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SHORT COMMUNICATION

Antenatal magnesium sulphate for preventing cerebral palsy: An economic evaluation of the impact of a quality improvement program

Amy Keir[1,2,3], Alice Rumbold[1,2], Emily Shepherd[1,2], Sarah Mcintyre[4], Charlotte Groves[3], Angela Cavallaro[3], Caroline Crowther[5] and Emily Callander[6]

[1]SAHMRI Women and Kids, South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia

[2]Adelaide Medical School and the Robinson Research Institute, The University of Adelaide, Adelaide, South Australia, Australia

[3]Women's and Babies Division, Women's and Children's Hospital, North Adelaide, South Australia, Australia

[4]Cerebral Palsy Alliance Research Institute, University of Sydney, Sydney, New South Wales, Australia

[5]Liggins Institute, University of Auckland, Auckland, New Zealand

[6]School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Correspondence: Associate Professor Amy Keir, Women's and Babies Division, Women's and Children's Hospital, 72 King William Road, North Adelaide, SA 5006, Australia.
Email: amy.keir@adelaide.edu.au

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Previous work demonstrated that implementing a quality improvement (QI) program improves the uptake of guideline-recommended antenatal magnesium sulphate, a critical intervention known to reduce cerebral palsy risk. Here we estimate potential cost savings attributable to the improved uptake. By expanding coverage from 63 to 83% of eligible women, we estimated that five children potentially would not have received a diagnosis of cerebral palsy, a potential cost saving of $AU4.8 million in lifetime healthcare costs. Our findings strengthen the case for embedding QI approaches in perinatal care to reduce the incidence of cerebral palsy.

KEYWORDS

magnesium sulphate, cerebral palsy, quality improvement, cost-benefit analysis

INTRODUCTION

In Australia, the rate of prenatally and perinatally acquired cerebral palsy (CP) is 1.4 per 1000 live births, with preterm birth being the most significant risk factor for CP.[1] As there is no known cure for CP, its prevention and reduction in severity are top priorities. Antenatal magnesium sulphate is one of few interventions during pregnancy or the first month of life with high-certainty evidence for CP prevention.[2] Several studies have reported on the cost-effectiveness of magnesium sulphate for CP prevention.[3,4] Cahill found that for every 10 000 women at risk of preterm birth treated with magnesium sulphate, regardless of whether they gave birth preterm or not, $US1.8 million were saved, and 52 quality-adjusted life years (QALYs) were gained.[3] Bickford showed that magnesium sulphate treatment enabled savings of $CAD112 602 for each QALY gained and $CAD1 554 198 for each case of CP prevented.[4] Despite this evidence of efficacy[5] and cost-effectiveness,[3,4] persistent gaps in the implementation of magnesium sulphate into perinatal care remain. For example, the Australian and New Zealand Neonatal Network (ANZNN) 2017 report suggests that only 66% of preterm babies born at <30 weeks' gestation bi-nationally were exposed to antenatal magnesium sulphate.[6]

Quality improvement (QI) approaches have been used with varying degrees of success to overcome barriers to translating evidence into perinatal practice.[7,8] The ongoing challenges of translating research evidence into everyday clinical practice are well known.[9] A frontline clinician-led QI program was implemented to increase the use of antenatal magnesium sulphate for CP prevention using a standard plan-do-study-act model. After the establishment of this QI program, an average of 86% of babies born at <30 weeks' gestation were exposed to antenatal magnesium sulphate (October 2018 to March 2021) compared with a historical baseline rate of 63% (January 2013 to September 2018).[10] Providing proof of the value of QI programs, particularly with context-specific cost-effectiveness data, is invaluable in resource-constrained healthcare settings. Therefore, our study aimed to estimate the number of children who likely would not have had CP and the associated cost savings if uptake of antenatal magnesium sulphate had been at a rate equivalent to post-implementation of this program.

MATERIALS AND METHODS

An economic evaluation simulating a counterfactual scenario using individual patient-level data was performed. Modelling was used to estimate the number of children with a diagnosis with CP that could have been prevented and the associated cost savings if the rate of magnesium sulphate use before the QI program (January 2013 to September 2018) had been equivalent to that after implementation (October 2018 to March 2021).

Analysis

A hypothetