveal new information that hasn't emerged in a previous group discussion. One of the researchers with expertise in qualitative methodology took the lead whilst the other researcher concentrated on listening, asking clarifying questions and thinking about the questions that required further exploration. Each focus group lasted approx. 60 minutes.

Interview content

The focus group discussion guide (see additional file 1) consisted of two parts. The initial part included broad questions about delirium in hip fractures and how it's assessed/ recognised and prioritised within the workplace in question. The initial discussion lead to further exploration of the routine clinical practices in detail to gain insight into their reported behaviours and the factors which hindered or enabled achievement of the recommended clinical practice.

Analysis

Focus group discussions were audiotaped and transcribed verbatim by a professional transcription service SmartDocs Pty., Ltd©. Staff who participated in the focus group discussions were asked to review the transcripts to ensure any discrepancies were altered prior to analyses. Checked transcripts were imported into NVIVO 11(QSR International Pty Ltd, Australia) to manage the data and facilitate the analysis.

Data was analysed using an iterative process. Two researchers (TO and MK) independently coded the interview transcripts, first via open coding, followed by axial and then selective coding. The two researchers undertook a dynamic process of interpretation including attaching significance to what was found, offering explanations, attaching meanings, imposing order and dealing with relevant explanations (Patton 1990). They then compared and discussed their individual and combined results at length on several occasions, before deciding on the final labels or themes.

Ethics

This study was approved by Southern Adelaide Local Health Network Office of Research Ethics Committee- Project Number: SALHN HREA-133.17.

RESULTS

A total number of 17 individuals (14 Nurses, 1 Geriatric Registrar, 1 Nursing Manager and 1 Speech Therapist) participated in the focus groups. None of the registrars from the orthopaedic team participated in the focus group discussions. All of the interviewed clinicians reported that they routinely manage patients who have sustained a hip fracture with suspected delirium or cognitive impairment. Four major themes were identified regarding assessment and management of delirium in the acute care orthopaedic setting: 1. Delirium is important but can be hard to recognize and validate 2. Ambiguity on the use of delirium screening tool 3. Need of designated delirium care pathway 4. Vital role of family.

Delirium is important but can be hard to recognize and validate

Clinicians expressed their thoughts that delirium is something which you "commonly see" and is "high on the list of priorities" due to its association with "longer length of stay".

Nurses suggested that delirium can have dire effects on patients including resulting in them being malnourished and reducing their ability to engage in therapy.

"They're so delirious that they don't want to eat. And mobility as well is delayed. The physio can't get them to do exercise with them".

Nurses recognised delirium if it presented in a more tradionally recognised manner e.g. confused, argumentative, but tended to become uncertain of the validity of the symptoms when patients required high doses of pain relief and appeared overly drowsy or if they had come from high level care nursing home with diagnosed dementia. Nurses expressed that in instances of delirium in addition to dementia they often contacted the nursing home to enquire about the patient's baseline cognitive functioning.

"Sometimes it is easily recognised because they'll come back from theatre and they're hitting, punching, kicking, biting, thrashing around and that's just an obvious they're in a post-op delirium, but then sometimes they'll come back and they'll just be really sleepy and they're the ones that the delirium gets missed because people don't see it as a delirium, they just see they're sleeping, they're fine, they're not doing anything so no one worries about them".

Ambiguity on the use of delirium screening tool

Although participants acknowledged that delirium could be misdiagnosed, and was a "big deal" there still seemed to be a reluctance to utilise a specific screening tool as they were not convinced of the benefit. There were many reasons cited for not introducing and using another tool, in particular a delirium screening tool. The majority of clinicians reported they had currently all the knowledge, experience and skills and assessment forms to recognize and evaluate delirium. They were comfortable that their current forms reporting mood and their behaviors were sufficient to monitor delirium, and another form would be a duplication and of no further value.

"Truthfully, I think it's just another piece of paperwork really. It just adds to the pile of paperwork that we already don't get to".

A majority of nurses considered the existing nursing documentation which gets completed as part of routine nursing care as sufficient to monitor delirium.

"We've got half hourly revision charts which quite often we'll fill in for delirious patients and score them zero to four. And that's a really good indicator so I can discern if they're scoring twos or threes and they're unsociable. So, for me, I can look at that and go, well, yeah, that patient's delirium is settling or no it's not".

It was only when participants were pressed to consider any value in quantifying the condition and tracking the effect over time, that the interviewers received some affirmation that possibly there might be some value in utilizing the tool. However lack of time was considered to be a pressing factor which still made the screening tool a "non-priority".

"Although the paperwork's all very important, patient care, as nurses, is our number one role. I need to get on the floor and look at my patient's first instead of wasting an hour sitting down and doing forms".

Some nurses suggested that use of formal screening tools may be useful for junior, more inexperienced staff rather than those experienced staff who felt confident in their abilities.

In addition, a number of nurses considered the tool did not consider specific enough questions to diagnose delirium.

"I don't think those questions specifically give you the diagnosis of delirium, it's just a bunch of questions that you ask and then what do you do with the answer"?

"It's just too standard. Delirium isn't standard with everybody. Someone can have a perfect 4AT but be totally off their tree".

Not only did they not consider the tool valid, but they also felt undertaking the screening once a patient clearly had developed delirium was a waste of time. Nurses expressed that most patients already have delirium when they arrive to the orthopaedic unit so there is no use completing it.

Need of designated delirium care pathway

The participants of all the focus groups expressed the need for a designated delirium care pathway if they were to spend time completing the assessment form. If they were being asked to prioritise delirium assessment and management, they reported the need to set up a process that would utilize the information. Firstly, clinicians requested more clarity about roles and responsibility of doctors involved in the care of the hip fracture patients and development of local clinical guidelines as a priority. The nurses indicated that not having an action plan to follow leads to uncertainty of care. Nurses believed that they spend a lot more time with the patients compared to other healthcare professionals and this lead to nurses having more insight on patients' symptoms of delirium. They felt it was important that there was a process in place where any quantified delirium assessments they completed were available to all team members and there being a clear action pathway in place.

"There's nothing worse than getting all these scores and all these things that you know are right and tell the doctor and they just, "Oh yeah, we'll look at it later" and no one comes back, no one follows it up and that's frustrating and it makes you think why am I bothering".

Nurses agreed that tracking the quantitative score of delirium on a graph (as with other observations e.g. temperature, blood pressure) could be useful in monitoring the delirium symptoms. It was also felt that this could make documentation more user-friendly as the clinicians would be able to see the patients delirium score without having to look through a whole set of patient notes.

Although participants were initially reluctant to incorporate the delirium screening tool at all, once they had discussed and agreed on the value of the tool, they identified the need

for multiple assessments each day to accommodate the issues of fluctuating cognitive states common in delirium. The suggestion was put forward by a number of participants and consensus reached at each focus group that the screening tool should be completed once each shift to monitor the fluctuation over 24-hour period.

"If there was a table on the back on the form then you might be able to compare it to the day before and I guess you're not blind then to what's happened before and then it becomes perhaps more meaningful".

In addition, a senior nurse suggested that setting up a pathway for two groups might be helpful: delirium on a background of dementia and patients with post-operative delirium who do not normally have impaired cognitive function. This idea gained support from the other participants of the focus group.

Vital Role of Family

The clinicians agreed that family plays a vital role in recognizing delirium and confirming their relative's baseline cognition status especially for the patients with hypoactive delirium which is dominated by symptoms of drowsiness and inactivity. [68]

"This isn't mum and dad, they're not normally like this. So it just depends a lot on the family input for the very quiet ones, but the other ones it's just obvious, they come back and they're combative right off.

Nurses expressed that delirium can be quite concerning for the families due to lack of families awareness on delirium related symptoms. All the participants agreed that providing the family information on delirium would assist them in knowing what to expect and how to support their relative. Most participants agreed that information could be provided in the form of a written pamphlet or by video on the patient bedside screen monitor.

" I suppose we can give that handout, the family awareness handout maybe on day zero to the family because we don't need to wait for delirium to happen so actually they can see and say you know what, I'm going to brings mum's glasses tomorrow" or their hearing aids or favourite book or their blanket".

DISCUSSION

This qualitative study provides insight into multiple factors impacting on why clinical staff, particularly orthopaedic nurses working with patients following hip fracture repair, do not routinely choose to screen for delirium using a validated tool.

Nurses expressed that they can easily identify patients experiencing hyperactive delirium by symptomology such as agitation, verbal and physical outbursts. They recognised more difficulty in identifying hypoactive delirium states such as lethargy and loss of appetite. This finding is consistent with earlier studies highlighting the difficulty of recognising hypoactive delirium in hospitalised older patients. [69, 70] Difficulty in recognising delirium related symptoms on a background of dementia or existing cognitive impairment was reported in this present study and is supported by other studies. [47, 69]

Most nurses expressed that using an objective screening tool to recognise delirium would not add any value as nurses already assess or observe patients while undertaking daily care tasks such as showering, giving medications and measurement of vital signs. However, in contrast to their perceptions, it has been reported in other studies that effective recognition and assessment of delirium cannot be solely achieved though clinicians' bedside interaction with patients.[71] . Participants in this current study also believed that they and their colleagues possess sufficient knowledge and experience to identify at-risk delirious patients so completing another piece of documentation would serve no purpose. This is similar to the findings from other studies.[72]

In addition it is likely that nurses are unable to provide effective description of patients' delirium to others without completing a comprehensive delirium assessment. This may explain why some nurses in our study reported frustration and lack of response from doctors to their observation of delirium symptoms. Nurses in many other studies have reported feeling dismissed or ignored when reporting delirium symptoms to medical specialists.[73, 74] This then forms a barrier to effective multidisciplinary team approaches to timely recognition and engagement in prevention strategies. Timely multidisciplinary care formed the basis of the treatment planning for many studies where investigators were able to successfully reduce incidence of delirium. [34, 35, 40] To overcome the barrier of not being heard by doctors nurses suggested that a clear action plan or delirium care pathway might be a way forward.

Several studies on known barriers to clinicians' recognition of delirium across various healthcare settings have identified obstacles including insufficient knowledge, lack of understanding of their role [72], perceptions of not being heard when communicating

delirium symptoms [73] and absence of structured delirium screening and assessment processes.[75] [72, 76] Addressing each of these barriers is required to optimise delirium care practices within orthopaedic speciality. Following in-depth discussion in each focus group in this current study, despite their earlier reservations, most of the participants agreed that education regarding these barriers would be beneficial. The uniqueness of this study is that despite the initial lack of agreement on use of the objective tool to screen delirium, nurses did propose a number of methods to integrate the formal screening tool into practice and nursing documentation, which they felt was essential for implementation. It was after lengthy debate and discussion was facilitated within the focus groups by the experienced interviewer that staff began to verbalize the value of collecting and tracking quantitative data to inform patient's delirium status. Discussion concerning delirium management was positive with nurses keen to engage in any strategies which could potentially prevent incidence of delirium such as use of clocks and calendars to orientate patients. The valuable role of engaging family to obtain insight into patients' pre-injury status and seeking their support to prevent delirium was also recognised. Nurses described that educating the family through handout or a video on delirium might reduce fears family members have about their loved ones health as well as increase their awareness on various ways in which family can assist in preventing delirium.

In the recent years our understanding of delirium has increased vastly from the basic neuropathological descriptors through screening and diagnosis to treatment. The papers cover a range of areas including the frequency of delirium in a primary care and hospital setting, detection, diagnosis and impact of cognitive impairment among inpatients, understanding delirium trajectory, recognition and management of delirium among multidisciplinary team and the effectiveness of multicomponent interventions for preventing delirium in older hip fracture patients. These studies illustrated that delirium is primarily a hospital based phenomenon yet it's under-recognised, its negative impact on patient outcomes and role of multicomponent interventions in delirium prevention in at-risk hospitalised older adults. [77-79] Suh et al. emphasized the importance of recognising delirium and providing timely interventions which can delay cognitive decline as well as eliminate distress and disability.[80] G Bellelli et al. concluded that there are underlying gaps between the clinical guidelines and actual clinical practices which need to be addressed in future research so that changes in practice can be initiated.[81]

Our paper extends the results of existing studies as involving nurses in the discussion illuminates some of the common barriers identified by others in clinical practice settings across the globe. All the previous literature shows importance of screening yet poor adherence by clinicians. Engaging with clinicians systematically to understand their perceptions is vital to address this common and complex syndrome. Adding to the

existing body of literature is essential, especially when recommendations come from those in-charge for identification, prevention and management of delirium.

Limitations

The use of focus groups in this small study allowed for open conversation related to assessment and management of delirium in hospitalised older patients with hip fractures. But there were some limitations. First of all, although the invitation to participate in the focus group discussions was extended to all clinicians working in orthopaedic ward the majority of the participants in the focus groups were nurses. This study would have benefitted from a wider participation of health professionals. This was a single site study conducted in an orthopaedic unit of a metropolitan hospital. In addition as a qualitative study conducted in one country only, the findings might not be generalised to other settings. However, similar findings in other studies from many different countries have been documented in literature and increases the generalizability of this work and so potentially our findings can be transferred with caution, to other healthcare settings.

Future perspective

The results of the current qualitative study will be used to implement the Delirium Observation through Treatment Engagement (DOTE) program by targeting the identified barriers and facilitators with inclusion of relevant behaviour change techniques. A description of the development and content of the DOTE program and the subsequent knowledge translation study will be reported separately.

Conclusion

The lack of participation of orthopedic surgeons, geriatricians and allied health in this study suggests that delirium is perceived as a nursing issue. The findings of this study suggest that although orthopedic nurses are aiming to provide effective care to patients with hip fracture experiencing delirium symptoms, they are doing so with limited delirium knowledge and in the absence of structured screening, assessment and multidisciplinary team approach. Given the high incidence of delirium within patients with hip fracture, this study further emphasizes the various barriers which need to be addressed before attempting to facilitate a change of practice. The nurses in this study made numerous valuable suggestions on integrating delirium screening and preventive

strategies into routine nursing care as well as developing a delirium care pathway to engage multidisciplinary team members to optimize treatment for these patients.

REFERENCES

1. Magaziner J, Hawkes W, Hebel JR, et al. Recovery from hip fracture in eight areas of function. J Gerontol A Biol Sci Med Sci. 2000; 55: M498-507.DOI:10.1093/gerona/55.9.m498.

2. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. *Ageing Res Rev.* 2003; 2: 57-93

3. Hirsch CH, Sommers L, Olsen A, et al. The natural history of functional morbidity in hospitalized older patients. *Journal of the American Geriatrics Society.* 1990; 38: 1296-303

4. Rae HC, Harris IA, McEvoy L, Todorova T. Delay to surgery and mortality after hip fracture. *ANZ J Surg*. 2007; 77: 889-91.DOI:10.1111/j.1445-2197.2007.04267.x.

5. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? *The Journal of bone and joint surgery American volume.* 2005; 87: 483-9.DOI:10.2106/JBJS.D.01796.

6. Gustafson Y, Berggren D, Brannstrom B, et al. Acute confusional states in elderly patients treated for femoral neck fracture. *J Am Geriatr Soc*. 1988; 36: 525-30

7. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. *Arch Intern Med*. 2000; 160: 1856-60.DOI:10.1001/archinte.160.12.1856.

8. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *Journal of the American Geriatrics Society.* 2001; 49: 1335-40

9. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

10. Cole MG. Delirium in elderly patients. *Am J Geriatr Psychiatry.* 2004; 12: 7-21

11. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. *JAMA*. 1990; 263: 1097-101

12. McCusker J, Cole M, Dendukuri N, et al. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. *CMAJ.* 2001; 165: 575-83

13. Rockwood K, Cosway S, Carver D, et al. The risk of dementia and death after delirium. *Age Ageing*. 1999; 28: 551-6

14. Harris DP, Chodosh J, Vassar SD, et al. Primary care providers' views of challenges and rewards of dementia care relative to other conditions. *J Am Geriatr Soc*. 2009; 57: 2209-16.DOI:10.1111/j.1532-5415.2009.02572.x.

15. Hernlund E, Svedbom A, Ivergard M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos*. 2013; 8: 136.DOI:10.1007/s11657-013-0136-1.

16. Leal J, Gray AM, Prieto-Alhambra D, et al. Impact of hip fracture on hospital care costs: a population-based study. *Osteoporos Int*. 2016; 27: 549-58.DOI:10.1007/s00198-015-3277-9.

17. Liu S, Zhu Y, Chen W, et al. Risk factors for the second contralateral hip fracture in elderly patients: a systematic review and meta-analysis. *Clinical rehabilitation*. 2015; 29: 285-94. DOI:10.1177/0269215514542358.

18. Svensson O, Stromberg L, Ohlen G, Lindgren U. Prediction of the outcome after hip fracture in elderly patients. *The Journal of bone and joint surgery British volume*. 1996; 78: 115-8

19. Marcantonio ER. In the clinic. Delirium. *Annals of internal medicine*. 2011; 154: ITC6-1, ITC6-2, ITC6-3, ITC6-4, ITC6-5, ITC6-, ITC-7, ITC6-8, ITC6-9, ITC6-10, ITC6-1, ITC6-2, ITC6-3, ITC6-4, ITC6-5; quiz ITC6-6.DOI:10.7326/0003-4819-154-11-201106070-01006.

20. Yang Y, Zhao X, Dong T, et al. Risk factors for postoperative delirium following hip fracture repair in elderly patients: a systematic review and meta-analysis. *Aging Clinical and Experimental Research*. 2017; 29: 115-26.DOI:10.1007/s40520-016-0541-6.

21. Inouye SK, Schlesinger MJ, Lydon TJ. Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. *Am J Med*. 1999; 106: 565-73

22. Kalisvaart KJ, de Jonghe JF, Bogaards MJ, et al. Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study. *Journal of the American Geriatrics Society*. 2005; 53: 1658-66.DOI:10.1111/j.1532-5415.2005.53503.x.

23. Overshott R, Karim S, Burns A. Cholinesterase inhibitors for delirium. *The Cochrane database of systematic reviews*. 2008: CD005317.DOI:10.1002/14651858.CD005317.pub2.

24. de Jonghe A, van Munster BC, Goslings JC, et al. Effect of melatonin on incidence of delirium among patients with hip fracture: a multicentre, double-blind randomized controlled trial. *CMAJ*. 2014; 186: E547-56.DOI:10.1503/cmaj.140495.

25. Bjorkelund KB, Hommel A, Thorngren KG, et al. Reducing delirium in elderly patients with hip fracture: a multi-factorial intervention study. *Acta anaesthesiologica Scandinavica*. 2010; 54: 678-88.DOI:10.1111/j.1399-6576.2010.02232.x.

26. Kalisvaart CJ, Vreeswijk R, de Jonghe JF, Milisen K. [A systematic review of multifactorial interventions for primary prevention of delirium in the elderly]. *Tijdschrift voor gerontologie en geriatrie*. 2005; 36: 224-31

27. Siddiqi N, Stockdale R, Britton AM, Holmes J. Interventions for preventing delirium in hospitalised patients. *The Cochrane database of systematic reviews*. 2007: CD005563.DOI:10.1002/14651858.CD005563.pub2.

28. Thomas E, Smith JE, Forrester DA, et al. The effectiveness of non-pharmacological multi-component interventions for the prevention of delirium in non-intensive care unit older adult hospitalized patients: a systematic review. *2014*. 2014; 12: 53 <!-- jbi edits -->.DOI:10.11124/jbisrir-2014-1446.

29. Zimberg M, Berenson S. Delirium in patients with cancer: nursing assessment and intervention. *Oncology nursing forum*. 1990; 17: 529-38

30. Wanich CK, Sullivan-Marx EM, Gottlieb GL, Johnson JC. Functional status outcomes of a nursing intervention in hospitalized elderly. *Image--the journal of nursing scholarship*. 1992; 24: 201-7

31. Morency CR. Mental status change in the elderly: recognizing and treating delirium. *Journal of professional nursing : official journal of the American Association of Colleges of Nursing*. 1990; 6: 356-64; discussion 64-5

32. Holt J. How to help confused patients. *The American journal of nursing*. 1993; 93: 32-6

33. Bleasdale S, George J. Managing delirium in elderly people. *Elderly care*. 1996; 8: 13-4

34. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

35. Lundstrom M, Olofsson B, Stenvall M, et al. Postoperative delirium in old patients with femoral neck fracture: a randomized intervention study. *Aging Clin Exp Res*. 2007; 19: 178-86

36. Watne LO, Torbergsen AC, Conroy S, et al. The effect of a pre- and postoperative orthogeriatric service on cognitive function in patients with hip fracture: randomized controlled trial (Oslo Orthogeriatric Trial). *BMC Med*. 2014; 12: 63.DOI:http://dx.doi.org/10.1186/1741-7015-12-63.

37. Bjorkelund KB, Hommel A, Thorngren KG, et al. Reducing delirium in elderly patients with hip fracture: a multi-factorial intervention study. *Acta Anaesthesiol Scand*. 2010; 54: 678-88.DOI:http://dx.doi.org/10.1111/j.1399-6576.2010.02232.x.

38. Wong DM, Niam T, Bruce JJ, Bruce DG. Quality project to prevent delirium after hip fracture. *Australas J Ageing*. 2005; 24: 174-7.DOI:http://dx.doi.org/10.1111/j.1741-6612.2005.00108.x.

39. Deschodt M, Braes T, Flamaing J, et al. Preventing delirium in older adults with recent hip fracture through multidisciplinary geriatric consultation. *J Am Geriatr Soc*. 2012; 60: 733-9.DOI:http://dx.doi.org/10.1111/j.1532-5415.2012.03899.x.

40. Milisen K, Foreman MD, Abraham IL, et al. A nurse-led interdisciplinary intervention program for delirium in elderly hip-fracture patients. *J Am Geriatr Soc*. 2001; 49: 523-32

41. Inouye SK, Wagner DR, Acampora D, et al. A controlled trial of a nursing-centered intervention in hospitalized elderly medical patients: the Yale Geriatric Care Program. *J Am Geriatr Soc*. 1993; 41: 1353-60

42. Lundstrom M, Edlund A, Lundstrom G, Gustafson Y. Reorganization of nursing and medical care to reduce the incidence of postoperative delirium and improve rehabilitation outcome in elderly patients treated for femoral neck fractures. *Scand J Caring Sci*. 1999; 13: 193-200

43. Holroyd-Leduc JM, Abelseth GA, Khandwala F, et al. A pragmatic study exploring the prevention of delirium among hospitalized older hip fracture patients: Applying evidence to routine clinical practice using clinical decision support. *Implement Sci*. 2010; 5: 1-6.DOI:10.1186/1748-5908-5-81.

44. Chesser T, Handley R, Swift C. New NICE guideline to improve outcomes for hip fracture patients. *Injury*. 2011; 42: 727-9

45. Chehade M, Taylor A. Australian and New Zealand Guideline for Hip Fracture Care-improving outcomes in hip fracture management of adults. 2014:

46. Fick D, Foreman M. Consequences of not recognizing delirium superimposed on dementia in hospitalized elderly individuals. *J Gerontol Nurs*. 2000; 26: 30-40

47. Fick DM, Agostini JV, Inouye SK. Delirium superimposed on dementia: a systematic review. *J Am Geriatr Soc*. 2002; 50: 1723-32

48. Lerner AJ, Hedera P, Koss E, et al. Delirium in Alzheimer disease. *Alzheimer Dis Assoc Disord*. 1997; 11: 16-20

49. Eikelenboom P, Hoogendijk WJ. Do delirium and Alzheimer's dementia share specific pathogenetic mechanisms? *Dement Geriatr Cogn Disord*. 1999; 10: 319-24.DOI:10.1159/000017162.

50. Young J, Murthy L, Westby M, et al. Diagnosis, prevention, and management of delirium: summary of NICE guidance. *BMJ*. 2010; 341.DOI:10.1136/bmj.c3704.

51. Witlox J, Eurelings LM, de Jonghe JM, et al. Delirium in elderly patients and the risk of postdischarge mortality, institutionalization, and dementia: A meta-analysis. *Jama*. 2010; 304: 443-51. DOI:10.1001/jama.2010.1013.

52. Irving K, Fick D, Foreman M. Delirium: a new appraisal of an old problem. *Int J Older People Nurs*. 2006; 1: 106-12.DOI:10.1111/j.1748-3743.2006.00017.x.

53. Rice KL, Bennett M, Gomez M, et al. Nurses' recognition of delirium in the hospitalized older adult. *Clin Nurse Spec*. 2011; 25: 299-311.DOI:10.1097/NUR.0b013e318234897b.

54. Ely EW, Stephens RK, Jackson JC, et al. Current opinions regarding the importance, diagnosis, and management of delirium in the intensive care unit: A survey of 912 healthcare professionals*. *Critical Care Medicine*. 2004; 32: 106-12.DOI:10.1097/01.ccm.0000098033.94737.84.

55. Hare M, Wynaden D, McGowan S, et al. A questionnaire to determine nurses' knowledge of delirium and its risk factors. *Contemp Nurse*. 2008; 29: 23-31

56. Steis MR, Fick DM. Delirium superimposed on dementia: accuracy of nurse documentation. *J Gerontol Nurs*. 2012; 38: 32-42.DOI:10.3928/00989134-20110706-01.

57. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *Jama*. 1999; 282: 1458-65

58. Davison TE, Snowdon J, Castle N, et al. An evaluation of a national program to implement the Cornell Scale for Depression in Dementia into routine practice in aged care facilities. *Int Psychogeriatr*. 2012; 24: 631-41.DOI:10.1017/S1041610211002146.

59. Buchan H, Sewell JR, Sweet M. Translating evidence into practice. *Med J Aust*. 2004; 180: S43

60. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet*. 2003; 362: 1225-30.DOI:10.1016/S0140-6736(03)14546-1.

61. Francke AL, Smit MC, de Veer AJ, Mistiaen P. Factors influencing the implementation of clinical guidelines for health care professionals: A systematic meta-review. *BMC Medical Informatics and Decision Making*. 2008; 8: 38.DOI:10.1186/1472-6947-8-38.

62. Baker R, Camosso-Stefinovic J, Gillies C, et al. Tailored interventions to overcome identified barriers to change: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev*. 2010: CD005470.DOI:10.1002/14651858.CD005470.pub2.

63. Inouye SK, Bogardus ST, Jr., Baker DI, et al. The Hospital Elder Life Program: a model of care to prevent cognitive and functional decline in older hospitalized patients. Hospital Elder Life Program. *J Am Geriatr Soc*. 2000; 48: 1697-706

64. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011; 6: 42

65. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007; 19: 349-57.DOI:10.1093/intqhc/mzm042.

66. Morgan DL, Krueger RA, King JA. *The focus group kit, Vols. 1–6*. Thousand Oaks, CA, US: Sage Publications, Inc; 1998.

67. Charmaz K, Belgrave L. Qualitative interviewing and grounded theory analysis. *The SAGE handbook of interview research: The complexity of the craft*. 2012; 2: 347-65

68. Hosker C, Ward D. Hypoactive delirium. *BMJ*. 2017; 357.DOI:10.1136/bmj.j2047.

69. Fick DM, Hodo DM, Lawrence F, Inouye SK. Recognizing delirium superimposed on dementia: assessing nurses' knowledge using case vignettes. *J Gerontol Nurs*. 2007; 33: 40-7; quiz 8-9. DOI:10.3928/00989134-20070201-09.

70. Flagg B, Cox L, McDowell S, et al. Nursing identification of delirium. *Clin Nurse Spec*. 2010; 24: 260-6. DOI:10.1097/NUR.0b013e3181ee5f95.

71. Mistarz R, Eliott S, Whitfield A, Ernest D. Bedside nurse-patient interactions do not reliably detect delirium: an observational study. *Aust Crit Care*. 2011; 24: 126-32.DOI:10.1016/j.aucc.2011.01.002.

72. van de Steeg L, Langelaan M, Ijkema R, et al. Improving delirium care for hospitalized older patients. A qualitative study identifying barriers to guideline adherence. *J Eval Clin Pract*. 2014; 20: 813-9. DOI:10.1111/jep.12229.

73. Kjorven M, Rush K, Hole R. A discursive exploration of the practices that shape and discipline nurses' responses to postoperative delirium. *Nurs Inq*. 2011; 18: 325-35.DOI:10.1111/j.1440-1800.2011.00534.x.

74. Al-Qadheeb NS, Hoffmeister J, Roberts R, et al. Perceptions of nurses and physicians of their communication at night about intensive care patients' pain, agitation, and delirium. *Am J Crit Care*. 2013; 22: e49-61.DOI:10.4037/ajcc2013565.

75. Steis MR, Fick DM. Are nurses recognizing delirium? A systematic review. *J Gerontol Nurs*. 2008; 34: 40-8

76. Yevchak A, Steis M, Diehl T, et al. Managing delirium in the acute care setting: a pilot focus group study. *Int J Older People Nurs*. 2012; 7: 152-62.DOI:10.1111/j.1748-3743.2012.00324.x.

77. Bohlken J, Kostev K. Prevalence and risk factors for delirium diagnosis in patients followed in general practices in Germany. *Int Psychogeriatr*. 2018; 30: 511-8.DOI:10.1017/S1041610217002587.

78. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. *Int Psychogeriatr*. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

79. Power C, Duffy R, Bates H, et al. The detection, diagnosis, and impact of cognitive impairment among inpatients aged 65 years and over in an Irish general hospital - a prospective observational study. *Int Psychogeriatr*. 2017; 29: 1879-88.DOI:10.1017/S1041610217001326.

80. Suh GH, Gega L. Understanding delirium trajectory and its importance in care provision for older people. *Int Psychogeriatr*. 2017; 29: 9-10.DOI:10.1017/S1041610216001988.

81. Bellelli G, Morandi A, Zanetti E, et al. Recognition and management of delirium among doctors, nurses, physiotherapists, and psychologists: an Italian survey. *Int Psychogeriatr*. 2014; 26: 2093-102.DOI:10.1017/S1041610214001653.

CHAPTER 6

A comparison of delirium care practices in hospitalised older hip fracture patients in Australia and Netherlands: what can we learn?

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ABSTRACT

Background

Despite the guidelines giving recommendations to clinicians on early detection, prevention and management of delirium the actual practices in the various clinical settings across the globe can be vastly different. The aim of this study is to evaluate three components of delirium care guidelines as performed in day to day practice comparing an orthopaedic trauma unit in Australia with one in the Netherlands.

Methods

Data were collected using direct observation. The same independent researcher observed registered nurses caring for patients with hip fractures on the orthopedic ward over a one-week period each in two medical centres one in Australia and the other in the Netherlands. The researcher made note of the environmental setup, routine nursing practices whilst undertaking normal care and responsibilities and `family engagement allowed in the care of older hip fracture patients. Descriptive analysis summarized the data and comparisons were made between the two medical centres.

Results

Even though the delirium prevention and management guidelines in Australia and Netherlands follow the same principles of person-centred care, the actual clinical practices carried out in the two hospitals were different. Vast differences in environmental set-up, nursing practices as well as family engagement were observed in between the orthopaedic units.

Conclusion

Practice guidelines developed in isolation without promoting the initiatives of patient-centred care, family engagement and ongoing rigorous evaluation are more likely to be unsuccessful. The healthcare institutions should take into consideration how a system of constant rigorous evaluation and consequences for non- compliance is set-up for effective translation of guidelines.

BACKGROUND

Delirium is a complex clinical syndrome characterized by disturbed consciousness, attention, cognitive function or perception, which usually develops over hours to a few days [1]. Development of delirium during the hospital stay results in a range of poor outcomes including; longer stay in hospital, higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge [2-4]. While delirium can occur in patients of any age, older patients with cognitive impairment, dementia, severe medical illness or a hip fracture are considered those at greatest risk during a hospital admission [1]. Rates of delirium vary according to the different healthcare settings, with the incidence ranging from 35% to 65% following hip surgery [5-8]. In Australia alone,there were an estimated 132 595 occurrences of delirium in 2016–2017, and more than 900 deaths were attributed to delirium in 2016–2017. Delirium causes an estimated 10.6% of dementia in Australia. The total costs of delirium in Australia were estimated to be $A8.8 billion (£4.3 billion) in 2016–2017, ranging between $A5.3 billion (£2.6 billion) and $A12.1 billion (£5.9 billion). [9]

Early engagement of multidisciplinary staff, including geriatricians, who address the risk factors of delirium as soon as the patient presents to the acute care environment is a key element of a successful delirium prevention program [10] Various best practice guidelines provide healthcare professionals in the acute care setting with a set of evidence based recommendations regarding the optimal care of older adults with delirium [11-13]. Both the Australian Delirium Clinical Care Standard [13] and the Dutch Guidelines for Diagnosis and Treatment of Delirium [12] are adapted from the guideline of the National Institute of Clinical Excellence (NICE), published in 2010 [1] and focus on screening and non-pharmaceutical prevention and treatment. The aim of clinical practice guidelines is to assist clinicians in determining the appropriate course of action for a given medical condition.[14] The use of clinical practice guidelines promotes the standardization of medical practice in-line with the principles of evidence based medicine. [15]

Despite the guidelines giving recommendations to clinicians on early detection, prevention and management of delirium the actual practices in the various clinical settings across the globe remain can be vastly different and delirium continues to be under-recognised [16, 17]. In this study we focused on environmental setups, routine nursing practices and family engagement in hospitalised older hip fracture patients with delirium. We specifically chose these components of delirium care as several studies reporting on prevention of delirium indicated these were critical factors to address [8, 18-20]. The aim of this study is to evaluate three components of delirium care guidelines as performed in

day to day practice comparing an orthopaedic trauma unit in Australia (Aus) with one in the Netherlands (NL).

METHODS

Study design

Data were collected using a direct observation method. Direct observation was identified as the most appropriate method as it allows for the regular nursing practices to be observed first hand, without potential changes to normal responsibilities and setting. It allows the researcher to see how participants work within their usual environment. [21] Observation has been referred to as gold standard [22] and is a systematic approach to data collection, whereby the researcher gathers information by seeing what people actually do, rather than what they report they do. [21]

Participants, setting and procedure

The same independent researcher observed practices for patients with hip fractures on the orthopedic ward over a one-week period each in two medical centers one in Australia (Adelaide, South Australia) and the other in the Netherlands (Breda).

We chose to compare the practices in the Netherlands and Australia as both countries follow national delirium care guidelines that are based on the NICE guidelines. There is an existing close relationship between the orthopaedic units chosen for these observations, with regular exchange of clinical and research fellows. The chosen clinical units are also very comparable in their surgical management of patients with hip fracture. Both units treat approx. 350 to 400 hip fracture patients per year and the average age of hip fracture patients in both units is approximately 84 years. The hip fracture management in both countries is driven by national guidelines built on similar quality indicators. [23, 24] Hence the practices of the chosen clinical units are representative of practices in both countries.

In the Netherlands ethics approval was not required as observational research is exempt. In Australia, ethics approval had been granted by the local ethics committee as part of a larger project on delirium.

Nurse unit managers from both settings helped identify registered nurses and informed them of the observations. The nurse unit managers also assisted with identification of the patients with hip fractures on the days of the scheduled observation. The observer had

permission from the nurse unit managers to enter the setting on predetermined dates and times to perform the observations. The observations were made for the duration of 7 days each in both the hospitals.

The researcher made note of the environmental setup, routine nursing practices whilst undertaking normal care and responsibilities and `family engagement allowed in the care of older hip fracture patients **(Table 1).** Descriptive analysis was used to describe and summarize the data so that direct comparison between the two medical centres could be made.

RESULTS

Even though the delirium prevention and management guidelines in Australia and Netherlands follow the same principles of person-centred care, the actual clinical practices carried out in the two hospitals were different (**Table 2**)

Environmental set-up

Things present in all patient rooms in Netherlands but in no rooms in Australia included: clocks and calendars; an orientation board with date and nurse in-charge.

Nursing practices

Significant differences were observed in the nursing practices of Netherlands and Australia.

Regular completion of delirium screening tool- DOS (3x per day) was part of everyday clinical practice in Netherlands.[25] This was observed by assessing the electronic patient records for the duration of 7 days. Patients' were dressed up in their own clothes and were assisted to sit in a chair before breakfast. Patients' sensory needs were optimised with glasses, hearing aids and dentures. Hydration and nutrition assistance was provided either by nurses/care-givers or hospital volunteers.

On the orthopaedic ward in Australia paper notes were used and the nurses had access to the 4AT as an early recognition screening tool for delirium. [26] However, the recognition of delirium using a validated screening tool was inconsistent. The nursing practices to optimise the patient's sensory, hydration and nutritional needs were not systematically

followed. Nurses provided assistance on an adhoc basis according to perceived patient needs.

Family engagement

The Dutch hospital had a structured system to engage patient's family and care-givers. Families were provided with verbal and written information on delirium. Extended visitation was allowed and family could stay overnight. The Family was provided with free car parking and there was provision for family to eat meals provided by the hospital.

In the Australian hospital, nurses provided verbal information regarding delirium when prompted by the family. Family could only visit during prescribed hospital visiting hours (14:00 to 20:30 hours). Parking and food were not provided.

DISCUSSION

Implementation of the delirium prevention and management guideline in the Australian hospital was observed to be variable while the level of adherence to this policy in the Dutch hospital was high. Despite using the same guidelines, clinical practices in the two medical centres were found to differ. In the Netherlands, clinical practices which promote early recognition and prevention of delirium were noted to be embedded into the routine nursing and medical care. In addition, they were embedded in a patient centred approach which focused on including families as much as possible. The Dutch Guidelines on Delirium place an emphasis on placing delirium care within routine hospital care but the observations suggested that the patient centred focus was a key facilitator of adherence. [12]

The Australian Delirium care guidelines also place importance on early recognition and prevention however; the actual practice in the Australian medical centre was noted to differ from the guidelines. The observations suggested that nurses did not prioritise screening older patients for delirium and there was reduced family presence on the wards (less often, for shorter periods and a lower level of partnership between the nurses and families). While it is difficult to know how this is linked, higher levels of patient centred care are associated with better clinical outcomes and quality of care. [27, 28].

Variations between in practice and guidelines have been discussed in the literature since the late eighties. Brennan and colleagues precisely concluded in their thematic review

health care decision makers operate in systems that are oversupplied with guidelines. Managers do not require a checklist of their pros and cons, because the destiny of guidelines depends on their reception rather than their production. They do need decision support on how to engineer and reengineer guidelines so they merge with evolving systems of health care delivery. [29] A key study in the US proposed that unless there are incentives or removal of disincentives, guidelines for practice may not effect a change in actual practice. [30] Grimshaw et al. recommended that guidelines may not effect change in actual practice and or may produce change in clinical practice only when accompanied with rigorous evaluations. [31] It was evident through direct observations in the Dutch hospital that not only the electronic patient medical records system prompted the clinicians to complete relevant documentation in timely manner and also red-flagged non-adherence to senior staff which promoted the rigorous evaluation of the system.

Limitations

This study has several limitations. Like in any observational study, there was a potential for observer bias, and staff or patient behaviour may have been altered by the observers' presence. Potential for observer bias was considered, with the observer adopting an open and honest approach, maintaining confidentiality and privacy both in the setting and in field notes. The observer was conscious and mindful not to impose personal thoughts or assumptions while collecting and analysing data. [32-34] Two further potential limitations, associated with all observational work, are social desirability and observer effect. Social desirability occurs when participants respond in conversations, or their behaviour is influenced during the observation period, to ensure they or their performance is viewed favourably by the observer [35]The observer effect transpires when the presence of the observer influences behaviours or activities of participants. This observer effect can be decreased with the development of close relationships with participants and ensuring data are analysed "in light of the context in which they were generated". [36] In this study, these limitations were minimised by ensuring that observations were passive, focused on the components of data collection sheet and limiting interaction between observer and nurses.

Conclusion

In conclusion, practice guidelines developed in isolation without creating the local system level change which promotes patient-centred care, family engagement and ongoing rigorous evaluation are more likely to be unsuccessful. The healthcare institutions should

take into consideration how a system of constant rigorous evaluation and consequences for non- compliance is set-up for effective translation of guidelines.

Table 1: Data to be collected

Module	Intervention
Environmental setup	clock calendar orientation board, bed next to window
Nursing practice	Regular delirium screening using objective tool Regular Orientation conversation Improve sensory input Glasses Hearing aid Dentures Hydration and nutrition assistance
Family engagement	Delirium information provided- which modality- leaflet, verbal, digital Extended visitation allowed by family Provision of family to stay overnight

Table 2: Summary of observations

Institute	Clock	Calendar	Orientation board	Regular Screening tool	Prompt Orientation conversation	Glasses	Hearing aid	Dentures	Hydration and nutrition assistance	Verbal Delirium Information	Written Delirium information	Extended visitation allowed	Overnight family stay	Car park and food provided to family
NL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aus	✓	×	×	×	Variable	Variable	Variable	Variable	Variable	✓	×	✓	×	×

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REFERENCES

1. Young J, Murthy L, Westby M, et al. Diagnosis, prevention, and management of delirium: summary of NICE guidance. *BMJ*. 2010; 341: c3704.DOI:10.1136/bmj.c3704.

2. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. *JAMA*. 1990; 263: 1097-101

3. McCusker J, Cole M, Dendukuri N, et al. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. *CMAJ*. 2001; 165: 575-83

4. Rockwood K, Cosway S, Carver D, et al. The risk of dementia and death after delirium. *Age Ageing*. 1999; 28: 551-6

5. Gustafson Y, Berggren D, Brannstrom B, et al. Acute confusional states in elderly patients treated for femoral neck fracture. *Journal of the American Geriatrics Society*. 1988; 36: 525-30

6. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. *Arch Intern Med*. 2000; 160: 1856-60.DOI:10.1001/archinte.160.12.1856.

7. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *Journal of the American Geriatrics Society*. 2001; 49: 1335-40

8. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

9. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.

10. Tarandeep O, Laver K, Crotty M, Killington M. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. 2018:

11. Postoperative delirium in older adults: best practice statement from the American Geriatrics Society. *J Am Coll Surg*. 2015; 220: 136-48.e1.DOI:10.1016/j.jamcollsurg.2014.10.019.

12. Leentjens AF, Molag ML, Van Munster BC, et al. Changing perspectives on delirium care: the new Dutch guideline on delirium. *J Psychosom Res*. 2014; 77: 240-1.DOI:10.1016/j.jpsychores.2014.07.014.

13. Delirium Clinical Care Standard. Sydney: ACSQHC, 2016; 1-36

14. Lohr KN, Field MJ. *Clinical practice guidelines: directions for a new program*. National Academies Press; 1990.

15. Davis DA, Taylor-Vaisey AJC. Translating guidelines into practice: a systematic review of theoretic concepts, practical experience and research evidence in the adoption of clinical practice guidelines. 1997; 157: 408-16

16. Inouye SK, Schlesinger MJ, Lydon TJ. Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. *Am J Med*. 1999; 106: 565-73

17. Irving K, Fick D, Foreman M. Delirium: a new appraisal of an old problem. *Int J Older People Nurs*. 2006; 1: 106-12.DOI:10.1111/j.1748-3743.2006.00017.x.

18. Inouye SK, Bogardus ST, Jr., Charpentier PA, et al. A multicomponent intervention to prevent delirium in hospitalized older patients. *N Engl J Med*. 1999; 340: 669-76.DOI:10.1056/NEJM199903043400901.

19. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. *Int Psychogeriatr*. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

20. Inouye SK. A practical program for preventing delirium in hospitalized elderly patients. *Cleve Clin J Med*. 2004; 71: 890-6

21. Mulhall A. In the field: notes on observation in qualitative research. *J Adv Nurs*. 2003; 41: 306-13.DOI:10.1046/j.1365-2648.2003.02514.

22. Murphy E, Dingwall R. Informed consent, anticipatory regulation and ethnographic practice. *Soc Sci Med*. 2007; 65: 2223-34.DOI:10.1016/j.socscimed.2007.08.008.

23. Chesser TJS, Inman D, Johansen A, et al. Hip fracture systems—European experience. 2020; 3: e050. DOI:10.1097/oi9.0000000000000050.

24. 2018. AaNZHFRA. ANZHFR Bi-National Annual Report of Hip Fracture Care 2018., 2018

25. Schuurmans MJ, Shortridge-Baggett LM, Duursma SA. The Delirium Observation Screening Scale: a screening instrument for delirium. *Research and theory for nursing practice*. 2003; 17: 31

26. Bellelli G, Morandi A, Davis DH, et al. Validation of the 4AT, a new instrument for rapid delirium screening: a study in 234 hospitalised older people. *Age and ageing*. 2014; 43: 496-502.DOI:10.1093/ageing/afu181.

27. Wolf DM, Lehman L, Quinlin R, et al. Effect of patient-centered care on patient satisfaction and quality of care. *Journal of nursing care quality*. 2008; 23: 316-21

28. Rathert C, Wyrwich MD, Boren SA. Patient-centered care and outcomes: a systematic review of the literature. *Medical Care Research and Review*. 2013; 70: 351-79.DOI: 10.1177/1077558712465774.

29. Brennan C, Greenhalgh J, Pawson R. Guidance on guidelines: Understanding the evidence on the uptake of health care guidelines. *Journal of Evaluation in Clinical Practice*. 2018; 24: 105-16. DOI:10.1111/jep.12734.

30. Lomas J, Anderson GM, Domnick-Pierre K, et al. Do practice guidelines guide practice? *New England Journal of Medicine*. 1989; 321: 1306-11

31. Grimshaw JM, Russell IT. Effect of clinical guidelines on medical practice: a systematic review of rigorous evaluations. *The Lancet*. 1993; 342: 1317-22.DOI:10.1016/0140-6736(93)92244-N.

32. Guba EGJE. Criteria for assessing the trustworthiness of naturalistic inquiries. 1981; 29: 75

33. Guest G, Bunce A, Johnson LJFm. How many interviews are enough? An experiment with data saturation and variability. 2006; 18: 59-82.DOI:10.1177/1525822X05279903.

34. Borbasi S, Jackson D, Wilkes LJJoan. Fieldwork in nursing research: positionality, practicalities and predicaments. 2005; 51: 493-501

35. Schneider Z, Whitehead D, LoBiondo-Wood G, et al. *Nursing and midwifery research: Methods and appraisal for evidence based practice*. Elsevier; 2016.

36. Monahan T, Fisher JAJQr. Benefits of 'observer effects': lessons from the field. 2010; 10: 357-76

CHAPTER 7

No longer lost in translation: study protocol for preventing delirium post hip fracture

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ABSTRACT

Introduction

Hip fractures are serious injuries commonly experienced by older adults. Delirium has been identified as the most frequent post-operative complication among hospitalized older people, following hip fracture. A quality assurance audit within our hospital demonstrated that delirium screening, prevention and management were not performed routinely or systematically. This study protocol describes an implementation research project which aims to implement and evaluate the effect of an intervention bundle to prevent delirium in patients with hip fracture admitted to an acute orthopaedic ward.

Methods

This implementation research project seeks to assess whether the intervention bundle reduces the incidence of delirium in patients with hip fracture patients identified via the use of a validated tool in screening delirium. We will also examine the length of hospital stay, duration of delirium episode and the prevalence of the use of a validated tool to screen delirium.

Intervention

Specific intervention strategies, informed by contemporary Behaviour Change Wheel Framework have been selected to address the identified barriers. The final components of the intervention are care pathway, education, audit and feedback, change champions, adaptation of forms and documentation and infographics.

Conclusion

This study describes an implementation project which evaluates the effect of delirium prevention bundle on incidence of delirium in patients with hip fractures. The clinical goal of the delirium prevention care bundle is to bridge the gap between the current and best practice in delirium recognition, prevention and management.

INTRODUCTION

Hip fractures are serious injuries commonly experienced by older adults [1, 2]. These injuries have a major impact not only on older individuals' long-term health, but also on their families, health services and the community [3]. Globally, the 30-day mortality after a neck of femur fracture is between 7% and 9% and the one-year mortality ranges from 21.6% to 30% [4, 5] .

Delirium has been identified as the most frequent post-operative complication among hospitalized older people, following hip fracture [6-8]. Research suggests 35% to 65% of patients who have undergone surgery for a hip fracture repair experience delirium post-operatively [9]. Delirium, an acute decline in attention and cognition, is a common, serious, expensive and potentially preventable complication for hospitalised older people [10]. Development of delirium during the hospital stay results in a worse prognosis, longer stay in hospital, higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge [11-13]. Due to the high incidence and its relationship to poor outcomes delirium prevention should be a higher priority for clinicians [14].

Research suggests that clinicians are able to effectively identify patients in their care who are confused however identification is usually done without the use of psychometrically sound assessment tools which allows the objective tracking of the condition [15, 16]. Multicomponent intervention strategies can have positive effects on preventing delirium in patients with hip fracture. Early engagement of multidisciplinary staff, including geriatricians, who address the risk factors of delirium as soon as the patient presents to the acute care environment is a key element of a successful delirium prevention program [17].

In summary, delirium is acknowledged to be problematic and is gradually gaining increasing attention from policy makers. In Australia, The National Safety and Quality Health Service Standards (NSQHS) have recently included comprehensive care standards and cognitive impairment is one of the identified areas within the comprehensive care standards. As of January 2019, all hospitals in Australia will be required to meet all the eight standards including the comprehensive care standard to be able to maintain their accreditation [18].

Under this clinical care standard, a patient that

- presents to hospital with one or more key risk factors (aged > 65, known cognitive impairment, hip fracture) for delirium receives cognitive screening using a validated test.
- has cognitive impairment on presentation to hospital, or who has an acute change in behaviour or cognitive function during a hospital stay, is promptly assessed for delirium by a clinician trained and competent in delirium diagnosis and in the use of a validated diagnostic tool.
- is at risk of delirium is offered a set of interventions to prevent delirium and regular monitoring for changes in behaviour, cognition and physical condition.

Prior to the introduction of the standards (November 2017) we completed a retrospective case note audit to determine the frequency of delirium screening. The orthopaedic ward is situated within a level 1 trauma centre in South Australia. The results of this unpublished audit suggested that less than 1% of patients with a hip fracture received pre-operative cognitive assessment on admission. Although 48% of patients had documented evidence of behaviour change during the post-operative period, only 9% of patients received cognitive screening with a validated tool. This quality assurance audit demonstrated that delirium screening, prevention and management were not performed systematically within this acute care environment. This audit also suggested that care was not consistent with Delirium Clinical Care standard as specified by Australian Commission on Safety and Quality in Healthcare. The commission developed the National Safety and Quality Health Service (NSQHS) Standards to improve the quality of health service provision in Australia. The NSQHS standards provide a nationally consistent statement of the level of care consumers can expect from health service. Much work is required in this setting for the ward to achieve adherence to the National Standards.

Implementation research is particularly concerned with engaging the key stakeholders and developing effective collaborative relationships to achieve successful interventions and outcomes. We conducted focus groups to identify clinicians' (nurses, allied health and medical doctors') perceptions of the barriers and enablers to recognizing, assessing, actively preventing and managing delirium symptoms in hip fracture patients admitted to orthopaedic setting. The focus group discussions identified four major themes regarding assessment and management of delirium in the acute orthopaedic setting: delirium is important but can be hard to recognize and validate; another piece of paper is just not my priority; making it worth my while; and vital role of family. In addition, we explored the knowledge, skills and attitudes of orthopaedic nurses towards caring for older hip fracture patients with delirium by application of a knowledge, skills and attitude

survey. The results of this survey demonstrated gaps in nursing knowledge regarding characteristics of delirium and its risk factors and use of appropriate screening tool to measure delirium. Based on these known barriers this study aims to implement and evaluate the effect of an intervention bundle to prevent delirium in patients with hip fracture admitted to an acute orthopaedic ward.

Expected outcomes:

Implementation of an intervention which embeds the contribution from the clinical team will increase adherence to National Safety and Quality Health Service Standards (NSQHS), thereby reducing incidence of delirium.

METHODS

Project design

This implementation research project seeks to understand the efficacy of a delirium prevention intervention bundle which will work within an existing orthopaedic speciality care system and resources. Implementation research is defined as the scientific study of methods to promote the systematic uptake of research findings and other evidence based practices into routine practice to improve the quality and effectiveness of health services and care [19]. The goal of implementation science is to understand how evidence based health interventions are made feasible and integrated into the organisational, social and policy environment [20].

Process models inform the process of translating research into practice; the Knowledge to Action framework (KTA) developed by Graham et al. provides the foundation for this project [21, 22]. The Knowledge to Action framework consists of a central knowledge creation cycle and a concurrent action cycle, Figure 1 demonstrates the steps of this project as they relate to the KTA framework. In preparatory work, issues were identified, and knowledge was synthesized to develop strategies to mitigate the identified issues. The results led to the development of the current project which begins with the phase of adapting the knowledge to the local context and identifying barriers to knowledge uptake and will continue with selecting, tailoring and implementing knowledge translation intervention, monitoring and sustaining knowledge use and evaluating outcomes. An overview of the implementation model used within the project is presented in Figure 2. (Ppt. diagram).

This study was approved by Southern Adelaide Local Health Network Office of Research Ethics Committee- Project Number: SALHN HREA-204.17.

Participants and setting

Clinical staff (geriatricians and orthopaedic doctors, nurses, and allied health) managing patients with hip fracture in an acute care setting within a level 1 trauma centre in Adelaide, South Australia will be participating in the project. The intervention will be applicable for patients admitted following hip fracture to the hospital. The journey of these patients starts in the emergency department before being admitted to the 28-bed orthopaedic ward. The service admits 400 people per year with hip fracture.

The interventions will be targeted at all staff caring for the patients with hip fracture however the primary outcome of interest relates to patients aged 65 years and over with diagnosis of hip fracture admitted to an Orthopaedic ward.

Intervention

Improving the implementation of evidence-based practice and public health depends on behaviour change. Behaviour change interventions can be defined as coordinated sets of activities designed to change specified behaviour patterns [23]. In our study interventions will be based upon strategies identified through the Behaviour Change Wheel framework to identify and explain the factors that contribute to the development, implementation and integration of the delirium prevention intervention bundle [24].

Specific intervention strategies, informed by contemporary behaviour change techniques have been selected to address the identified barriers [25]. Current barriers and enablers and selected intervention approaches to address these barriers are presented in Table 1. As can be seen the barriers identified in focus groups, knowledge gap identified through the survey and possible interventions resulted in a number of different strategies. The steering group met to agree on the intervention and intervention strategies suggested within the focus groups were prioritised.

Evaluation of intervention

Using an interrupted time series approach over 28 months we will assess whether introduction of the intervention bundle reduces the incidence of delirium in patients with hip fracture patients identified via the use of a validated tool in screening delirium.

We will also examine the length of hospital stay, duration of delirium episode and the prevalence of the use of a validated tool to screen delirium. We will assess the acceptance and effectiveness of the intervention with repeated delivery of a knowledge, skills and attitude survey.

The effects of the program will be measured by assessing the incidence of delirium and the prevalence of screening tool use over time, with data aggregated at weekly intervals. This aggregated data will be analysed using an interrupted time series approach which will allow detection of any significant shifts in incidence at the time of the intervention implementation and for any changes in incidence trends following the intervention. Interrupted time series (ITS) analysis has been deemed as a preferred study design particularly when a randomized trial is unfeasible or unethical [26] [27, 28]. Strengths of ITS include the ability to control for secular trends in the data before the intervention, the ability to evaluate outcomes using aggregated data, clear graphical presentation of data, the ability to stratify analyses, and the ability to determine both intended and unintended consequences of interventions [29].

Data Collection Procedures

Data on the estimated incidence of delirium will be obtained by regular assessment of hip fracture patients for delirium using the 4AT screening tool. A trained clinician will identify and screen all new hip fracture admissions and then continue to assess these patients for delirium daily for their complete hospital stay. Initially, we chose to collect one week's worth of data at monthly intervals due to limited resources. However, in order to ensure more robust data we will now gather data every week to ensure that it is representative of the true prevalence of delirium and compliance with completion of 4AT screening tool. Data on compliance with the use of delirium 4AT screening tool will be obtained by examining the medical records of all hip fracture patients that are admitted in the orthopaedic unit.

The duration of any episodes of delirium that occur will be recorded following the discharge of each patient from the hospital.

The data for delirium incidence and compliance with the screening tool will be aggregated over weekly periods and used for ITS analysis. We anticipate a 14-month data collection period prior to the implementation of the intervention (commencing July 2017) and a 14-month data collection period post intervention (completion October 2019). A weekly collection period will ensure both sufficient numbers of patients to obtain a reliable

estimate of incidence for each period and will also allow for 60 time points pre and post intervention which is considered adequate [30].

We will also review case notes of all patients with hip fracture admitted in between July 2017 to October 2019 to establish where delirium or acute confusion or behaviour change symptoms have been noted.

Data on the hospital length of stay will be collected retrospectively using the administrative hospital database.

Sample size

In relation to our primary outcome of incidence of delirium we have calculated:
Assuming an underlying prevalence of 45%, a sample size of 60 data points both pre and post intervention will provide us with 84% power to detect a difference of 25% using a 2-tailed test and a type 1 error rate of alpha=0.05. In relation to our secondary outcome of compliance with the use of delirium 4AT screening tool; the assessment of approximately 5 hip fracture patients per day at monthly intervals to assess compliance with screening assessment (i.e. 75 patients pre and post intervention) will also provide 91% power to detect a difference in screening rates from 20% to 40% between pre and post intervention.

Statistical analysis

Analysis will be performed using Stata version 15.2 (StataCorp, College Station, USA). Differences in hip fracture patient characteristics between those with and without delirium and between the pre and post-intervention periods will be compared using independent t-tests or a Mann-Whitney-U test for continuous variables and either chi-squared tests or Fishers exact test for categorical variables. The incidence of delirium amongst hip fracture patients and the prevalence of use of the delirium screening tool will be assessed using the ITS approach described above. Specifically, we will assess the immediate impact of the intervention by comparing the intercepts of the estimated linear slopes for the pre-intervention and post-intervention period. Changes in the trends in incidence will be assessed by including a term for the change in slope from pre to post intervention in the ITS analysis. The ITS analysis will be performed in Stata using the user-written "itsa" command. Differences in the length of hospital stay between patients with and without delirium will be analysed using survival analysis with discharge from hospital the defined event of interest and the time (in days) between admission and discharge as the time variable. The survival analysis will include log-rank analysis, Kaplan-

Meier curves and Cox egression with adjustment for relevant confounders including age, gender, and Charlson comorbidity index. We will report on possible economic benefits of the intervention by examining changes in LOS over time.

DISCUSSION

This study describes an implementation project which evaluates the effect of delirium prevention bundle on incidence of delirium in patients with hip fractures. The clinical goal of the delirium prevention care bundle is to bridge the gap between the current and best practice in delirium recognition, prevention and management. Without careful consideration of system design, function and end-user perspective, interventions can fail [31]. If the clinical pathways such as delirium prevention care pathway are integrated without evaluating how they might impact end users/ participants or their existing workflow, they have the potential to be ineffective and may function poorly [32]. To meet the specific needs of multi-disciplinary team, customisation of clinical pathways such as delirium prevention care pathway need to match and support the workflow [33, 34].

We anticipate that the delirium prevention care pathway will benefit clinicians, patients as well their carers. This benefit may include increased awareness for clinicians about delirium and its associated risk factors and symptoms. In addition, availability of relevant information about what can be done about these symptoms and the opportunity to discuss this information and a management plan with family can be an added benefit. Nurses in many other studies have reported feeling dismissed or ignored when reporting delirium symptoms to medical specialists [35, 36]. This forms a barrier to effective multidisciplinary team approaches to timely recognition and engagement in prevention strategies. Delirium prevention care bundle might be a way forward to overcome the barrier of not being heard by doctors as it can be utilised as a decision-making tool.

Assessing the problem	BCW COM-B Domains	Linking components of the COM-B system to relevant intervention functions	Behaviour change strategies
Which barriers and enablers need to be addressed?	**Relevant components of the COM-B system**	**Intervention function**	**Interventions developed to overcome identified barriers and enhance enablers.**
Low awareness of guideline recommendations of delirium assessment and providing individualised care	Physical capability	• Education • Training- imparting skills • Enabling (increasing means/reducing barriers to increase capability beyond education and training)	• Online education sessions: for all doctors, nurses, allied health on delirium symptoms, general awareness, delirium related risk factors and raising awareness of delirium clinical care standards. Education sessions will be mandatory and each participant will be asked to show certificate of completion. • Ward in-service training sessions: these sessions will be tailored with orthopaedic specific information and documentation
Beliefs of the nurses on existing documentation Example: "Existing documentation is sufficient" "Formal screening tool doesn't add any value" "Ability to track scores will make it useful"	Psychological capability Reflective motivation Automatic motivation	• Education, training and enabling • Education, persuasion, incentives • Environmental restructuring	• Modification of screening tool to include tracking scoring system • Modification of screening tool to include prompts and possible actions • Identify change champions to enable behaviour change • Provide feedback on audit results to provide persuasion as well as incentive for best practice
Lack of consistent leadership, guidance oversight and reinforcement of appropriate processes	Physical opportunity	Environmental restructuring and enabling	• Ensure the change champion role gets time off floor to reinforce best practice and provide encouragement • Improve accessibility of documentation as well as items needed to promote preventative strategies e.g. clocks, calendars
High workload pressure: Lack of time which means that use of screening tool is not prioritised	Reflective motivation Physical Opportunity	• Education, persuasion, incentive • Enabling, environment restructuring, modelling	• Identify change champions to enable behaviour change and reinforce best practice • Infographic posters which include delirium information (reminders) • Make documentation more accessible in the patient notes (reducing barriers by increasing accessibility) • Provide feedback of audit results relating to targets with support of management

Perception of nurses of what is considered to be a priority intervention within a time-limited environment Example: Completing delirium screening tool is not considered a priority Belief of nurses that screening tool doesn't add any value	Reflective motivation Physical opportunity Social opportunity	• Education, persuasion, incentives • Environmental restructuring and enabling	• Education on importance of early diagnosis and screening • Recruit change champions to reinforce importance • Provide feedback of data related to targets with support of management • make 4 AT into a tracking form to make it more efficient as well as make it more useful
Lack of feedback to nurses how appropriate actions have been taken Example: What happens to the screening forms once they have been completed?	Automatic motivation	Enabling, persuasion and environmental restructuring	• Establish and disseminate a clear delirium prevention care pathway for identification, prevention and management
Junior staff and new staff members model their behaviour on senior or more experienced clinical staff members (who do not follow care guidelines)	Social opportunity	Restriction, environmental restructuring and enabling	• Develop delirium prevention care pathway to promote best practice • Education sessions for all junior and new staff • Audit and feedback • Modify existing documentation • Improve accessibility of documents by putting them in Hip Fracture package. Hip fracture package is a bundle of documents which need to be completed for every patient who gets admitted with a hip fracture.

Abbreviations:
BCW: Behaviour Change Wheel
COM-B- Capability Opportunity Motivation - Behaviour
4AT- A Rapid Clinical Instrument for Delirium Detection

Figure 1: Knowledge to Action Framework with delirium prevention project content, adapted from Graham et al.

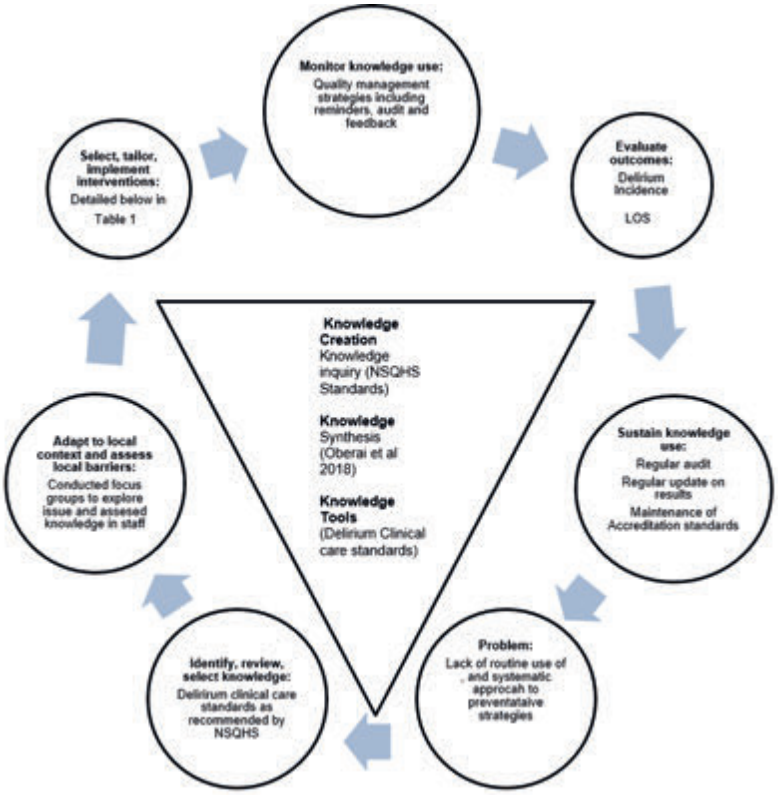
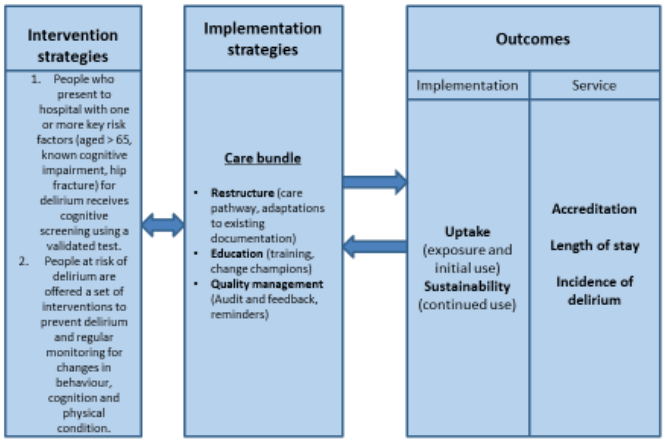


Figure 2: Implementation model used within the project



Model based on Proctor 2009.

REFERENCES:

1. Magaziner J, Hawkes W, Hebel JR, Zimmerman SI, Fox KM, Dolan M, et al. Recovery from hip fracture in eight areas of function. J Gerontol A Biol Sci Med Sci. 2000;55(9):M498-507.

2. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. Ageing Res Rev. 2003;2(1):57-93.

3. Hirsch CH, Sommers L, Olsen A, Mullen L, Winograd CH. The natural history of functional morbidity in hospitalized older patients. Journal of the American Geriatrics Society. 1990;38(12):1296-303.

4. Rae HC, Harris IA, McEvoy L, Todorova T. Delay to surgery and mortality after hip fracture. ANZ J Surg. 2007;77(10):889-91.

5. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? The Journal of bone and joint surgery. American volume. 2005;87(3):483-9.

6. Gustafson Y, Berggren D, Brannstrom B, Bucht G, Norberg A, Hansson LI, et al. Acute confusional states in elderly patients treated for femoral neck fracture. Journal of the American Geriatrics Society. 1988;36(6):525-30.

7. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. Archives of internal medicine. 2000;160(12):1856-60.

8. Edlund A, Lundstrom M, Brannstrom B, Bucht G, Gustafson Y. Delirium before and after operation for femoral neck fracture. Journal of the American Geriatrics Society. 2001;49(10):1335-40.

9. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. J Am Geriatr Soc. 2001;49(5):516-22.

10. Cole MG. Delirium in elderly patients. Am J Geriatr Psychiatry. 2004;12(1):7-21.

11. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. JAMA. 1990;263(8):1097-101.

12. McCusker J, Cole M, Dendukuri N, Belzile E, Primeau F. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. CMAJ. 2001;165(5):575-83.

13. Rockwood K, Cosway S, Carver D, Jarrett P, Stadnyk K, Fisk J. The risk of dementia and death after delirium. Age Ageing. 1999;28(6):551-6.

14. Harris DP, Chodosh J, Vassar SD, Vickrey BG, Shapiro MF. Primary care providers' views of challenges and rewards of dementia care relative to other conditions. J Am Geriatr Soc. 2009;57(12):2209-16.

15. Hare M, Wynaden D, McGowan S, Landsborough I, Speed G. A questionnaire to determine nurses' knowledge of delirium and its risk factors. Contemp Nurse. 2008;29(1):23-31.

16. Steis MR, Fick DM. Delirium superimposed on dementia: accuracy of nurse documentation. J Gerontol Nurs. 2012;38(1):32-42.

17. Tarandeep O, Laver K, Crotty M, Killington M. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. 2018.

18. Australian Commission on Safety and Quality in Health Care. Delirium Clinical Care Standard. Sydney: ACSQHC, 2016.

19. Eccles MP, Mittman BS. Welcome to implementation science. BioMed Central; 2006.

20. Hodgson NA, Gitlin LN. The role of implementation science in behavioral intervention research. Behavioral intervention research: designing, evaluating and implementing. New York: Springer Publishers. 2016.

21. Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, et al. Lost in knowledge translation: Time for a map? Journal of Continuing Education in the Health Professions. 2006;26(1):13-24.

22. Wilson KM, Brady TJ, Lesesne C, Translation NWGo. An organizing framework for translation in public health: the Knowledge to Action Framework. Prev Chronic Dis. 2011;8(2):A46.

23. Grimshaw JM, Shirran L, Thomas R, Mowatt G, Fraser C, Bero L, et al. Changing provider behavior: an overview of systematic reviews of interventions. Medical care. 2001:II2-II45.

24. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6(1):42.

25. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6:42.

26. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol. 2017;46(1):348-55.

27. Shadish WR, Cook TD, Campbell DT. Experimental and quasi-experimental designs for generalized causal inference: Wadsworth Cengage learning; 2002.

28. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. Journal of clinical pharmacy and therapeutics. 2002;27(4):299-309.

29. Penfold RB, Zhang F. Use of Interrupted Time Series Analysis in Evaluating Health Care Quality Improvements. Academic Pediatrics. 2013;13(6):S38-S44.

30. Fretheim A, Zhang F, Ross-Degnan D, Oxman AD, Cheyne H, Foy R, et al. A reanalysis of cluster randomized trials showed interrupted time-series studies were valuable in health system evaluation. Journal of Clinical Epidemiology.68(3):324-33.

31. Donaldson A, Finch CF. Planning for implementation and translation: seek first to understand the end-users' perspectives. Br J Sports Med. 2012;46(5):306-7.

32. De Allegri M, Schwarzbach M, Loerbroks A, Ronellenfitsch U. Which factors are important for the successful development and implementation of clinical pathways? A qualitative study. BMJ Qual Saf. 2011;20(3):203-8.

33. Kinsman L, James E, Ham J. An interdisciplinary, evidence-based process of clinical pathway implementation increases pathway usage. Lippincotts Case Manag. 2004;9(4):184-96.

34. Gurzick M, Kesten KS. The impact of clinical nurse specialists on clinical pathways in the application of evidence-based practice. J Prof Nurs. 2010;26(1):42-8.

35. Kjorven M, Rush K, Hole R. A discursive exploration of the practices that shape and discipline nurses' responses to postoperative delirium. Nurs Inq. 2011;18(4):325-35.

36. Al-Qadheeb NS, Hoffmeister J, Roberts R, Shanahan K, Garpestad E, Devlin JW. Perceptions of nurses and physicians of their communication at night about intensive care patients' pain, agitation, and delirium. Am J Crit Care. 2013;22(5):e49-61.

CHAPTER 8

The effect of an educational intervention to improve orthopaedic nurses' knowledge of delirium: a quasi-experimental study

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ABSTRACT

Aim

The aim of this paper is to investigate the effectiveness of the delirium awareness educational program on nurses' knowledge about delirium prevention and management.

Background

Lack of delirium knowledge and its clinical repercussions contributes to the absence of delirium prevention activities in routine clinical practice.

Methods

A quasi-experimental (pre-intervention, post-intervention test) design was used to test the effectiveness of an educational intervention using a knowledge survey.

Results

There was no difference in the knowledge scores between the 2 periods for domains 1, 2 3 and 4. However, the median (IQR) knowledge scores for domain 5 (risk factors) and domain 6 (recognising delirium) was higher at post intervention compared to pre-intervention.

Conclusion

We showed that a multi-step educational intervention had a positive but small impact on nurses' knowledge of delirium. However, the training was not mandatory and uptake of the training was not as high as we would have hoped. We observed that nurses most preferred ward-based education which was combination of formal knowledge delivery and informal practice discussion. Future studies should focus on programs which are ward-based including variety of teaching styles.

Relevance to clinical practice

Education of nurses in is essential for early engagement, recognition and primary prevention of delirium. The key topics should be mandatory and should be assessed as part of continuous professional development. Education strategies should engage nurses in practice discussions on clinical scenarios. The education should also be scheduled out of hours to extend this opportunity to nurses working on late and night shifts.

INTRODUCTION

Delirium, an "*acute decline in attention and cognition*", is common, severe, costly and a potentially preventable complication for hospitalized older patients [1]. Delirium during the hospitalisation is associated with an inferior prognosis, longer stay in hospital, greater mortality rates, poorer functional recovery and higher institutionalization rates after hospital discharge [2]. Delirium is the most frequent complication among patients undergoing surgery following hip fracture [3]. Post-operatively approximately 39% of patients develop delirium after undergoing surgery for a hip fracture repair [4] . The total cost associated with delirium in Australia alone was estimated to be $A8.8 billion (£4.3 billion) in 2016–2017 with approximately 35% of those costs related to direct costs and 65% to the value of healthy life lost [5].

The specific factors which cause delirium are not fully understood. A number of probable, preventable and treatable risk factors have also been associated with this condition [6]. Infections, medications, pain, constipation, dehydration and environmental factors such as emergency room waiting time, multiple staff encounters and disturbed sleep are some of the common triggers [7]. Multi-component interventions which target the risk factors are currently the most effective way known in preventing delirium in patients with hip fractures[8]. Nurses are nicely positioned to take the lead in delirium screening and identification due to their engagement with patients in providing 24- hour care [9]. It allows them to observe variation in health status which is characteristic of delirium [9, 10]. Clinical practice and research validates that nurses are efficient in recognizing acute confusion in their patients however this is done without utilising the available objective screening tool [11] . Evidence also suggests that patient care activities such nutrition, hydration and family engagement which are essential components of delirium prevention are not given priority and can be missing in usual nursing care [12]. The articles included in this scoping review were deemed to be of high methodological quality. Lack of delirium knowledge and its clinical repercussions contributes to the absence of delirium prevention activities in routine clinical practice [9].

In Australia, The National Safety and Quality Health Service Standards (NSQHS) introduced comprehensive care standards [13]. The Comprehensive Care Standard includes "*actions related to falls, pressure injuries, nutrition, mental health, cognitive impairment and end-of-life care"(page 1).* Delirium prevention and care fits within the cognitive impairment action. Hospitals in Australia are required to meet all the eight standards including the comprehensive care standard to be able to maintain their accreditation.

Delirium prevention was identified as an area for improvement in our Orthopaedic unit in a Level 1 University Trauma Centre in Australia. A retrospective quality assurance case note audit (n=200) was completed to determine the frequency of delirium screening on the unit (Unpublished data). The results of this audit demonstrated that less than 1% of patients with hip fracture received pre-operative cognitive assessment on admission. Overall, 48% of patients had evidence of behaviour change during the post-operative period however only 9% of patients had documented delirium screening using a validated tool in this period. Findings of the audit suggested that care was not consistent with comprehensive care standard as specified by Australian Commission on Safety and Quality in Healthcare. In response, we implemented specific intervention strategies, informed by contemporary behaviour change techniques [14]. Education was one of the components in a larger quality improvement project for delirium prevention and care. The aim of this paper is to investigate the effectiveness of the delirium awareness educational program on nurses' knowledge about delirium prevention and management.

METHODS

Research design

A quasi-experimental (pre-intervention, post-intervention test) design was used to test the effectiveness of an educational intervention on increasing knowledge. Quasi-experiments are often conducted in settings in which random assignment is hard. They are frequently conducted to evaluate the effectiveness of a treatment— like an educational intervention[15]. Nurses were familiar with the background and purpose of the study as this study was part of a larger quality improvement project for delirium prevention and care. As it was quality improvement project completion of education and survey was taken as implied consent. A self-administered structured survey was used to determine the delirium related knowledge. The survey was completed by nurses during work hours and took about 5 to 7 minutes to complete. The nurse unit manager distributed hard copy of the delirium knowledge survey to all nurses working in the ward at two different time points, September 2017 (to assess the baseline knowledge before the implementation of intervention) and June 2020 (6-months after the completion of the implementation project to assess the effectiveness and sustainability of the knowledge).

The specific objective of the study was: to evaluate the effectiveness of the education intervention and assess if there was sustained knowledge at 6 months.

Setting and participants

The education program was conducted with nursing staff from 28 bed orthopaedic ward of a level 1 trauma centre in South Australia between September, 2018 to December, 2019. This orthopaedic ward is the ward where patients with a hip fracture are admitted. Registered nurses and enrolled nurses were included in the education intervention. The key difference between the registered nurses and enrolled nurses is the level of qualifications obtained by each. An enrolled nurse (EN) would have completed a Diploma of Enrolled Nursing and registered nurse would have completed a Degree of Nursing.

Intervention

The three-step education intervention was offered. Nurses were expected to have attended step 1 and step 2 before they could progress to step 3. The education was based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality [16].

The self-directed on-line modules were introduced in September, 2018

Nurses on shift attended the formal in-service and informal discussions about using the screening tool and incorporating delirium care in routine clinical practice. The sessions held every week in between September 2018 to March 2019; and

Nurses who had completed the on-line modules and attended the in-service and practice discussions attended a Delirium Care workshop which included simulations. Two workshops were scheduled in 2019 (Feb, 2019 and Oct, 2019).

On-line module

The on-line, self-directed, delirium prevention a module was designed based on evidence based practice which approximately tool 30 minutes complete. In brief it included: definition, risk factors and clinical manifestation of delirium, Screening and assessment of delirium, Prevention and management strategies for delirium, post-operative delirium, explanation of delirium care standard lastly, an on-line quiz

In-service and practice discussion

The weekly in-services (focused on delirium care) were led by specialist nurse educator whilst practice discussions were facilitated by senior nurse who had taken up delirium as “portfolio project” as well as range of other experts (e.g. allied health, geriatricians).

In-services and discussions were timetabled most convenient times for clinicians which was advised to be at handover times for nursing staff when both early and late shift staff were present. The in-services were structured and primarily focussed on use of a validated screening tool to recognise delirium. The discussions were responsive to the needs or queries expressed by staff attending and usually included discussions around difficult clinical scenarios. The practice discussions were semi-structured and provided an opportunity to share ideas, express concerns and problem solve in a meaningful manner.

Delirium workshop

The Half-day workshop was offered to nurses who had completed both the online module and ward in-service/discussion session. The workshop included a brief refresher tutorial on delirium, videos on "The Patient experience of delirium" and simulation scenarios. The overall learning outcomes of this workshop were:

- Importance of delirium screening and early identification of delirium on and during admission
- Importance of engaging family and carers
- To develop and enhance individualised **person-**centered care
- Available "delirium Awareness" education/resources

Simulation session was specifically designed to depict and manage a patient presenting with delirium. Each simulation was facilitated by clinician specialising in delirium. Each simulation session included one educator as a patient, one educator as clinical facilitator, a clinician who acted as family member and two nurses who volunteered to engage as nurses caring for the patient. The learning outcomes of the simulation session were:

- Recognise clinical presentation of a patient experiencing delirium (3 subtypes)
- Identify delirium assessment tools
- List the risk factors and causes associated with delirium
- Describe nursing interventions to be implemented when caring for the person with delirium
- Describe the possible outcomes for the person with delirium

Study Instrument

The questionnaire utilized in this study has been previously used in a similar study [17]. Consent to use this questionnaire was sought from its original developers (M. Hare personal communication on 26/10/2016). The knowledge of delirium and its related risk factors questionnaire has not been validated and its reliability has not been established

either however has been widely used [18, 19]. The questionnaire has three sections: a 7-question section for demographic data collection, 36 specific delirium related questions called the knowledge section. In the demographic section the participants provide their age, gender, designation, level of education and years of nursing experience. In the knowledge section participants identified the definition of delirium in a multiple choice question, and the seven assessment tools commonly used when screening patients with delirium, dementia, and/or depression. The remaining 28 questions in knowledge section assessed participants general knowledge of delirium (4 on delirium symptoms, 1 on diagnostic tool, 15 on risk factors and 8 on recognising delirium) using Likert scale (agree, disagree or unsure). Independently completed questionnaires were returned to Nurse Unit Manager of the orthopedic unit. The questionnaire did not ask any identifying information from the nurses so the confidentiality could be maintained. Completed questionnaires were crosschecked manually with answer book and entered into an excel spreadsheet to construct a database. Correct answers were coded as 1 while an incorrect answer (including unsure) was coded as 0.

The survey was divided in following domains for ease of interpretation of results: 1 Delirium definition (1 question); 2 Screening tool (7 questions); 3 Symptoms (4 questions); 4 Preferred diagnostic tool (1 question); 5. Risk factors (15 questions); 6. Recognising symptoms (8 questions).

Statistical analysis

Descriptive statistics and Fishers Exact tests were used to compare the demographic characteristics of the 2 groups of nurses in the pre and post intervention periods.

Domain knowledge scores for domains 2, 3, 5 and 6 were created by summing the corrected responses for the individual questions within each domain. The frequency and percentage of correct responses were used to describe the results for domains 1 and 4, and the median (inter-quartile range) were used to describe the results for domains 2, 3, 5 and 6. Chi-squared tests were used to compare the differences in the frequency of correct responses for domains and 1 and 4 between the pre and post intervention periods, and a Mann-Whitney U test was used to compare the medians for the other 4 domains. Given that nurses in the pre and post periods could have been different nurses, the scores obtained for the pre and post surveys were independent of each other. Where observations are independent of one another, a chi-squared test is appropriate for testing differences in a categorical exposure variable and the Pre/Post period, and a Mann-Whitney test is appropriate for assessing differences in medians between the Pre/Post period and a skewed continuous variable [20]. All analysis was performed using Stata version 16.0 (StataCorp, USA).

Ethical considerations

This study was approved as part of the larger delirium prevention implementation project by our institutional Research Ethics Committee - Project Number: SALHN HREA-204.17.

RESULTS

A considerable amount of coordination work was required from the nurse unit manager as well as clinical nurse educator. Of the 55 eligible nurses, 35 (64%) nurses completed the self-directed online learning modules, 37(68%) nurses attended the ward in-service/ practice discussion and 3 (6%) eligible nurses attended the half-day delirium workshop.

A total of 49 nurses completed the survey questionnaire pre-intervention and 46 nurses post-intervention. **Table 1** describes the demographic characteristics for the 2 groups for which there were no significant differences. A majority of nurses in both groups were aged between 20 to 40 years and had more than 10 years of nursing experience.

Table 2 describes the results for the knowledge survey amongst nurses before and after the intervention period. There was no difference in the knowledge scores between the 2 periods for domains 1, 2 3 and 4. However, the median (IQR) knowledge scores for domain 5 (risk factors) was higher at post intervention compared to pre-intervention (9 (8-10) versus 7 (6-8) $p < 0.001$) and domain 6 (recognising delirium) was also higher post-intervention compared to pre-intervention (7 (6-8) versus 6 (5-6) $p<0.001$).

DISCUSSION

The three-step education intervention was based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality. The three steps gave opportunity to nurses to learn in different styles via online learning, practice discussions and workshop based simulations. During the course of study period, self-directed online learning was accessible to nurses at all times, 18 ward in-services/ discussions were held and 2 half day delirium workshops were scheduled.

A significant improvement in scores across domains 5 and 6 is associated with improvement in knowledge associated with risk factors of delirium and recognising delirium in hospitalised older patients. These two domains comprised majority of the

knowledge survey questions (19/28). The post-intervention survey was scheduled for 6 months after the completion of the project suggests that the knowledge gained through the education intervention was sustained over-time. The ward-based in-service which included formal education through power-point and informal practice discussions was most attended by the nurses. The half day delirium workshop received the least participation. The higher participation of the ward based in-service could possibly be as it was scheduled during handover times which was a very convenient time for nurses. The nurses needed to attend the half-day workshop in their own time which possibly could have resulted in least participation. The potential effect of low participation in the workshop was no improvement in knowledge across domains 1- 4 (Delirium definition, Screening tool, Symptoms and preferred diagnostic tool). Our findings of improvement in knowledge in domains of delirium recognition and risk factors are consistent with the study by Detroyer and colleagues however the knowledge wasn't monitored over time [21]. The finding of sustained knowledge over-time was only shown in two other studies [18, 22]. Similar to our study, Grealish et al. also implemented the three-step program which included web based learning, discussion group and simulation sessions. However, unlike our study their staff participation in simulation was much better. The sustained knowledge over time may have led to conversation of delirium recognition and identifying its risk factors amongst nurses in this setting. The nurses may have developed a culture of change through social discussions. The concept of social transformation through informal learning has been discussed in literature since early nineties [23]. Increased knowledge in this study lead to changes in practice; we were able to demonstrate significant decrease in delirium incidence and a significant improvement in use of validated screening tool was observed within the orthopaedic unit[24].

Delirium can be difficult to recognise hence it's under-recognised and under-treated by health care workers [9]. However nurses have the duty to identify risk factors, signs and symptoms of delirium to decrease the pre and post-operative complications in acute care setting [9]. As identified in literature prevention is the most effective strategic approach to deal with delirium [25]. Nurses' deficit in knowledge especially related to risk factors has significant impact on management of elderly patients. Identifying the gap in knowledge of nurses through our pre-intervention survey was a crucial step for us towards implementing relevant education interventions.

Limitations

The important limitation of this research was that the tool has not been formally assessed for validity and reliability by any of the previous researchers who have used this survey.

However, our research group is working on the study to test psychometric properties of this survey. Whilst the surveys were conducted at 2 quite different periods of time and were not likely to include the same nurses twice, there is a possibility that the some of the nurses were surveyed at both of the 2 timepoints and the observations were therefore not completely independent of one another. Unfortunately, we were unable to determine with certainty whether this was the case or not for all subjects and therefore analysed the data assuming the observations were independent of one another. If the subjects in the 2 periods were not completely different then an analytical approach that allows for the non-independent nature of the data would be required using for example multi-level models. Also, due to the nature of the nursing rosters some nurses would have had more opportunity to attend the ward-based sessions as well as workshops. However, as the survey was repeated 6 months after the completion of the project, this allowed us to test the sustainability of acquired knowledge.

Conclusion

In this study, we showed that a multi-step educational intervention had a positive but small impact on nurses' knowledge of delirium recognition and its risk factors. However, the training was not mandatory and uptake of the training was not as high as we would have hoped. In our study we observed that nurses most preferred ward-based education which was combination of formal knowledge delivery and informal practice discussion. Future studies should focus on an education program which is ward-based and include variety of teaching styles.

Relevance to clinical practice

Education of nurses in any setting including orthopaedics is essential for early engagement, recognition and primary prevention of delirium. The key topics should be mandatory and should be assessed as part of continuous professional development. Education strategies should focus engaging nurses in practice discussions to allow conversation about management of clinical scenarios. The ward-based education sessions should also be scheduled out of hours to extend this opportunity to nurses working on late and night shifts.

Table 1: Demographic characteristics of the nurses in each of the 2 periods.

	Pre (n=49)	Post (n=46)	P-value[1]
Age			
20-30	15 (30.6)	10 (21.7)	0.172
31-40	10 (20.4)	19 (41.3)	
41-50	14 (28.6)	11 (23.9)	
50+	10 (20.4)	6 (13.0)	
Designation			
Enrolled Nurse	18 (36.7)	9 (20.5)	0.110
Registered Nurse	31 (63.3)	35 (79.5)	
Time in current position			
<6 months	4 (8.2)	5 (10.9)	0.534
6-12 months	1 (2.0)	3 (6.5)	
>12 months	44 (89.8)	38 (82.6)	
Hrs/fortnight			
<40	15 (30.6)	12 (26.1)	0.842
40-64	20 (40.8)	19 (41.3)	
>64	14 (28.6)	15 (32.6)	
Years Nursing			
5 or less	12 (24.5)	11 (23.9)	0.310
6-12	15 (30.6)	19 (41.3)	
13-20	11 (22.45)	12 (26.1)	
20+	11 (22.45)	4 (8.7)	
Qualification			
Enrolled Nurse	16 (32.7)	7 (15.2)	0.058
Registered Nurse - Bachelor	33 (67.3)	39 (84.8)	

[1]Using Fishers exact.

Table 2: Pre and post intervention survey knowledge scores

Domain	Pre (n=49)	Post (n=46)	p-value[1]
1 Delirium definition, n (%)	38 (77.6)	40 (87.0)	0.232
2 Screening tool Median (IQR)	5 (5-6)	5 (4-6)	0.805
Range (min-max)	1-7	4-7	
3 Symptoms Median (IQR)	3 (2-3)	3 (2-4)	0.963
Range (min-max)	0-4	0-4	
4 Diagnostic tool, n (%)	36 (73.5)	26 (56.5)	0.083
5.Risk factors Median (IQR)	7 (6-8)	9 (8-10)	<0.001
Range (min-max)	4-11	2-12	
6.Recognising delirium Median (IQR)	6 (5-6)	7 (6-8)	<0.001
Range (min-max)	3-8	4-8	

[1]From Mann-Whitney U test or chi-squared test.

REFERENCES

1. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. *Lancet*. 2014; 383: 911-22. DOI:10.1016/S0140-6736(13)60688-1.

2. Mosk CA, Mus M, Vroemen JP, et al. Dementia and delirium, the outcomes in elderly hip fracture patients. 2017; 12: 421.DOI:10.2147/CIA.S115945.

3. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *J Am Geriatr Soc*. 2001; 49: 1335-40

4. Oberai T, Oosterhoff JHF, Woodman R, et al. Development of a postoperative delirium risk scoring tool using data from the Australian and New Zealand Hip Fracture Registry: an analysis of 6672 patients 2017-2018. *Arch Gerontol Geriatr*. 2021; 94: 104368.DOI:10.1016/j.archger.2021.104368.

5. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.

6. Ahmed S, Leurent B, Sampson EL. Risk factors for incident delirium among older people in acute hospital medical units: a systematic review and meta-analysis. *Age Ageing*. 2014; 43: 326-33. DOI:10.1093/ageing/afu022.

7. Dahlke S, Phinney A. Caring for hospitalized older adults at risk for delirium: the silent, unspoken piece of nursing practice. *J Gerontol Nurs*. 2008; 34: 41-7.DOI:10.3928/00989134-20080601-03.

8. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. *Int Psychogeriatr*. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

9. Rice KL, Bennett M, Gomez M, et al. Nurses' recognition of delirium in the hospitalized older adult. *Clin Nurse Spec*. 2011; 25: 299-311.DOI:10.1097/NUR.0b013e318234897b.

10. Irving K, Fick D, Foreman M. Delirium: a new appraisal of an old problem. *Int J Older People Nurs*. 2006; 1: 106-12.DOI:10.1111/j.1748-3743.2006.00017.x.

11. Steis MR, Fick DM. Delirium superimposed on dementia: accuracy of nurse documentation. *J Gerontol Nurs*. 2012; 38: 32-42.DOI:10.3928/00989134-20110706-01.

12. El Hussein M, Hirst S, Salyers V. Factors that contribute to underrecognition of delirium by registered nurses in acute care settings: a scoping review of the literature to explain this phenomenon. *J Clin Nurs*. 2015; 24: 906-15.DOI:10.1111/jocn.12693.

13. Care ACoSaQiH. Implementing the Comprehensive Care Standard: A conceptual model for supporting comprehensive care delivery. Sydney: ACSQHC; 2018: Australian Commission on Safety and Quality in Health Care, 2018; 1-28

14. Oberai T, Laver K, Killington M, et al. No longer lost in translation: study protocol for preventing delirium post hip fracture. *European Journal for Person Centered Healthcare*. 2019; 7: 98-105. DOI:10.5750/ejpch.v7i1.1607.

15. Price PC, Jhangiani RS, Chiang ICA. Quasi-experimental research. In: Research Methods in Psychology. *4th ed*. 2015:207-236:

16. Care ACoSaQiH. Delirium Clinical Care Standard. Sydney: ACSQHC, 2016; 1-36

17. Hare M, Wynaden D, McGowan S, et al. A questionnaire to determine nurses' knowledge of delirium and its risk factors. *Contemp Nurse*. 2008; 29: 23-31.DOI:10.5172/conu.673.29.1.23.

18. Grealish L, Todd J-A, Krug M, Teodorczuk AJNeip. Education for delirium prevention: Knowing, meaning and doing. 2019; 40: 102622.DOI:10.1016/j.nepr.2019.102622.

19. Toye C, Kitchen S, Hill A, et al. Piloting staff education in Australia to reduce falls in older hospital patients experiencing delirium. 2017; 19: 51-8.DOI:10.1111/nhs.12300.

20. Kirkwood BR, Sterne JA. *Essential medical statistics*. John Wiley & Sons; 2010.

21. Detroyer E, Dobbels F, Debonnaire D, et al. The effect of an interactive delirium e-learning tool on healthcare workers' delirium recognition, knowledge and strain in caring for delirious patients: a pilot pre-test/post-test study. 2016; 16: 17.DOI:10.1186/s12909-016-0537-0.

22. McCrow J, Sullivan KA, Beattie ERJNet. Delirium knowledge and recognition: A randomized controlled trial of a web-based educational intervention for acute care nurses. 2014; 34: 912-7

23. Lave J, Wenger E. *Situated learning: Legitimate peripheral participation*. Cambridge university press; 1991.

24. Oberai T, Laver K, Woodman R, et al. Does Implementation of a Tailored Intervention Increase Adherence to a National Safety and Quality Standard? A Study to Improve Delirium Care. 2021:

25. Inouye SK, Bogardus ST, Jr., Williams CS, et al. The role of adherence on the effectiveness of nonpharmacologic interventions: evidence from the delirium prevention trial. *Arch Intern Med*. 2003; 163: 958-64.DOI:10.1001/archinte.163.8.958.

CHAPTER 9

Development and validation of a questionnaire to assess orthopaedic nurse's knowledge of delirium

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ABSTRACT

Aim

The aim of this paper was to develop and validate a delirium knowledge questionnaire.

Methods

The construct validity of the survey was assessed using Bayesian exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on responses obtained from the 35 knowledge-items of the knowledge survey.

Results

In the EFA, each model had satisfactory fit according to 95% CI and the posterior predictive p-value for χ^2 was >0.05 indicating good fit. Cronbach's alpha for the 11-items for the final construct for the pre and post education data indicated moderate internal consistency. Significant increase in the mean (SD) of the sum of correct responses for the 11-items between the pre- and post-education periods was observed.

Conclusion

An 11-item questionnaire to test nurses' knowledge of delirium was developed and validated allowing accurate assessment of nurses' knowledge of delirium and help increase survey participation rates.

INTRODUCTION

Delirium, an acute decline in attention and cognition, is common, serious, expensive and a potentially preventable complication for hospitalized older patients [1]. Development of delirium during the hospital stay is associated with a worse prognosis, longer stay in hospital, higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge [2]. Delirium is the most frequent complication among patients undergoing surgery following hip fracture [3]. Literature suggests approximately 39% of patients develop delirium post-operatively [4]. The total cost associated with delirium in Australia alone was estimated to be $A8.8 billion (£4.3 billion) in 2016–2017 with approximately 35% of those costs related to direct costs and 65% to the value of healthy life lost [5].

The explicit causative factors of delirium are not fully understood. A range of possible, preventable and treatable risk factors have been linked with this condition [6]. Infections, medications, pain, constipation, dehydration and environmental factors such as emergency room waiting time, multiple staff encounters and disturbed sleep are some of the common triggers [7]. Multi-component interventions which target these risk factors are currently the most effective way known in preventing delirium in patients with hip fractures [8].

Nurses are well placed to take a central role in delirium screening. The provision of 24-hour care for patients allows them to observe fluctuations in their health status which is characteristic of delirium [9, 10]. Even though early recognition of delirium leads to better patient outcomes, many nurses are unable to accurately recognise the development of delirium in older hospitalised patients [11, 12]. Consequently, patient care activities such nutrition, hydration and family engagement which are essential components of delirium prevention are not prioritised and are often left unfinished [13]. A lack of knowledge about delirium and its clinical repercussions contributes to the absence of delirium prevention activities in routine clinical practice [10].

In recent years education programs have improved nurses' knowledge of delirium [10, 14-16]. The improvement of such knowledge is one of main objectives of these education programs and its assessment is an important part of the intervention. However, most delirium education programs have only assessed nurse's knowledge of delirium using self-developed questionnaires or other pre-existing knowledge questionnaires that to our knowledge do not have established psychometric properties [10, 14, 16, 17]. It is important to determine the validity of delirium knowledge questionnaires in order to conduct rigorous evaluation and to minimise burden for participants. Therefore, we used data

collected from ward nursing staff before and after an intervention to assess the construct validity of an existing delirium knowledge questionnaire.

METHODS

Study design

A self-administered structured survey was used to determine efficacy of the delirium awareness educational program on nurses' knowledge about delirium prevention and management. This manuscript was published in early 2021. [18]. The following text on the study design, setting and participants, intervention and study instrument has overlap with the previously published study. The analysis of the responses received in the previous study was further used to establish the construct validity of the knowledge questionnaire. The nurse unit manager distributed the delirium knowledge survey to all nurses working in the ward at two different time points, September 2017 and June 2020.

Setting and participants

The education program was conducted with nursing staff from 28 bed orthopaedic ward of a level 1 trauma centre in South Australia between September 2018 to December 2019. This orthopaedic ward is the ward where patients with a hip fracture are admitted. Registered nurses and enrolled nurses were included in the education intervention. The nurse unit manager distributed the delirium knowledge survey to all nurses working in the ward at two different time points, September 2017 (to assess the baseline knowledge before the implementation of intervention) and June 2020 (6-months after the completion of the implementation project to assess the effectiveness and sustainability of the knowledge).

Intervention

The three-step education intervention was offered. Nurses were expected to have attended step 1 and step 2 before they could progress to step 3. The education was based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality [19].

The self-directed on-line modules were introduced in September 2018

Nurses on shift attended the formal in-service and informal discussions about using the screening tool and incorporating delirium care in routine clinical practice. The sessions held every week in between September 2018 to March 2019; and

Nurses who had completed the on-line modules and attended the in-service and practice discussions attended a Delirium Care workshop which included simulations. Two workshops were scheduled in 2019 (Feb, 2019 and Oct, 2019).

Study Instrument

The questionnaire utilized in this study has been previously used in a similar study [17]. Consent to use this questionnaire was sought from its original developers (M. Hare personal communication on 26/10/2016). The "knowledge of delirium and its related risk factors questionnaire" has not been validated and its reliability has not been established either however has been widely used [14, 16]. The questionnaire has two sections: a 7-question section for demographic data collection, 35 specific delirium related questions called the knowledge section. In the demographic section the participants provide their age, gender, designation, level of education and years of nursing experience. In the knowledge section participants are asked to identify the definition of delirium in a multiple-choice question, and the seven assessment tools commonly used when screening patients with delirium, dementia, and/or depression. The remaining 28 questions in the knowledge section assess participants general knowledge of delirium (4 on delirium symptoms, 1 on diagnostic tool, 15 on risk factors and 8 on recognising delirium) using Likert scale (agree, disagree or unsure). Independently completed questionnaires were returned to Nurse Unit Manager of the orthopedic unit. The questionnaire did not ask any identifying information from the nurses so the confidentiality could be maintained. Completed questionnaires were crosschecked manually with answer book and entered an excel spreadsheet to construct a database. Correct answers were coded as 1 while an incorrect answer (including unsure) was coded as 0.

The survey was divided in following domains for ease of interpretation of results: 1 Delirium definition (1 question); 2 Screening tool (7 questions); 3 Symptoms (4 questions); 4 Preferred diagnostic tool (1 question); 5. Risk factors (14 questions); 6. Recognising symptoms (8 questions).

Statistical analysis

The construct validity of nurse's knowledge of delirium was assessed using Bayesian exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on responses

obtained from the 35 knowledge-items of the nurse knowledge of delirium survey. The EFA analysis was performed on the survey data obtained prior to the nurse education program that was designed to increase knowledge of delirium. Only 34 of the 35-items for the survey were available for the EFA and CFA, since the last item of the survey had no variability between participants in the post intervention survey.

Following the EFA, the dimensionality of the knowledge construct was confirmed with CFA using only those items with factor loadings of >0.6 in the EFA. We assessed the dimensionality using separate CFA analyses with the pre-program and post-program nurse cohorts. The model fit for the EFA and each CFA was examined using Posterior Predictive (PP) checking of the χ^2-value for the observed-expected correlation matrix, with p>0.05 and a 95% CI including zero each indicating adequate model fit. The R-squared value for each item were also reported to allow assessment of the extent to which each CFA item was related to the underlying knowledge factors. Internal consistency of the construct was assessed using Cronbach's alpha. The acceptable range of values is from 0.70 to 0.90. Known-group validity was assessed by comparing the knowledge scores between enrolled and registered nurses using linear regression with and without adjustment for age and gender. The registered nurses would be expected to have better knowledge scores in the pre-program survey because of their additional training, but not necessarily in the post-program survey given that the education on delirium had been delivered to all nurses in the post-education nurse cohort. The relationship between total knowledge scores (using 35-items), the sum of the knowledge scores from only the items in used in the CFA, and the factor scores obtained from the CFA were examined using Pearson's r correlation coefficient. The difference in total knowledge scores between the pre and post education campaign periods was assessed using an independent t-test.

The EFA and CFA was performed using MPlus (version 8.2; Muthen & Muthen, Los Angeles, CA). All other analysis was performed using Stata version 16.0 (StataCorp, USA). Statistical significance was defined using a 2-tailed Type 1 error rate of alpha=0.05.

Ethical considerations

This study was approved as part of the larger delirium prevention implementation project by our institutional Research Ethics Committee - Project Number: SALHN HREA-204.17.

RESULTS

Participants

Table 1 describes the characteristics of the 2 groups of nurses that participated before and after the nurse delirium education program. The nurses were similar regarding age, gender, time spent in their current position, hours worked per fortnight and years spent nursing. However, there was a higher percentage of registered nurses in the post-education cohort (84.8% vs 67.4%, p=0.047). The mean (±SD) score obtained from the 35 questions on knowledge of delirium was also higher for nurses participating after the delirium education program (25.1±3.3 vs 22.6±3.4 respectively, p<0.001).

Exploratory factor analysis

Table 2 describes the results for the EFA using the data prior to the delirium education program. Each of the models with 2 to 5 factors had satisfactory fit according to 95% CI and p-value for the posterior predictive (PP) check of the χ^2 value. The number of loadings>0.6 were similar for the 2-factor and 1-factor models (12 and 11 respectively) and based on parsimony a 1-factor model was therefore chosen. Table 3 shows the individual factor loadings for the 35 items in the EFA. The 11 items with an absolute value for the loading of >0.6 shown in bold.

Confirmatory factor analysis

Table 4 shows results for the 2 CFA's using the pre and post -delirium education program data. There was an adequate model fit for the 1-factor model with 11 items for both the nurse cohorts (p>0.05 for PP checking of the χ^2 value). The absolute value for most of the factor loadings was greater than 0.4 for each of the 2 models. There was considerable variation in the r-squared values indicating variation in the degree to which each item could explain the variation in the values for the knowledge construct. Items S5-4, S5-5, S5-8, S5-12, and S5-13 each had r-squared values greater than 0.6 for both the pre-education and post-education CFA's indicating these items were strongly related to the underlying knowledge construct. All these items were related to a knowledge of risk factors for delirium.

Internal consistency

The Cronbach's alpha for the 11-items included in the CFA for the pre and post education nurse cohorts was alpha=0.682 and alpha=0.704 respectively indicating an overall respectable level of internal consistency.

Known-group validity

Table 5 shows the unadjusted and age and gender-adjusted associations between total knowledge scores, factor scores and nurse qualification (registered versus enrolled). Within the pre-education group of nurses, the adjusted total survey scores and the factor scores were higher for registered nurses compared with non-registered nurses (p=0.040 and p=-0.032 respectively). However, within the post-education group of nurses, the factor scores were similar for registered nurses and non-registered nurses (Table 5) suggesting the education program removed the generally higher knowledge of delirium that existed between enrolled and registered nurses prior to the program. Conversely, the adjusted total knowledge scores were higher for registered nurses versus enrolled nurses both before and after the intervention (p=0.016 and p=0.030 respectively). These results suggest that the factor scores better reflect knowledge of delirium than the total knowledge scores which likely reflect a higher general knowledge as well as delirium knowledge. Figure 1 shows the linear association between total knowledge scores and the factor scores for the pre and post education nurse cohorts. Following the delirium education intervention, the knowledge and factor scores both increased but the association between the scores weakened. A strong association existed between the knowledge score using the sum of correct responses for the 11-items from the questionnaire used in the CFA and the factor scores for the CFA, both pre and post-education (ρ=0.89 and ρ=0.790 respectively) (Figure 2) indicating that a sum of the correct responses for the 11 items could be used as a proxy for the factor scores and thereby an individual's knowledge of delirium.

Change in 11-item knowledge scores following education

There was a significant increase in the mean (SD) of the sum of correct responses for the chosen 11-items between the pre-education and post-education periods (7.94±1.66 versus 8.89±1.68 respectively; p=0.007).

DISCUSSION

There is currently no psychometrically tested instrument available for the assessment of ward nurses' knowledge of delirium, and their knowledge gap in this specific area is a well-recognised issue[10, 12]. A lack of knowledge is a major factor for nurses failing to recognise delirium in an acute care setting [13, 20], and nurse education is therefore a high priority in recognizing and preventing delirium. An accurate and formal assessment of

their knowledge of delirium and of changes in their knowledge in response to education using validated instruments is also essential to help identify patients with delirium. We therefore validated a new delirium knowledge questionnaire for use amongst nurses using exploratory and confirmatory factor analysis. Amongst the thirty-six delirium related questions taken from an original knowledge questionnaire, eleven were identified as loading strongly onto a single underlying construct in the exploratory factor analysis, and which could therefore be used alone for the purpose of assessing delirium knowledge. In addition, in the confirmatory factor analysis, five or these questions remained strongly associated with the underlying construct in both the pre-intervention or post intervention surveys, and the 11-items together allowed good model fit. Each of the five questions are also established as being specifically related to risk factors of delirium; impaired vision, urinary catheter in-situ, pre-existing dementia, impaired hearing and obesity [4, 21-25]. We can therefore be confident that all 11 items were related to knowledge of delirium and together would be suitable for accurately establishing knowledge of delirium in nurses. In addition, the other unused 25 items which were less strongly associated with the knowledge construct can be thought of as being less specific to delirium and correct responses to these questions might reflect a knowledge in a different aspect of general medical knowledge. In addition to establishing construct validity, our study also established known group validity, with the factor scores being associated with whether nurses were enrolled or registered. Other studies have also reported that registered nurses exhibited greater knowledge and consequently performed better in the knowledge questionaries [26, 27].

Finally, the strong correlation between the 11-item factor scores and the 11-item total knowledge scores suggests that a simple summation of correct responses for the 11 items would provide an accurate assessment of a nurses knowledge of delirium, without the need to create factor scores with more complicated weightings for each item. The weaker correlation with the 35-item total knowledge scores also emphasises that the 35-items likely assess areas of knowledge outside of delirium and would not therefore be suitable for inclusion in a questionnaire that aims to specifically focus on delirium.

Our study also showed a small but significant increase in the knowledge of nurses according to the 11-items following the education campaign, suggesting the effectiveness of the education, as well as further verifying the suitability of the 11-items for assessing delirium knowledge. Our findings of improvement in knowledge in domains of delirium recognition and risk factors are consistent with the study by Detroyer and colleagues however the knowledge wasn't monitored over time [28]. The result of sustained knowledge over-time was only shown in two other studies [14, 15]. Like our study, Grealish et al. also implemented the three-step program which included web-based learning, discussion

group and simulation sessions. However, our education program was bespoke to our needs as it was based on the nationally recommended Delirium Care Guidelines from the Australian Commission of Safety and Quality.

Our study used a rigorous and statistically appropriate approach to establishing the validity of the new knowledge questionnaire including the use of both EFA and CFA, the use of several different measures of validity, and the use of a separate cohort of nurses to perform the CFA. However, our study still had several limitations. Firstly, the sample size was relatively small, with only forty-nine and forty-six nurses used for analysis in the two periods. Our study was not originally designed as a validation study which commonly employ in the order of 200 subjects to establish construct validity. However, the adequacy of model fit and strong factor loadings for the chosen items together with much weaker factor loadings for the non-chosen items suggest that a similar set of items would have also been chosen in a larger study setting, although this requires further verification. Second, although the nurses that performed the pre and post education surveys were not all the same, we did not deliver the post education surveys immediately following the delirium training. Therefore, some delirium knowledge gained during the education program may have been lost. However, if this were the case then the improvement in delirium knowledge scores between the 2 periods would likely have been greater. Finally, in establishing the known-group validity of our tool using the level of nurse qualification as a surrogate for knowledge, we were unable to control for factors that may have confounded this association such as level of education, income, and previous employment.

Conclusion

In summary, we have developed and statistically validated an 11-item knowledge questionnaire to test nurses' knowledge of delirium with face, construct and known group-validity. Use of the validated delirium knowledge questionnaire with just 11 questions may improve uptake in the delivery of nurse surveys to establish delirium knowledge. It may also provide guidance towards the relevant areas of study. Larger cross-sectional studies are still required to confirm the validity of the tool in a clinical setting. Prospective studies should also be developed to establish the usefulness of different education programs at improving nurse's knowledge of delirium.

Table 1. Demographics of Nurses before and after the delirium education intervention

	Pre-education N=49	Post-education N=46	p-value[1]
Age, n (%)			
20-30	15 (30.6)	10 (21.7)	0.167
31-40	10 (20.4)	19 (41.3)	
41-50	14 (28.6)	11 (23.9)	
51+	10 (20.4)	6 (13.0)	
Gender, n (%)			
Female	40 (81.6)	42 (91.3)	0.170
Male	9 (18.4)	4 (8.7)	
Time spent in current position, n (%)			
<6 months	4 (8.2)	5 (10.9)	0.483
6-12 months	1 (2.0)	3 (6.5)	
>12 months	44 (89.8)	38 (82.6)	
Hours worked per fortnight, n (%)			
<40	15 (30.6)	12 (26.1)	0.861
40-64	20 (40.8)	19 (41.3)	
>64	14 (28.6)	15 (32.6)	
Years spent nursing			
5 or less	12 (24.5)	11 (23.9)	0.292
6-12	15 (30.6)	19 (41.3)	
13-20	11 (22.5)	12 (26.0)	
20+	11 (22.5)	4 (8.7)	
Qualification, n (%)			
Enrolled Nurse	16 (32.65)	7 (15.2)	0.047
Registered Nurse	33 (67.35)	39 (84.8)	
Total knowledge score from 35-item questionnaire (maximum=35)	22.6±3.4	25.1±3.3	<0.001

Values are mean±SD unless specified. [1]From independent t-test or chi-squared test.

Table 2. Model fit statistics for exploratory factor analysis with 2 to 5 factors

	No. of parameters	χ^2 95% PP CI	χ^2 p-value	Total No. factor loadings>0.6
1-factor	68	-108.5, 196.9	0.248	11
2-factor	101	-98.1, 194.7	0.313	12
3-factor	133	-98.3, 220.0	0.256	8
4-factor	164	-106.8, 246.9	0.264	6
5-factor	194	-99.1, 264.6	0.247	8

PP CI=Posterior Predictive 95% Confidence Interval

Table 3. Geomin-rotated factor loadings for individual items from the EFA

Section-Question	Loading	Section-Question	Loading	Section-Question	Loading
S1-1	0.472	S4-1	0.434	S5-12	**0.669**
S2-1	-0.204	S5-1	0.238	S5-13	**0.863**
S2-2	0.387	S5-2	-0.427	S5-14	0.124
S2-3	**-0.627**	S5-3	0.442	S6-1	**0.793**
S2-4	-0.244	S5-4	**0.917**	S6-2	-0.006
S2-5	**-0.763**	S5-5	**0.731**	S6-3	0.416
S2-6	0.058	S5-6	0.403	S6-4	0.078
S2-7	-0.130	S5-7	-0.029	S6-5	-0.032
S3-1	0.154	S5-8	**0.798**	S6-6	**0.761**
S3-2	0.554	S5-9	-0.128	S6-7	**-0.677**
S3-3	**0.638**	S5-10	0.170		
S3-4	0.340	S5-11	0.049		

Bold indicates loadings with absolute values >0.6 that were used for CFA.

Table 4: Results of the CFA showing model fit, factor loadings and R-squared for the 11 knowledge items.

	Pre-program data		Post-program data	
χ^2 95% PP CI; p-value	-37.6, 38.6; p=0.474		-37.0, 38.4; p=0.490	
Section-Question no.	**Factor Loading**	**R-squared**	**Factor Loading**	**R-squared**
S2-3	0.442	0.195	0.509	0.259
S2-5	-0.398	0.160	-0.391	0.153
S3-3	0.437	0.191	0.012	0.037
S5-4	0.836	0.699	0.861	0.742
S5-5	0.661	0.437	0.738	0.545
S5-8	0.677	0.458	0.643	0.413
S5-12	0.610	0.373	0.840	0.705
S5-13	0.817	0.668	0.893	0.797
S6-1	0.602	0.362	-0.415	0.172
S6-6	0.629	0.396	0.032	0.103
S6-7	-0.528	0.279	0.383	0.160

R-squared denotes the variance explained in the knowledge construct by each individual question. The 95% PP CI indicates the χ^2 test of model fit for the CFA using Posterior Predictive checking; p>0.05 indicates adequate model fit.

Table 5. Linear Regression analysis for Registered Nurses versus Enrolled Nurses for Total knowledge score and CFA factor scores both before and after the education program.

	Unadjusted		Adjusted[1]	
	B (95 % CI)	**p-value**	**B (95% CI)**	**p-value**
Pre-Education campaign				
Total knowledge score				
Enrolled Nurse	Ref	-	Ref	-
Registered Nurse	1.93	0.062	2.45	0.040
CFA Factor score				
Enrolled Nurse	Ref	-	Ref	-
Registered Nurse	0.202	0.122	0.295	0.032
Post-Education campaign				
Total knowledge score				
Enrolled Nurse	Ref	-	Ref	-
Registered Nurse	3.77	0.016	3.73	0.030
CFA Factor score				
Enrolled Nurse	Ref	-	Ref	-
Registered Nurse	0.118	0.679	-0.080	0.610

[1]Adjusted for age and gender. CFA scores have a mean=0 and SD=1.

FIGURES

Figure 1: Association between total knowledge score from 35-item questionnaire and the 11-item predicted factor scores.

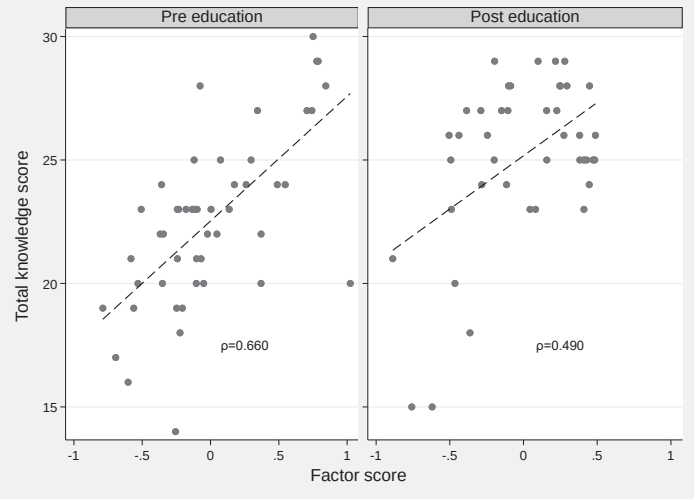
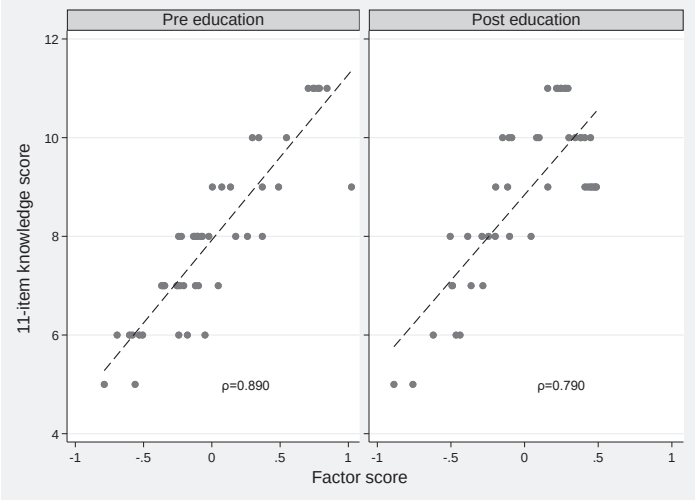


Figure 2: Association between the 11-item knowledge score from the 11 items used for CFA and the 11-item factor scores.



APPENDIX

Nurses' Knowledge of Delirium

The purpose of this questionnaire is to assess nurses' knowledge regarding delirium. Your answers will remain confidential. **Please complete the questionnaire on your own.**

Instructions: **Please answer all questions.** Please respond by filling in the circle using a black pen (eg ☐)

Demographic Data

Your Age (Years) **(A) 20-30; (B) 31-40; (C) 41-50: (D) 51+**	1.1 Answer ☐
Gender **(M = Male, F = Female)**	1.2 Answer
Designation: **(A) = SRN; (B) = CN; (C) = SDN; (D) = RN; (E) = EN**	**1.3 Answer** ☐
Length of time in current position: **(A) = less than 6 months; (B) = 6 to 12 months; (C) = more than 12 months**	1.4 Answer ☐
Working hours per fortnight: **(A) = less than 40; (B) = 40 to 64; (C) = more than 64**	1.5 Answer ☐
Number of years in nursing **(A) = 5 or less; (B) = 6 to 12; (C) = 13 to 20; (D) = more than 20**	1.6 Answer ☐
Qualifications **(choose all that apply)**	1.7 Answers
TAFE/Hospital Based (EN)	O
Hospital Based (RN, General)	O
Hospital Based (RN, Mental Health)	O
Bachelor's Degree (General)	O
Bachelor's Degree (Comprehensive)	O
Post graduate Certificate/Diploma (Mental Health)	O
Post graduate Certificate/ Diploma (Other)	O
Masters Degree / Doctorate	O

SECTION 1: Definition of delirium

Which of the following groups of symptoms best describe or define delirium? (choose the **best** answer):

a)	O	Amnesic, drowsy, sudden onset of incontinence, uncontrolled salivation, disorganised thinking
b)	O	Acute confusion, fluctuating mental state, disorganised thinking, altered level of consciousness.
c)	O	Anxiety, diaphoresis, trembling, muscle weakness, dysphasia, altered arousal level.
d)	O	Slow onset of confusion, memory loss, disorientation, lack of spontaneity, change in personality.

SECTION 2: Identifying Delirium using screening tool

The following rating scales/tools are commonly used to detect certain conditions. Match the tool to the most appropriate condition(s). Note that "None of these" may be the best answer. **You may choose more than one condition for each tool.**

	Delirium	Dementia	Depression	None of these
Mini Mental State Examination (MMSE)	O	O	O	O
Glasgow Coma Scale (GCS)	O	O	O	O
Delirium Rating Scale (DRS)	O	O	O	O
Alcohol Withdrawal Scale (AWS)	O	O	O	O
Confusion Assessment Method (CAM)	O	O	O	O
Beck's Depression Inventory	O	O	O	O
4AT	O	O	O	O

SECTION 3: Symptoms of delirium

Please answer Agree, Disagree or Unsure for the following statements:

Fluctuation between orientation and disorientation is not typical of delirium.	Agree	O	Disagree	O	Unsure	O
Symptoms of depression may mimic delirium.	Agree	O	Disagree	O	Unsure	O
Treatment for delirium always includes sedation.	Agree	O	Disagree	O	Unsure	O
Patients never remember episodes of delirium.	Agree	O	Disagree	O	Unsure	O
Section 4: Preferred diagnostic tool						
A Mini Mental Status Examination (MMSE) is the best way to diagnose delirium.	Agree	O	Disagree	O	Unsure	O
Section 5: Risk factors of delirium	Agree	O	Disagree	O	Unsure	O
A patient having a repair of a fractured neck of femur has the same risk for delirium as a patient having an elective hip replacement.						
Delirium never lasts for more than a few hours.	Agree	O	Disagree	O	Unsure	O
The risk for delirium increases with age.	Agree	O	Disagree	O	Unsure	O
A patient with impaired vision is at increased risk of delirium.	Agree	O	Disagree	O	Unsure	O
The greater the number of medications a patient is taking, the greater their risk of delirium.	Agree	O	Disagree	O	Unsure	O
A urinary catheter in situ reduces the risk of delirium.	Agree	O	Disagree	O	Unsure	O
Gender has no effect on the development of delirium	Agree	O	Disagree	O	Unsure	O
Poor nutrition increases the risk of delirium.	Agree	O	Disagree	O	Unsure	O
Dementia is the greatest risk factor for delirium.	Agree	O	Disagree	O	Unsure	O
Males are more at risk for delirium than females.	Agree	O	Disagree	O	Unsure	O
Diabetes is a high risk factor for delirium.	Agree	O	Disagree	O	Unsure	O
Dehydration can be a risk factor for delirium.	Agree	O	Disagree	O	Unsure	O

Hearing impairment increases the risk of delirium.	Agree	O	Disagree	O	Unsure	O
Obesity is a risk factor for delirium.	Agree	O	Disagree	O	Unsure	O
Section 6: Recognising symptoms						
A patient who is lethargic and difficult to rouse does not have a delirium.	Agree	O	Disagree	O	Unsure	O
Delirium is generally caused by alcohol withdrawal.	Agree	O	Disagree	O	Unsure	O
Patients with delirium have a higher mortality rate.	Agree	O	Disagree	O	Unsure	O
A family history of dementia predisposes a patient to delirium.	Agree	O	Disagree	O	Unsure	O
Behavioural changes in the course of the day are typical of delirium.	Agree	O	Disagree	O	Unsure	O
A patient with delirium is likely to be easily distracted and/or have difficulty following a conversation.	Agree	O	Disagree	O	Unsure	O
Patients with delirium will often experience perceptual disturbances.	Agree	O	Disagree	O	Unsure	O
Altered sleep/wake cycle may be a symptom of delirium.	Agree	O	Disagree	O	Unsure	O

REFERENCES

1. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. *Lancet*. 2014; 383: 911-22. DOI:10.1016/S0140-6736(13)60688-1.

2. Mosk CA, Mus M, Vroemen JP, et al. Dementia and delirium, the outcomes in elderly hip fracture patients. 2017; 12: 421.DOI:10.2147/CIA.S115945.

3. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *J Am Geriatr Soc*. 2001; 49: 1335-40

4. Oberai T, Oosterhoff JHF, Woodman R, et al. Development of a postoperative delirium risk scoring tool using data from the Australian and New Zealand Hip Fracture Registry: an analysis of 6672 patients 2017-2018. *Arch Gerontol Geriatr*. 2021; 94: 104368.DOI:10.1016/j.archger.2021.104368.

5. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.

6. Ahmed S, Leurent B, Sampson EL. Risk factors for incident delirium among older people in acute hospital medical units: a systematic review and meta-analysis. *Age Ageing*. 2014; 43: 326-33. DOI:10.1093/ageing/afu022.

7. Dahlke S, Phinney A. Caring for hospitalized older adults at risk for delirium: the silent, unspoken piece of nursing practice. *J Gerontol Nurs*. 2008; 34: 41-7.DOI:10.3928/00989134-20080601-03.

8. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. *Int Psychogeriatr*. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

9. Irving K, Fick D, Foreman M. Delirium: a new appraisal of an old problem. *Int J Older People Nurs*. 2006; 1: 106-12.DOI:10.1111/j.1748-3743.2006.00017.x.

10. Rice KL, Bennett M, Gomez M, et al. Nurses' recognition of delirium in the hospitalized older adult. *Clin Nurse Spec*. 2011; 25: 299-311.DOI:10.1097/NUR.0b013e318234897b.

11. Fick DM, Hodo DM, Lawrence F, Inouye SK. Recognizing delirium superimposed on dementia: assessing nurses' knowledge using case vignettes. *J Gerontol Nurs*. 2007; 33: 40-7; quiz 8-9. DOI:10.3928/00989134-20070201-09.

12. Inouye SK, Foreman MD, Mion LC, et al. Nurses' recognition of delirium and its symptoms: Comparison of nurse and researcher ratings. *Archives of Internal Medicine*. 2001; 161: 2467-73. DOI:10.1001/archinte.161.20.2467.

13. El Hussein M, Hirst S, Salyers V. Factors that contribute to underrecognition of delirium by registered nurses in acute care settings: a scoping review of the literature to explain this phenomenon. *J Clin Nurs*. 2015; 24: 906-15.DOI:10.1111/jocn.12693.

14. Grealish L, Todd J-A, Krug M, Teodorczuk AJNeip. Education for delirium prevention: Knowing, meaning and doing. 2019; 40: 102622.DOI:10.1016/j.nepr.2019.102622.

15. McCrow J, Sullivan KA, Beattie ERJNet. Delirium knowledge and recognition: A randomized controlled trial of a web-based educational intervention for acute care nurses. 2014; 34: 912-7

16. Toye C, Kitchen S, Hill A, et al. Piloting staff education in Australia to reduce falls in older hospital patients experiencing delirium. 2017; 19: 51-8.DOI:10.1111/nhs.12300.

17. Hare M, Wynaden D, McGowan S, et al. A questionnaire to determine nurses' knowledge of delirium and its risk factors. *Contemp Nurse*. 2008; 29: 23-31.DOI:10.5172/conu.673.29.1.23.

18. Oberai T, Laver K, Woodman R, et al. The effect of an educational intervention to improve orthopaedic nurses' knowledge of delirium: A quasi-experimental study. 2021; 42: 100862

19. Care ACoSaQiH. Delirium Clinical Care Standard. Sydney: ACSQHC, 2016; 1-36

20. Young RS, Hinami K, Arseven A, et al. Hospitalists' lack of knowledge of the Confusion Assessment Method: a barrier to systematic validated delirium surveillance. 2012; 40: 56-62

21. Dovjak P, Iglseder B, Mikosch P, et al. Treatment and prevention of postoperative complications in hip fracture patients: infections and delirium. 2013; 163: 448-54

22. Feinkohl I, Winterer G, Pischon TJDmr, reviews. Obesity and post-operative cognitive dysfunction: a systematic review and meta-analysis. 2016; 32: 643-51

23. Freter S, Dunbar M, Koller K, et al. Risk of pre-and post-operative delirium and the delirium elderly at risk (DEAR) tool in hip fracture patients. 2015; 18: 212

24. Schor JD, Levkoff SE, Lipsitz LA, et al. Risk factors for delirium in hospitalized elderly. 1992; 267: 827-31

25. Yang Y, Zhao X, Dong T, et al. Risk factors for postoperative delirium following hip fracture repair in elderly patients: a systematic review and meta-analysis. 2017; 29: 115-26

26. Panagiotopoulou K, Kerr SMJJoAN. Pressure area care: an exploration of Greek nurses' knowledge and practice. 2002; 40: 285-96

27. Christensen MJKTNNZ. Nurses' knowledge of delirium: A survey of theoretical knowing. 2016; 7: 11-8

28. Detroyer E, Dobbels F, Debonnaire D, et al. The effect of an interactive delirium e-learning tool on healthcare workers' delirium recognition, knowledge and strain in caring for delirious patients: a pilot pre-test/post-test study. 2016; 16: 17.DOI:10.1186/s12909-016-0537-0.

CHAPTER 10

Does implementation of a tailored intervention increase adherence to a National Safety and Quality Standard? A study to improve delirium care

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BACKGROUND

Hip fractures are serious injuries commonly experienced by older adults. Delirium in patients with hip fractures is a multifactorial disorder most frequently seen post-operatively (incidence ranging from 35% to 65%). Hospitals in Australia are required to meet eight standards including the comprehensive care standard to be able to maintain their accreditation. It includes actions related to falls, pressure injuries, nutrition, mental health, cognitive impairment and end-of-life care. Delirium prevention was identified as an area for improvement in our Orthopaedic unit in a Level 1 University Trauma Centre in Australia. This implementation research project aimed to understand the efficacy of a delirium prevention intervention within an existing orthopaedic speciality care system.

Expected outcome:
Implementation of the tailored intervention will increase adherence to National Safety and Quality Health Service Standards, thereby reducing rate of delirium.

Methods
This was a prospective cohort study using interrupted time series design conducted among patients admitted with a hip fracture. Clinical staff caring for patients with hip fracture in an acute care setting within a level 1 trauma centre in Adelaide, South Australia participated in the project. In brief intervention included; education, environmental restructuring, change champions, infographics and audit feedback reports. The primary outcome of interest was rate of delirium. Secondary outcome was compliance with the use of delirium 4AT screening tool, duration of delirium and hospital length of stay.

Results
The rate of change per month in patients with delirium decreased significantly by 19.2%. There was no significant change observed in trend for duration of delirium and length of hospital stay between pre-intervention and post-intervention phase. A significant increase in the use of screening tool was observed from 4.7% in the pre-intervention phase to 33.6% in the post-intervention phase.

Conclusion
Translation of evidence-based intervention model incorporating well considered implementation strategies had mixed impact on the decreasing the rate of delirium. The scheduled hospital accreditation enhanced the use of validated screening tool to recognise delirium. This project highlights the importance of aligning implementation goals with the wider goals of the organisation as well as making clinicians accountable by consistent auditing.

INTRODUCTION

Hip fractures are serious injuries commonly experienced by older adults [1]. Hip fractures place a considerable burden upon the healthcare system because of the associated increase in morbidity. The total annual hospital costs associated with hip fractures in UK in 2012 – 2013 were estimated at £ 1.1 billion [2]. Patients with a hip fracture are at risk of functional, physical, and cognitive decline [3]. Poor general health, older age, existing cognitive impairment and decreased physical activity level increase the risk of complications associated with hip fractures. Delirium in patients with hip fractures is a multifactorial and chronic disorder most frequently seen post-operatively [4-6]. Incidence of delirium ranges from 35% to 65% in patients who have undergone surgery for a hip fracture repair [7]. Delirium, an acute decline in attention and cognition, is a common, serious, expensive and potentially preventable complication for hospitalised older people [8]. Delirium during the hospital stay results in a worse prognosis, longer stay in hospital, higher mortality rates, worse functional recovery and higher institutionalization rates after hospital discharge [9-12]. The total cost associated with delirium in Australia alone was estimated to be $A8.8 billion (£4.3 billion) in 2016–2017 with approximately 35% of those costs related to direct costs and 65% to the value of healthy life lost [13].

In Australia, The National Safety and Quality Health Service Standards (NSQHS) have recently included comprehensive care standards [14]. The Comprehensive Care Standard integrates patient care processes to identify patient needs and prevent harm. It includes actions related to falls, pressure injuries, nutrition, mental health, cognitive impairment and end-of-life care. Hospitals in Australia are required to meet all the eight standards including the comprehensive care standard to be able to maintain their accreditation.

Delirium prevention was identified as an area for improvement in our Orthopaedic unit in a Level 1 University Trauma Centre in Australia. A retrospective quality assurance case note audit (n=200) was completed to determine the frequency of delirium screening in the same orthopaedic unit of a level 1 trauma centre in Australia (Unpublished data). The results of this unpublished audit suggested that less than 1% of patients with a hip fracture received pre-operative cognitive assessment on admission and only 9% of patients received cognitive screening with a validated tool post-operatively. Findings of the audit also suggested that care was not consistent with Delirium Clinical Care standard as specified by Australian Commission on Safety and Quality in Healthcare. Much work was required in this setting to achieve adherence to the National Standards.

As part of a broader program of implementation research we conducted focus groups to identify clinicians' (nurses, allied health and medical doctors') perceptions of the barriers

and enablers to recognizing, assessing, actively preventing and managing delirium symptoms in hip fracture patients admitted to an orthopaedic setting [15]. In addition we explored the knowledge, skills and attitudes of orthopaedic nurses towards caring for older hip fracture patients with delirium by application of a knowledge, skills and attitude survey. The results of this survey demonstrated gaps in nursing knowledge regarding characteristics of delirium and its risk factors and use of appropriate screening tool to measure delirium. Based on the local barriers identified this study aimed to implement and evaluate the effect of an intervention to prevent delirium in patients with hip fracture admitted to an acute orthopaedic ward.

Implementation research is defined as the scientific study of methods to promote the systematic uptake of research findings and other evidence based practices into routine practice to improve the quality and effectiveness of health services and care [16]. The goal of implementation research was to understand how evidence based health interventions are made feasible and integrated into the organisational, social and policy environment [17]. This implementation research project aimed to understand the efficacy of a delirium prevention intervention within an existing orthopaedic speciality care system.

Expected outcomes:

Implementation of the tailored intervention will increase adherence to National Safety and Quality Health Service Standards (NSQHS), thereby the reducing rate of delirium.

Methods

The Knowledge to Action framework (KTA) developed by Graham et al. provides the foundation for this project [18 19]. In preparatory work, issues were identified and knowledge was synthesized to develop strategies to mitigate the identified issues [15, 20]. The results led to the development of the current project which began with the phase of adapting the knowledge to the local context and identifying barriers to knowledge uptake. It continued with selecting, tailoring and implementing knowledge translation interventions.

Project design

This was a prospective cohort study using interrupted time series design conducted among patients admitted with a hip fracture. Interrupted time series (ITS) analysis

has been deemed as a preferred study design particularly when a randomized trial is unfeasible or unethical [21]. Strengths of ITS include the ability to control for secular trends in the data before the intervention, the ability to evaluate outcomes using aggregated data, clear graphical presentation of data, the ability to stratify analyses, and the ability to determine both intended and unintended consequences of interventions [22]. In the pre-intervention phase patients were monitored in between July 2017 to August 2018. The intervention was implemented in between September 2018 to December 2018 and evaluated between October 2018 and December 2019. Details of the protocol have been published previously [23]. This project was undertaken to improve the compliance towards National Safety and Quality Health Service Standards. Since this is recommended practice which needs to be followed seeking consent to participate in the study was not necessary. All data relating to patients is routinely collected and was recorded for study purposes as de-identified data.

Participants and setting

Clinical staff (geriatricians and orthopaedic doctors, nurses, and allied health) caring for patients with a hip fracture in an acute care setting within a level 1 trauma centre participated in the project. The intervention was applicable for patients admitted to the hospital following hip fracture. The interventions were targeted at all staff caring for the patients with a hip fracture however the primary outcome of interest relates to patients aged 65 years and over with diagnosis of hip fracture admitted to the orthopaedic ward.

Intervention

Improving the implementation of evidence based practice and public health depends on behaviour change. Specific intervention strategies, informed by contemporary behaviour change techniques were selected to address the identified barriers [24]. In brief this included; education, environmental restructuring, change champions, infographics and audit feedback reports. Selected intervention approaches used and intervention timeline is presented in **Figure 1.**

The barriers identified in focus groups, knowledge gap identified through the survey and possible interventions resulted in a number of different strategies. The steering group met to agree on the intervention and intervention strategies suggested within the focus groups were prioritised.

The intervention model included education (online, in-person training and change champions), restructure (adaptation of existing documentation, improving accessibility of documents) and quality management (audit and feedback, reminders through infographics). The majority of the nurses (80%) completed cognitive impairment education. Five change champions were recruited to assist with quality management strategies however the commitment of the change champions remained unclear. Two designated delirium boards were created on either side of the clinical area which were resourced with infographics.

Evaluation of intervention

Using an interrupted time series approach over 28 months we assessed whether introduction of the intervention reduces the rate of delirium in patients with hip fractures identified via the use of a validated tool in screening delirium [25]. At the beginning of the pre-intervention phase (July 2017 to March 2018) one week's worth of data was collected at monthly intervals due to limited resources. However, to ensure more representative data we collected data weekly from April 2018 to December 2019. We also examined the length of hospital stay, duration of delirium episode and the prevalence of the use of a validated tool to screen for delirium. The effects of the program were measured by assessing the rate of delirium and the prevalence of screening tool use over time. Data on the estimated delirium rate were obtained by regular assessment of hip fracture patients using the 4AT screening tool. This aggregated data were analysed using an interrupted time series approach which allowed detection of any significant shifts in rate of delirium at the time of the intervention implementation and for any changes in rate trends following the intervention.

Sample size

The required sample size for the study was calculated in relation to our primary outcome of rate of delirium. Assuming an underlying delirium prevalence of 30% and approximately 150 patients assessed per month (n=45 with delirium) a sample size of 15 monthly data points for both pre and post intervention would provide approximately 81% power to detect an incidence rate reduction of 30% in delirium using a 2-tailed test and a type 1 error rate of alpha=0.05. In relation to our secondary outcome of compliance with the use of delirium screening tool (4AT); the assessment of approximately 6 hip fracture patients in any single day at monthly intervals to assess compliance with screening assessment (i.e. n=15x6=90 patients in each pre and post intervention period) provided approximately

84% power to detect a difference in screening rates from 20% to 40% between pre and post intervention.

Statistical analysis

Analysis was performed using Poisson regression in Stata version 15.2 (StataCorp, College Station, USA). The rate of delirium amongst hip fracture patients and duration of delirium was assessed using the ITS approach described above with aggregated data for each month. We assessed the immediate impact of the intervention by comparing the intercepts of the estimated linear slopes for the pre-intervention and post-intervention period. Changes in the trends in delirium rates were assessed by including a term for the change in slope from pre to post intervention in the Poisson regression model. Differences in the length of hospital stay between pre and post intervention were also assessed using Poisson regression, as were differences in the duration of delirium between pre and post intervention.

RESULTS

During the 121 week study period, 437 patients were admitted with hip fracture with mean age of 84 years (ranging from 66 years to 102 years). Among those included, 152/437 (34.7%) were in pre-intervention period and 285/437 (65.2%) were in post-intervention period. The majority of the patients in the pre-intervention (70.3%) and post-intervention period (61.1%) were females. Most of patients were residing in their own homes before sustaining a hip fracture (pre-intervention period- 71.7% and post-intervention period 66.3%). No pre-existing cognitive impairment was noted in 100/152 patients (65.8%) in the pre-intervention period and 208/285 (73%) in the post-intervention period.

Delirium Rate

The rate of change per month in patients with delirium decreased significantly by 19.2% (IRR 0.808, 95% CI: 0.78-0.83; p<0.001) **(Figure 2).** There was a 4.1% reduction per month from September 2018 in the number of patients with delirium (IRR 0.959, 95% CI: 0.95-0.97; p < 0.001). There was no level change at September 2018 (i.e. no immediate change in number of patients with delirium (IRR 0.959, 95% CI: 0.91 – 1.28; p< 0.405)) instead a gradual decrease in rate of delirium was observed.

Length of stay

The trend for mean LOS between pre-intervention and post-intervention phase was unchanged (IRR 0.972, 95% CI: 0.92 – 1.03; p< 0.335) **(Figure 3).**

Duration of delirium

There was no significant change observed in trend for duration of delirium between pre-intervention and post-intervention phase (IRR 0.96, 95% CI: 0.90- 1.02; p< 0.221) **(Figure 4).**

Compliance with the use of screening tool

There was a significant quadratic growth in the proportion of patients screened with the use of validated screen tool following the intervention (p<0.001) **(Figure 5).** Overall, the use of screening tool following the intervention increased by 28.9%, increasing from 4/120 (4.7%) pre-intervention to 45/136 (33.6%) post-intervention (p<0.001).

DISCUSSION

Statement of principal findings

This study describes an implementation project which evaluated the effect of introduction of a delirium screening and prevention intervention on rate of delirium in patients with hip fractures. The goal of the implementation strategies was to bridge the gap between the current clinical practice and best practice guidelines as described by delirium recognition, prevention and management guidelines. Our study showed that using well considered implementation strategies had a mixed impact on the outcome. In our study, the rate of patients with delirium decreased significantly by 19.2%. A significant overall increase in the use of screening tool was observed from 4.7% in the pre-intervention phase to 33.6% in the post-intervention phase. However, implementation of the intervention had no statistically significant effect on length of hospital stay and duration of delirium.

Strengths and Limitations

Our study had some limitations. This was a single centre study, so our sample size was smaller than would be expected in multi-centre studies. As a result, findings may not be generalizable to other settings or populations. However, in ITS studies, sample size

calculations are related to the estimation of the number of observations or time points at which data are collected rather than the number of sites and patients. As such, we included a higher number of data points (i.e., 30 data points before and 30 data points after the introduction of the intervention) than recommended (20 data points before/after) to ensure enough power to detect a change and to account for threats to internal validity [21]. Furthermore, data points were set closer together (i.e., each data point represented a weekly period rather than four weeks) to increase validity [21]. We recognize that the ITS methodology is inherently more susceptible to validity threats than would be a more rigorous RCT design. However, for this project, this methodology is most appropriate as ITS design is particularly relevant where the outcome is obtained from routinely collected data [26]. Another limitation of our study is that the number of patients in pre-intervention period (152) is lower than post-intervention period (285). Initially, one week's worth of data was collected at monthly intervals due to limited resources. In order to ensure more robust data we decided to collect data every week to ensure that it is representative of the true prevalence of delirium. However, in ITS studies, the number of observation or time points is an important factor instead of number of patients [21].

Interpretation within the context of the wider literature

Our findings are consistent with the other studies investigating delirium prevention and management summarised in our systematic review [20]. Other researchers also report that even with careful consideration of system design, function and end-user perspective, interventions can have no effect on the outcomes [27] . We made efforts to engage multidisciplinary clinicians (nurses, doctors and allied health) via focus groups as well as during development of the intervention model to ensure that all the barriers and enablers were addressed [15]. Despite the efforts from all levels, our project showed mixed results. Similarly, the evidence that support user involvement improves outcomes remains limited and mixed [28]. During the duration of this project the hospital went through scheduled accreditation in November, 2019. Due to the building pressure of the accreditation, a senior nurse was allocated to the "use of delirium screening tool" as a portfolio project which lead to regular auditing and feedback in clinical handover meetings. Consequently, this made a positive impact on use of the delirium screening tool and 80% compliance was observed in October, 2019. Woods et al and colleagues describe in their narrative review that, interventions that fit with strategic goals and organisational objectives at senior management level are more likely to be successful [28]. The review also states that improvement activities need to be aligned with staff priorities and improvement objectives. Ling et al suggest using an audit as a means of both supporting change

and reminding clinicians that they are being held to accountable. Ling and colleagues describe this approach as "harder edges" [29].

Implications for policy, practice and research

Although the project showed mixed results, we were able to highlight that engagement from the senior management level has potential to create significant improvements. As part of delirium prevention initiate we have developed a "Delirium Risk Score" using data from Australian and New Zealand Hip Fracture Registry. Delirium risk score has potential to be used as a stand-alone risk scoring tool. We would like to engage senior management of our organisation on validating the Delirium Risk Score for predicting postoperative delirium.

Conclusion

Translation of evidence-based intervention model incorporating well considered implementation strategies had mixed impact on the decreasing the rate of delirium. The scheduled hospital accreditation enhanced the use of validated screening tool to recognise delirium. This project highlights the importance of aligning implementation goals with the wider goals of the organisation as well as making clinicians accountable by consistent auditing.

Figure 1: Description and timing of the elements of the intervention

Figure 2: Monthly proportion patients with delirium

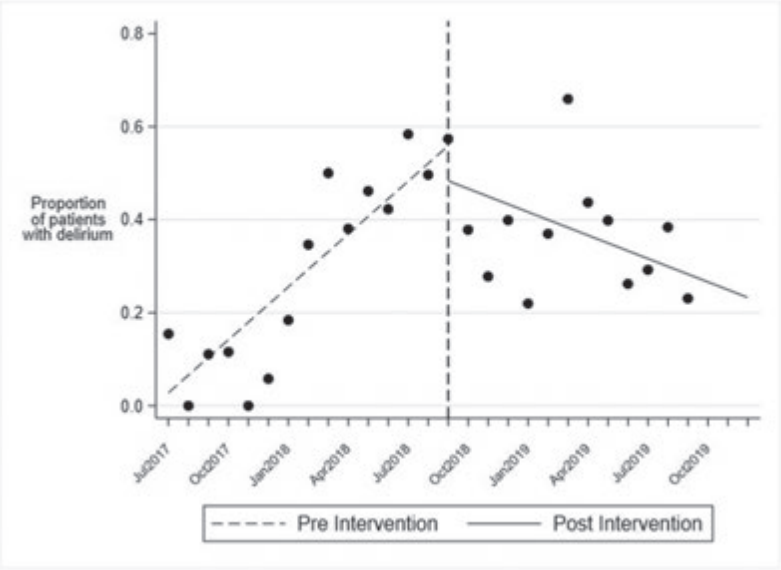


Figure 3: Mean monthly length of stay

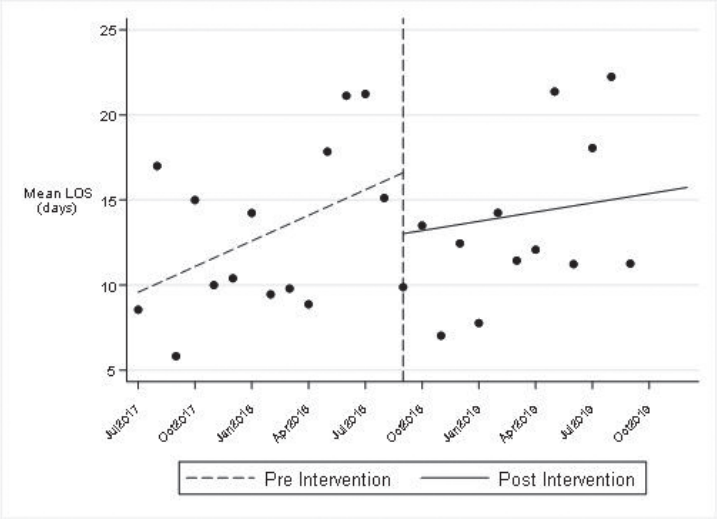


Figure 4: Monthly mean duration of delirium

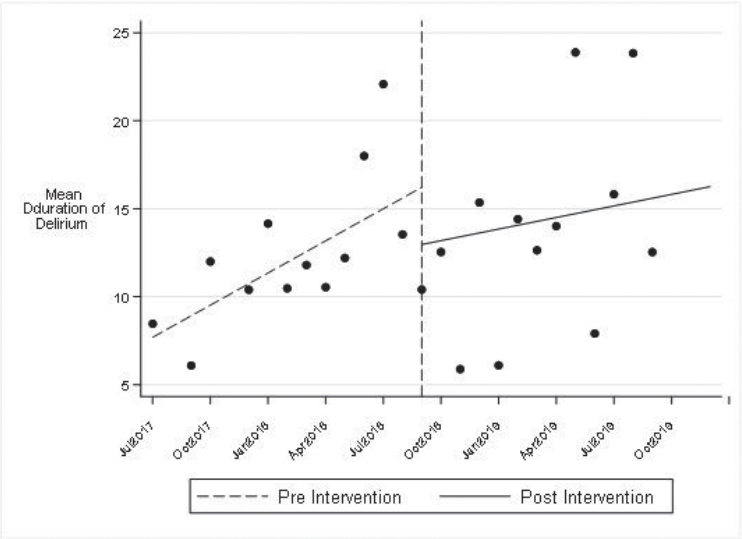
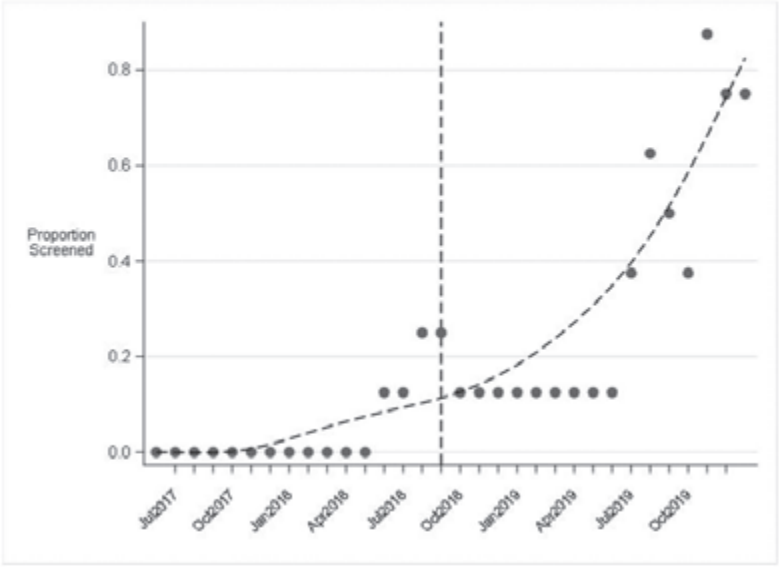


Figure 5: Compliance with the use of screening tool (4AT)



REFERENCES

1. Marks R, Allegrante JP, Ronald MacKenzie C, Lane JM. Hip fractures among the elderly: causes, consequences and control. *Ageing Res Rev.* 2003; 2: 57-93.DOI:10.1016/s1568-1637(02)00045-4.

2. Leal J, Gray AM, Prieto-Alhambra D, et al. Impact of hip fracture on hospital care costs: a population-based study. *Osteoporos Int*. 2016; 27: 549-58.DOI:10.1007/s00198-015-3277-9.

3. Hirsch CH, Sommers L, Olsen A, et al. The natural history of functional morbidity in hospitalized older patients. *Journal of the American Geriatrics Society.* 1990; 38: 1296-303

4. Brauer C, Morrison RS, Silberzweig SB, Siu AL. The cause of delirium in patients with hip fracture. *Arch Intern Med*. 2000; 160: 1856-60.DOI:10.1001/archinte.160.12.1856.

5. Edlund A, Lundstrom M, Brannstrom B, et al. Delirium before and after operation for femoral neck fracture. *J Am Geriatr Soc*. 2001; 49: 1335-40.DOI:10.1046/j.1532-5415.2001.49261.x.

6. Cole MG, McCusker J. Delirium in older adults: a chronic cognitive disorder? *International Psychogeriatrics*. 2016; 28: 1229-33.DOI:10.1017/S1041610216000776.

7. Marcantonio ER, Flacker JM, Wright RJ, Resnick NM. Reducing delirium after hip fracture: a randomized trial. *J Am Geriatr Soc*. 2001; 49: 516-22

8. Cole MG. Delirium in elderly patients. *Am J Geriatr Psychiatry.* 2004; 12: 7-21

9. Power C, Duffy R, Bates H, et al. The detection, diagnosis, and impact of cognitive impairment among inpatients aged 65 years and over in an Irish general hospital - a prospective observational study. *Int Psychogeriatr.* 2017; 29: 1879-88.DOI:10.1017/S1041610217001326.

10. Francis J, Martin D, Kapoor WN. A prospective study of delirium in hospitalized elderly. *JAMA*. 1990; 263: 1097-101.DOI:10.1001/jama.1990.03440080075027.

11. McCusker J, Cole M, Dendukuri N, et al. Delirium in older medical inpatients and subsequent cognitive and functional status: a prospective study. *CMAJ*. 2001; 165: 575-83

12. Rockwood K, Cosway S, Carver D, et al. The risk of dementia and death after delirium. *Age Ageing*. 1999; 28: 551-6.DOI:10.1093/ageing/28.6.551.

13. Pezzullo L, Streatfeild J, Hickson J, et al. Economic impact of delirium in Australia: a cost of illness study. 2019; 9: e027514.DOI:10.1136/bmjopen2018-027514.

14. Care ACoSaQiH. Implementing the Comprehensive Care Standard: A conceptual model for supporting comprehensive care delivery. Sydney: ACSQHC; 2018: Australian Commission on Safety and Quality in Health Care, 2018; 1-28

15. Oberai T, Killington M, Laver K, et al. "Just another piece of paperwork": perceptions of clinicians on delirium screening following hip fracture repair elicited in focus groups. *Int Psychogeriatr.* 2018: 1-8

16. Eccles MP, Mittman BS. Welcome to implementation science. BioMed Central, 2006

17. Hodgson NA, Gitlin LN. The role of implementation science in behavioral intervention research. *Behavioral intervention research: designing, evaluating and implementing New York: Springer Publishers*. 2016:

18. Graham ID, Logan J, Harrison MB, et al. Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions*. 2006; 26: 13-24.DOI:10.1002/chp.47.

19. Wilson KM, Brady TJ, Lesesne C, Translation NWGo. An organizing framework for translation in public health: the Knowledge to Action Framework. *Prev Chronic Dis*. 2011; 8: A46

20. Oberai T, Laver K, Crotty M, et al. Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. *Int Psychogeriatr*. 2018; 30: 481-92.DOI:10.1017/S1041610217002782.

21. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. *International journal of epidemiology*. 2017; 46: 348-55.DOI:10.1093/ije/dyw098.

22. Penfold RB, Zhang F. Use of Interrupted Time Series Analysis in Evaluating Health Care Quality Improvements. *Academic Pediatrics*. 2013; 13: S38-S44.DOI:http://dx.doi.org/10.1016/j.acap.2013.08.002.

23. Oberai T, Laver K, Killington M, et al. No longer lost in translation: study protocol for preventing delirium post hip fracture. *European Journal for Person Centered Healthcare*. 2019; 7: 98-105. DOI:10.5750/ejpch.v7i1.1607.

24. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011; 6: 42.DOI:10.1186/1748-5908-6-42.

25. Bellelli G, Morandi A, Davis DH, et al. Validation of the 4AT, a new instrument for rapid delirium screening: a study in 234 hospitalised older people. *Age and ageing*. 2014; 43: 496-502.DOI:10.1093/ageing/afu021.

26. Sanson-Fisher RW, D'Este CA, Carey ML, et al. Evaluation of systems-oriented public health interventions: alternative research designs. *Annu Rev Public Health*. 2014; 35: 9-27.DOI:10.1146/annurev-publhealth-032013-182445.

27. Donaldson A, Finch CF. Planning for implementation and translation: seek first to understand the end-users' perspectives. *Br J Sports Med*. 2012; 46: 306-7.DOI:10.1136/bjsports-2011-090461.

28. Dixon-Woods M, McNicol S, Martin G. Ten challenges in improving quality in healthcare: lessons from the Health Foundation's programme evaluations and relevant literature. 2012; 21: 876-84. DOI:10.1136/bmjqs-2011-000760.

29. Ling T. *How do you get clinicians involved in quality improvement?: an evaluation of the health Foundation's engaging with quality initiative: a programme of work to support clinicians to drive forward quality*. The Health Foundation; 2010.

SUMMARY

The aim of the research presented in this thesis was to reduce incidence of delirium through implementation of a tailored intervention and increase adherence to delirium screening assessment. We specifically focused on designing and implementing a tailored intervention to improve delirium care in an existing orthopaedic surgical unit.

Part 1 was aimed at enhancing our understanding of delirium within Australian and New Zealand population we analysed data from the Australian and New Zealand Hip fracture registry.

Chapter 1

We wanted to determine associations between delirium and health outcomes using the Australia and New Zealand population-based hip fracture patient registry (ANZHFR). Of the 4,904 patients with complete data and included in the analysis, 1,789 (36.5%) experienced delirium during their hospital stay. Patients with delirium also had a higher rate of in-hospital mortality (adjusted HR=1.76; 95% CI=1.24, 2.49; p<0.001), a higher rate of long-term mortality (adjusted HR=1.30; 95% CI=1.15, 1.48; p<0.001) and a higher odds of discharge to an aged care facility (adjusted OR=1.24; 95% CI=1.04, 1.48; p=0.019). In conclusion, we observed a high rate of postoperative delirium in a representative sample of hospitalized hip-fracture patients in Australia and New Zealand. Rates of hospital mortality, longer hospital stay and discharge to residential aged care were considerably higher in patients with delirium than in those without confirming that higher post-surgery surveillance is required in this population.

Chapter 2

We utilized the same data to identify predictors of delirium using univariate and multivariate logistic regression. Delirium developed in 2599/6672 (39.0%) hip fracture patients. Seven independent predictors of delirium were identified; age above 80 years (OR=1.6 CI 1.4-1.9; p=0.001), male (OR=1.3 CI 1.1-1.5; p=0.007), absent pre-operative cognitive assessment (OR=1.5 CI 1.3-1.9; p=0.001), impaired pre-operative cognitive state (OR=1.7 CI 1.3 -2.1; p=0.001), surgery delay (OR=1.7 CI 1.2-2.5; p=0.002) and mobilisation day 1 post-surgery (OR=1.9 CI 1.4-2.6; p=0.001). We then designed and validated a delirium risk score for predicting delirium following surgery for a hip fracture using the seven identified predicting factors. The C-statistics for the training and validation

datasets were 0.74 and 0.75, respectively. Calibration was good ($\chi 2=35.72$ (9); $p<0.001$). The Delirium Risk Score when used alone as a risk predictor, had good diagnostic accuracy (C-statistic=0.742) indicating its potential for use as a stand-alone risk scoring tool which could assist clinicians in identifying high risk patients requiring higher levels of observation and post-surgical care**.**

Chapter 3

The Australian and New Zealand hip fracture data was also utilized to externally validate a machine learning algorithm developed by our colleagues in United States *Massachusetts General Hospital, Harvard Medical School*. In total, 6,270 patients were operatively treated following a hip fracture in the ANZHFR. In comparison to the developmental cohort for the SORG Delirium ML algorithm, the ANZHFR population differed significantly ($p<.05$) on all included variables, including event rate (i.e. postoperative delirium, 39.2% validation cohort, 28.5% developmental cohort, $p<0.001$). Despite the differences, the algorithm performed well on discrimination (c-statistic 0.74) and Brier-score (0.22), but tend to miscalibration (intercept -0.28, slope 0.52). Initial results from external validation of the SORG ML algorithm on the ANZHFR should be interpreted with caution for the applicability to the Australian and New Zealand population due to heterogeneity between the developmental and validation cohort. Further studies are needed to identify the predictor measurement heterogeneity between the two cohorts and future studies are needed to externally validate the SORG ML algorithm for predicting postoperative delirium in elderly hip fracture patients in a prospective collected sample.

Chapter 4

Delirium is a neuropsychiatric disorder which is preventable. Our systematic review suggested that multicomponent intervention strategies can have positive effects on preventing delirium in patients with a hip fracture. After inclusion and exclusion criteria were applied, 9 full text articles were included in the review. The studies reported the following effect on delirium:

We pooled data regarding incidence of delirium from the three randomised controlled trials. The effect was in favour of the intervention group (odds ratio 0.64, 95% CI 0.46 to 0.87). All three RCT's reported that duration of delirium was shorter in the intervention group than in the usual care group (mean 2.9 vs 3.1 days, median 3 vs 4 days, median 5.0 vs 10.2 days). Studies reported shorter duration of delirium within the intervention

group. Four studies reported on severity of delirium with two research groups reporting significant results. We concluded that early engagement of multidisciplinary staff, including geriatricians, who address the risk factors of delirium as soon as the patient presents to the acute care environment, are a key element of a successful delirium prevention program.

Chapter 5

Multidisciplinary staff play a significant role in improving delirium care. Although orthopaedic clinicians aim to provide efficient care to patients experiencing delirium related symptoms, they do so in absence of structured screening, assessment and multidisciplinary team approach. Hence, we conducted focus groups interviews understand clinicians from orthopaedic speciality perceptions in relation to recognition, diagnosis and management of delirium. A total number of 17 individuals (14 Nurses, 1 Geriatric Registrar, 1 Nursing Manager and 1 Speech Therapist) participated in the focus groups. Four major themes were identified: 1. Delirium is important but can be hard to recognize and validate 2. Ambiguity on the use of delirium screening tool 3. Need of designated delirium care pathway 4. Vital role of family. Despite the initial lack of agreement on use of the objective tool to screen delirium, nurses in the focus group interviews did propose several ways that formal delirium screening could be included in routine nursing duties and existing nursing documentation. Addressing the identified barriers before attempting to change practice is a key in this area.

Chapter 6

This study evaluated three components of delirium care guidelines as performed in day to day practice comparing an orthopaedic trauma unit in Australia with one in the Netherlands.

We also observed that vast differences in environmental set-up, nursing practices as well as family engagement were observed between an orthopaedic unit in Australia and the Netherlands. We concluded that practice guidelines developed in isolation without promoting the initiatives of patient-centered care, family engagement and ongoing rigorous evaluation are more likely to be unsuccessful.

Chapter 7

We selected Specific intervention strategies informed by contemporary Behaviour Change Wheel Framework to address the identified barriers. The clinical goal of the intervention was to bridge the gap between the current and best practice guidelines in delirium recognition, prevention and management. In brief this included; education, environmental restructuring, change champions, infographics and audit feedback reports.

Chapter 8

Education was one of the major components of the intervention. We showed that a multi-step educational intervention had a positive but small impact on nurses' knowledge of delirium. The median (IQR) knowledge scores for domain 5 (risk factors) and domain 6 (recognising delirium) was higher at post intervention compared to pre-intervention.

However, the training was not mandatory, and uptake of the training was not as high as we would have hoped. Nurses within our cohort most preferred ward-based education which was combination of formal knowledge delivery and informal practice discussion. Future studies should focus on programs which are ward-based including variety of teaching styles.

Chapter 9

We were also able to develop and validate a shorter (11-item) knowledge survey to test nurse's knowledge of delirium. We did so by utilizing the responses obtained from the 35 knowledge-items of the knowledge survey. The construct validity of the survey was assessed using Bayesian exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). In the EFA, each model had satisfactory fit according to 95% CI and the posterior predictive p-value for χ^2 was >0.05 indicating good fit. Cronbach's alpha for the 11-items for the final construct for the pre and post education data indicated moderate internal consistency. Significant increase in the mean (SD) of the sum of correct responses for the 11-items between the pre- and post-education periods was observed. An 11-item questionnaire can not only help increase survey participation rates but also to our knowledge this is the first validated survey to assess nurse's knowledge of delirium.

Chapter 10

In our prospective study the primary outcome of interest was rate of delirium. Secondary outcome was compliance with the use of delirium 4AT screening tool, duration of delirium and hospital length of stay. The rate of change per month in patients with delirium decreased significantly by 19.2% and a significant increase in the use of screening tool was observed from 4.7% in the pre-intervention phase to 33.6% in the post-intervention phase. Translation of evidence-based intervention model, incorporating well considered implementation strategies, had mixed impact on decreasing the rate of delirium. During the duration of this project the hospital went through scheduled accreditation in November 2019. Due to the building pressure of the accreditation, a senior nurse was allocated to the "use of delirium screening tool" as a portfolio project which lead to regular auditing and feedback in clinical handover meetings. Consequently, this made a positive impact on use of the delirium screening tool and 80% compliance was observed in October 2019.This project highlights the importance of aligning implementation goals with the wider goals of the organisation as well as making clinicians accountable by consistent auditing.

The mixed impact of our knowledge translation project brought the international collaboration within this PhD to life. As an extension to this collaboration, we will be focussing on externally validating the Delirium Risk Score for predicting postoperative delirium. In addition, we are exploring the concept of Machine Learning. Promising alliance has been established to further develop a machine learning algorithm for preoperative prediction of postoperative delirium in elderly hip fracture patients. The data used for developing this algorithm was derived from The National Surgical Quality Improvement Program (NSQIP), United States. we have already used ANZHFR data to externally validate the above-mentioned machine learning algorithm. We are planning to also use the NSQIP data to externally validate the logistic regression prediction score presented in this thesis.

SAMENVATTING

Het doel van de onderzoeken gepresenteerd in dit proefschrift, is het reduceren van de incidentie van een delier door het implementeren van een interventie 'op maat' en het verbeteren van het gebruik van delier screening tools. De focus ligt hierbij op de ontwikkeling en implementatie van een op maat gemaakte interventie ter verbetering van de zorg voor patiënten met een delier op de orthopedische afdeling.

Deel 1 heeft als doel het verbeteren van ons begrip van een delier binnen de Australische en Nieuw-Zeelandse populatie gebruikmakend van data uit het Australische en Nieuw-Zeelandse heupfractuur patiënten register.

Hoofdstuk 1

In dit hoofdstuk is er gekeken naar de associatie tussen een delier en de bijbehorende patiënten-uitkomsten op basis van de Australische en Nieuw-Zeelandse heupfractuur patiëntenregistratie (ANZHFR). Van de 4.904 geïncludeerde patiënten, van wie de volledige data beschikbaar was, kregen 1.789 (36,5%) patiënten een delier tijdens hun ziekenhuisopname. Patiënten met een delier hadden daarbij een hogere kans op mortaliteit tijdens deze ziekenhuisopname (gecorrigeerde HR=1.76; 95% CI=1.24, 2.49; p<0.001), een hogere lange-termijn mortaliteit (gecorrigeerde HR=1.30; 95% CI=1.15, 1.48; p<0.001) en een hogere kans op ontslag naar een verpleeghuis (gecorrigeerde OR=1.24; 95% CI=1.04, 1.48; p=0.019). Kortom, er werd een hoog percentage postoperatief delier waargenomen in een representatieve groep van patiënten die werden opgenomen in het ziekenhuis vanwege een heupfractuur in Australië of Nieuw-Zeeland. De opnameduur, het aantal patiënten dat werd ontslagen naar een verpleeghuis en de mortaliteit tijdens ziekenhuisopname waren aanzienlijk hoger voor patiënten met een delier dan de patiënten zonder delier, wat bevestigt dat betere postoperatieve bewaking op dit gebied noodzakelijk is voor deze populatie.

Hoofdstuk 2

Wij hebben dezelfde data gebruikt om risicofactoren voor een delier te identificeren met behulp van een univariate en multivariate logistische regressie. Van de patiënten met een heupfractuur ontwikkelden 2.599 van de 6.672 (39%) patiënten een delier. Zeven onafhankelijke risicofactoren voor een delier werden geïdentificeerd; leeftijd > 80 jaar (OR=1.6 CI 1.4-1.9; p=0.001), mannelijk geslacht (OR=1.3 CI 1.1-1.5; p=0.007), afwezigheid

van preoperatieve cognitieve screening, (OR=1.5 CI 1.3-1.9; p=0.001), verslechterde preoperatieve cognitie (OR=1.7 CI 1.3 -2.1; p=0.001), uitstel van operatieve behandeling (OR=1.7 CI 1.2-2.5; p=0.002) en mobilisatie op dag 1 postoperatief (OR=1.9 CI 1.4-2.6; p=0.001).

Op basis van deze zeven risicofactoren hebben wij een gevalideerde delier risico score ontwikkeld om een delier na een heupoperatie te kunnen voorspellen. De C-statistiek voor de training en validatie van de datasets waren respectievelijk 0.74 en 0.75. De kalibratie was goed ($\chi 2=35.72$ (9); $p<0.001$). Wanneer de De Delier Risico Score op zichzelf wordt gebruikt als een risico voorspeller, heeft deze een goede diagnostische accuratesse (C-statistiek=0.742). Dit bevestigt de potentie van een dergelijke 'op zichzelf staande' tool die artsen kan ondersteunen bij het identificeren van hoog-risico patiënten die een hogere postoperatieve zorgbehoefte hebben.

Hoofdstuk 3

De data vanuit de Australische en Nieuw-Zeelandse heup fractuur patiëntenregistratie werd ook gebruikt voor de externe validatie van een machine learning algoritme, welke werd ontwikkeld door onze collega's in de Verenigde Staten vanuit het *Massachusetts General Hospital, Harvard Medical School.* In totaal werden er 6.270 patiënten geopereerd aan een heupfractuur vanuit de ANZHFR voor deze studie geincludeerd. Het cohort waarop het SORG Delirium ML algoritme werd ontwikkeld, bleek bij vergelijking met de ANZHFR populatie significant te verschillen ($p<.05$) voor alle geïncludeerde variabelen, waaronder de incidentie (bv. postoperatief delier, 39.2% validatie cohort, 28.5% ontwikkelingscohort, $p<0.001$). Ondanks de verschillen, scoorde het algoritme goed op discriminatie (c-statistiek 0.74) en de Brier-score (0.22), maar had een tendens tot miskalibratie (intercept -0.28, slope 0.52). De initiële resultaten van de externe validatie van het SORG ML algoritme op de ANZHFR moet zorgvuldig geïnterpreteerd worden voor de toepasbaarheid op de Australische en Nieuw-Zeelandse populatie vanwege de heterogeniteit tussen het ontwikkelingscohort en de validatieset. Meer onderzoek is noodzakelijk om de invloed van de heterogeniteit tussen twee cohorten te identificeren. Daarnaast zijn toekomstige studies nodig om het SORG ML algoritme voor het voorspellen van een postoperatief delier voor oudere patiënten met heupfracturen in ook een prospectieve dataset extern te valideren.

Hoofdstuk 4

Een delier is een neuropsychologische afwijking die te voorkomen is. Onze systematic review laat zien dat interventie strategieën op meerdere componenten een positief effect kunnen hebben op de preventie van een delier voor patiënten met een heupfractuur. Na het toepassen van de inclusie- en exclusiecriteria werden er negen full-tekst artikelen geïncludeerd in de review. De studies lieten de volgende uitkomsten zien op het gebied van een delier.

Wij hebben data over de incidentie van een delier vanuit drie randomized controlled trials (RCT's) gebundeld. Het effect liet betere uitkomsten zien voor de interventie groep (odds ratio 0.64, 95% CI 0.46 - 0.87). Alle drie RCT's lieten zien dat de duur van een delier korter was voor de interventie groep dan in de controlegroep (gemiddelde 2.9 vs 3.1 dagen, mediaan 3 vs 4 dagen, mediaan 5.0 vs 10.2 dagen). De studies lieten een kortere duur van een delier zien in de interventie groep. Vier studies rapporteerden over de ernst van een delier met twee studiegroepen met significante resultaten. Hieruit concludeerden wij dat het vroeg betrekken van een multidisciplinair team, inclusief geriaters, die de risicofactoren van een delier herkennen zodra een patiënt zich presenteert op de spoedeisende hulp, een belangrijk element zijn voor een succesvol delier preventie programma.

Hoofdstuk 5

De aanwezigheid van een multidisciplinair team speelt een significante rol voor de verbetering van zorg voor patiënten met een delier. Ondanks dat orthopedisch chirurgen het doel hebben om efficiënte zorg te leveren voor patiënten met symptomen van een delier, doen zij dit zonder de aanwezigheid van een structurele screening en beoordeling door een multidisciplinair team. Daarom hebben wij interviews verricht onder zorgverleners om een beter begrip te krijgen van hun perceptie op het gebied van het herkennen, de diagnose en de behandeling van een delier. In totaal werden er 17 individuen (14 verpleegkundigen, 1 AIOS geriatrie, 1 verpleegkundig afdelingshoofd en 1 logopedist) gevraagd om deel te nemen in een focusgroep. Vier belangrijke thema's werden geïdentificeerd: 1. Een delier is belangrijk, maar kan soms lastig zijn om te herkennen en valideren, 2. Er is een ambiguïteit in het gebruik van delier screening tools, 3. Er is noodzaak voor een zorgpad voor patiënten met een delier, 4. De rol van familie is enorm belangrijk.

Ondanks de afwezigheid van overeenstemming over het gebruik van een objectieve delier screening tool, werden er in de focusgroep interviews meerdere voorstellen gedaan door de verpleegkundigen om een formele delier screening toe te voegen aan de taken van verpleegkundigen en deze screening te documenteren in het bestaande verpleegkundige systeem. Het aanstippen van mogelijke problemen waar men tegen aan kan lopen bij het doorvoeren van deze verandering is van belang.

Hoofdstuk 6

Deze studie evalueerde drie componenten van delier richtlijnen die worden gebruikt in de dagelijkse praktijk, waarbij een orthopedische trauma afdeling in Australië wordt vergeleken met een vergelijkbare afdeling in Nederland.

Hierin werd geobserveerd dat er verschillen zijn in de opzet van het zorgsysteem, verpleegkundige praktijk en ook de betrokkenheid van familie tussen de trauma unit in Australië en Nederland. Hieruit concluderen wij dat de huidige richtlijnen, zonder toevoeging van een patiëntgerichte behandeling, de betrokkenheid van familie en zorgvuldige evaluatie, over het algemeen minder succesvol zijn.

Hoofdstuk 7

Wij hebben een specifieke interventie geselecteerd middels het 'raamwerk voor gedragsverandering' (contemporary behaviour change wheel framework) om problemen te identificeren. Het doel van deze interventie was om het gat op te vullen tussen de huidige en de gouden standaard richtlijnen voor de herkenning, preventie en behandeling van een delier. Kort samengevat hield dit in: educatie, herstructurering van het systeem, leiders die de verandering stimuleerden, infographics en interview feedback rapporten.

Hoofdstuk 8

Educatie is een van de hoofdcomponenten voor een interventie. Wij hebben aangetoond dat een stapsgewijze onderwijs interventie een positieve, maar kleine, impact heeft op de verpleegkundige kennis over een delier. De mediane (IQR) kennis scores voor domein 5 (risicofactoren) en domein 6 (herkenning van delier) was hoger na de interventie vergeleken met daarvoor.

Desalniettemin, de training was niet verplicht en de opkomst van de training was niet zo hoog als wij hadden gehoopt. Verpleegkundigen in onze cohort hadden de voorkeur voor afdelingsspecifieke educatie, wat een combinatie was van formele kennis overdracht en informele patiënten discussies. Toekomstige studies zouden zich moeten focussen op programma's die afdeling georiënteerd zijn en verschillende onderwijsstijlen bevatten.

Hoofdstuk 9

Wij hebben een kortere (11-punts) kennis vragenlijst ontwikkeld en gevalideerd om de kennis van verpleegkundigen op het gebied van een delier te kunnen testen. Deze test hebben wij ontwikkeld door de resultaten van een 35-punts kennis vragenlijst te gebruiken.

De validiteit van de vragenlijst werd beoordeeld door de Bayesian exploratory factor analyse (EFA) en de confirmatory factor analyse (CFA). In de EFA had elk model een zeer acceptable 95% CI en een goed passende negatief voorspellende p-waarde, welke <0.05 was voor χ^2. De Cronbach's alpha voor de 11 items die de basis vormen van de pre- en post-educatie, lieten een gemiddelde interne samenhang zien. Een significante stijging van het gemiddelde (SD) van de som van goede antwoorden van de 11-punts vragenlijst tussen de pre- en post-educatie periode werd geobserveerd. De 11-punts vragenlijst kan niet alleen helpen met het verbeteren van de participatie van verpleegkundigen, maar dit is zover wij weten ook de eerste gevalideerde vragenlijst om de kennis van verpleegkundigen over een delier te beoordelen.

Hoofdstuk 10

In onze prospectieve studie was de primaire uitkomstmaat de incidentie van een delier. De secondaire uitkomstmaat was de compliantie van het gebruik van de delirium 4AT screening tool, de duur van een delier en de duur van de ziekenhuisopname. De verandering van het aantal patiënten met een delier daalde significant naar 19.2% en een significante stijging in het gebruik van de screening tool werd gerapporteerd van 4.7% in de pre-interventie fase naar 33.6% in de post interventie fase. Translatie naar het evidence-based interventie model, met weloverwogen implementatiestrategieën, had een wisselende impact op het verlagen van de incidentie van een delier. Tijdens dit project onderging het ziekenhuis een geplande accreditatie in november 2019. Vanwege deze accreditatie werd een 'senior' verpleegkundige specifiek op dit project gezet, wat resulteerde in meer aandacht voor dit project, door regelmatig overleg en feedback tijdens

patiënten overdrachten. Dit heeft geresulteerd in een toename in het gebruik van de delier screenings tool en een compliantie van 80% werd geobserveerd in oktober 2019. Dit project laat het belang van implementatie doelstellingen zien vanuit een organisatie, maar ook vanuit de artsen die verantwoordelijk zijn voor het continu verbeteren van de zorg.

Vanuit dit kennisproject kwam er tijdens deze PhD een internationale samenwerking tot stand. Vanuit deze samenwerking hebben wij gefocust op de externe validatie van de Delier risico score voor het voorspellen van een postoperatief delier en zijn wij bezig met het ontdekken van het concept van Machine Learning. Een veelbelovende samenwerking is opgezet om een machine learning algoritme te ontwikkelen voor een preoperatieve voorspelling op de kans op een delier voor patiënten met een heup fractuur. De data die gebruikt is voor dit algoritme komt vanuit het 'Nationale Chirurgische Kwaliteit Verbetering Programma' (NSQIP) vanuit de Verenigde Staten. De data vanuit het ANZHFR hebben wij reeds gebruikt voor de externe validatie van het bovengenoemde machina learning algoritme. Het doel is om de data van het NSQIP ook te gebruiken ter externe validatie van het logistische regressie predictie score die reeds eerder genoemd is in deze thesis.

GENERAL DISCUSSION AND CONCLUSIONS

The major strength of this thesis is the wide variety of study designs used to improve understanding of delirium and consequently reduce the incidence of delirium. The retrospective studies utilizing the data from Australian and New Zealand Hip Fracture Registry are the first large cohort studies which aimed at understanding predictors and consequences of delirium. Furthermore, well considered process models as well behaviour change techniques were applied to develop the intervention. The large prospective cohort of consecutive patients was an additional strength of the data. We also developed quasi-experimental methodology to assess the efficacy of educational intervention. Additionally, we validated the delirium knowledge survey which is first delirium knowledge survey to be validated. By developing a shorter validated knowledge survey, we have laid a foundation for research in the relation to assessing nurse's knowledge of delirium.

This thesis is also limited by its weaknesses. We were not able to perform a randomized controlled trial to determine the efficacy of our tailored intervention due to ethical considerations as the delirium assessment was already standardized in our institution. However, we choose Interrupted time series methodology for our prospective study which is an appropriate study design when a randomized trial is not feasible or is unethical. Strengths of interrupted time series include the ability to control for secular trends in the data before the intervention, the ability to evaluate outcomes using aggregated data, clear graphical presentation of data, the ability to stratify analyses, and the ability to determine both intended and unintended consequences of interventions.

We can conclude that multicomponent interventions can have positive impact in reducing incidence of delirium in patients with hip fractures. However, even a well-considered intervention will only have small or mixed impact on the outcome unless the implementation goals are aligned with the wider goals of the organisation. This thesis highlights the importance of making clinicians accountable by rigorous evaluations and auditing. The increase in the use of screening tool to recognise delirium during the accreditation period for our institution aligned the improvement goals of our orthopaedic unit with the wider goals of the hospital hence the clinical staff did not require any nudging to complete the documentation. The accreditation activity also made clinicians accountable for their practice therefore they felt responsible to complete every required documentation for the allocated patients. Education was an integral part of our intervention bundle and we learnt through the course of this research is that the most attended education sessions were the informal in-services sessions held during the double staff times within the ward. The least attended was the half-day delirium

workshop organised in the education centre. For the informal in-service the staff did not have to leave their work environment and didn't get disrupted during the education session as it was double staff time, so someone was looking after their allocated patient; both these factors contributed to high attendance of these sessions. On the other hand, staff were expected to attend the half-day delirium workshop in their own time which may have been contributing for the least attendance. Therefore, in future we'll be providing staff allocated time to attend education sessions and education mandatory which'll be counted towards their professional development.

While we have come a step closer in reducing incidence of delirium and in the use of the objective screening tool, there is still room for improvement. The potential of using the delirium risk score as a stand-alone tool has provided us another opportunity to further improve delirium screening. We aim to engage with senior management of our organisation on validating the Delirium Risk Score for predicting postoperative delirium. We have already formed a continuous improvement program team within our unit. The team includes an academic, allied health clinician, emergency department clinician, senior nurse and ortho-geriatric doctor. The aim of this team is to improve early recognition of delirium and consequently implement prevention strategies which mitigate the identified risk factors. Through this thesis we learnt the significance of engagement from the senior management level is required to create significant and sustainable improvements in a clinical environment. Therefore, the team will regularly report to Chief Executive Officer of the hospital and seek support wherever needed. Through this thesis, we have also laid the foundation of promising global collaborations between three different continents (Australia, United States and Europe). The aim of the global collaboration is to share data so that efficient machine learning algorithms can be developed and prospectively validated to improve delirium care. As we have only been able to show impact of incidence of delirium, future research should focus on evaluating if systematic interventions have any significant impact on severity of delirium and duration of delirium. More research is also necessary to understand efficacy of multicomponent interventions for treatment of delirium.

APPENDICES

Portfolio

List of Publications

Acknowledgements

About the Author

PORTFOLIO

PortfolioPhD student: **T. Oberai**
PhD student: **T. Oberai**
PhD period: **2016-2024**
PhD Supervisors: **Prof. G.M. Kerkhoffs & Prof. R.L. Jaarsma**

PHD Training	**Year**
Training	
Secondary School	1993-1999
Bachelor in Physiotherapy	1999-2004
Postgraduate Diploma	2011-2012
Clinical Physiotherapist appointment	2007-2012
Academic Physiotherapist appointment	2014-present
Master Classes/Workshops	
Delirium Masterclass	2017
New technologies and changing behaviours	2018
Continuous Improvement program	2021-2022
Healing through Compassion with Dr Gabor Mate	2022
Mental Health First Aider	2022
Advancing women in Healthcare Leadership	2023
Courses	2018-2020
Endnote - Advanced Features	
English Writing for International Students	
Finding journals for publication -	
HDR Induction Seminar	
Introduction to Statistical Analysis	
Keeping up to date: tracking current research	
Mixed Research Methods	
NHMRC Projects Presentation	
NVivo - Advanced features	
Planning Your PhD	
Ways of Thinking About Publishing	
Word - Managing Long Documents	
Writing for the Sciences	
PhD with a Focus: Student Workshop	
Other	
Weekly Research meetings Orthopaedic Department	2015 - present
Supervising	
MD research Students	2018-present

Presentations and (Inter)national Conferences

- **Multicomponent Interventions to prevent delirium in hospitalized older patients with hip fracture: A systematic review**
  - Presentation: Australian Orthopaedic Association, SA Branch Meeting, 2017
  - Poster: Fragility Fracture Network Congress, 2017
- **Exploring the Knowledge, Skills and Attitude of Orthopaedic Nurses towards caring for Older Hip Fracture Patients with Delirium**
  - Presentation: Fragility Fracture network Congress, 2017 Malmo, Sweden
  - Presentation: Orthopaedic Department convocation, 2018 Adelaide, South Australia
  - Presentation: Australasian Delirium Society Conference, 2018 Melbourne, Australia
- ***"Just another piece of paperwork": perceptions of clinicians on delirium screening following hip fracture repair elicited in focus groups***
  - Poster: Australasian Orthopaedic Trauma Society, 2018 Melbourne, Australia
- **A comparison of delirium care practices in hospitalised older hip fracture patients in Adelaide, Australia and Amphia, Netherlands**
  - Poster: International Psychogeriatric Association Conference, 2019 Santiago Compostela, Spain
- **Lost in translation: multidisciplinary care for patients with hip fractures experiencing delirium**
  - Presentation: Fragility Fracture Network Congress, 2022 Melbourne, Australia

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LIST OF PUBLICATIONS

- **Oberai T**, Lizarondo L, Jaarsma R (2017) Effectiveness of multi-component interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review protocol. JBI Database System Rev Implement Rep 15:259-268
- **Oberai T**, Laver K, Crotty M, Killington M and Jaarsma R (2018) Effectiveness of multicomponent interventions on incidence of delirium in hospitalized older patients with hip fracture: a systematic review. Int Psychogeriatrics 30:481-492
- **Oberai T**, Killington M, Laver K, Crotty M and Jaarsma R (2018) "Just another piece of paperwork": perceptions of clinicians on delirium screening following hip fracture repair elicited in focus groups. *Int Psychogeriatrics*:1-8
- **Oberai T**, Laver K, Killington M, Woodman R, Crotty M and Jaarsma R (2019) "No longer lost in translation: study protocol for preventing delirium post hip fracture." *European Journal for Person Centered Healthcare 7.1* (2019): 98-105.
- Kenyon-Smith T, Nguyen E, **Oberai T** and R. Jaarsma (2019) Early Mobilization Post-Hip Fracture Surgery. *Geriatric Orthopaedic Surgery Rehabilitation*
- **Oberai T**, Crotty M, Jaarsma and Kerkhoffs G (2020) A comparison of delirium care practices in hospitalised older hip fracture patients in Australia and Netherlands Osteoporosis International (Vol. 31, No. SUPPL 1)
- Wormald JS, **Oberai T**, Branford-White H, et al (2020) Design and establishment of a cancer registry: a literature review. ANZ J Surgery 90:1277-1282
- **Oberai T**, Laver K, Woodman R, Crotty M and Jaarsma R (2021) Does implementation of a tailored intervention increase adherence to a National Safety and Quality Standard? A study to improve delirium care. Int J Qual Health Care 33
- **Oberai T**, Oosterhoff JHF, Woodman R, Doornberg J, Kerkhoffs G and Jaarsma R (2021) Development of a postoperative delirium risk scoring tool using data from the Australian and New Zealand Hip Fracture Registry: an analysis of 6672 patients 2017-2018. Arch Gerontology Geriatrics 94:104368
- Oosterhoff JHF, Karhade AV, **Oberai T**, Franco-Garcia E, Doornberg J and Schwab J (2021) **Prediction of Postoperative** Delirium in Geriatric Hip Fracture Patients: A Clinical Prediction Model Using Machine Learning Algorithms**.** Geriatric Orthopaedic Surg Rehabilitation 12:21514593211062277
- **Oberai T**, Woodman R, Laver K, Crotty M, Kerkhoffs G and Jaarsma R (2022) Is delirium associated with negative outcomes in older patients with hip fracture: analysis of the 4904 patients 2017-2018 from the Australian and New Zealand hip fracture registry**.** ANZ J Surgery 92:200-205
- Oosterhoff J, **Oberai T**, Karhade A, Doornberg J, Kerkhoffs G, Jaarsma R, Schwab and Heng, M (2022) Does the SORG Orthopaedic Research Group Hip Fracture

Delirium Algorithm Perform Well on an Independent Intercontinental Cohort of Patients with Hip Fractures Who Are 60 Years or Older? Clinical Orthopaedics and Related Research: May 10, 2022 - Volume - Issue - 10.1097/CORR.0000000000002246

- Lin DY, Woodman R, **Oberai T**, Brown B, Morrison C, Kroon H, Jaarsma R. Association of anesthesia and analgesia with long-term mortality after hip fracture surgery: an analysis of the Australian and New Zealand hip fracture registry. Reg Anesthesia Pain Med. 2022 Sep 22:rapm-2022-103550

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CURRICULUM VITAE

Tarandeep (Taran) Kaur Oberai was born in the city of Jalandhar, India on February 15Th, 1981. Taran spend all her childhood and completed her primary, secondary, and undergraduate degree in Jalandhar. She moved to London in October 2004 after completing her undergraduate degree in Physiotherapy. This was her first time travelling and it came as a culture shock to say the least. Whilst it was a shock to the system it also opened her eyes to a world like she had never imagined. Taran completed the registration process to practice a physiotherapist in UK whilst raising her baby girl. She started her first job in a stroke unit for an acute hospital in West London in January 2007. Working in a public healthcare system which was accessible to everyone unlike in India felt like a dream. It was steep learning curve for Taran, and she was coached by some of excellent leaders and mentors in the industry. In London, she had opportunity to work in some of the best institutions like Guys and St Thomas hospital, Barts and Royal London Hospital and St Marys Hospital. In 2012, Taran completed Post Graduate Diploma from Loughborough in Back care management in healthcare. In the same year, she was offered a job in Royal Adelaide Hospital which dictated a move to Adelaide, Australia. In November 2014, Taran got opportunity to back-fill a maternity leave position for 6 Months in Department of Orthopaedic and Trauma Surgery as an orthopaedic physiotherapist/ research coordinator. This is where Taran's curiosity was nurtured by Prof. Jaarsma and some of the other senior Colleagues like Dr Tamblyn and Dr Jadav. Prof. Jaarsma inspired Taran to see a theme in the research projects Taran was collaborating on. Consequently, her PhD was born (supervised By Prof. Jaarsma and Prof. Kerkhoffs and co-supervised by Prof. Crotty and Prof. Doornberg). This PhD has given some lifetime opportunities to Taran which she would have never imagined given the humble beginnings she had in a small town in India. Taran passion in research continues and she feels empowered to create influence in areas of Indigenous health research, accessible healthcare systems for rural Australia and health services research.

A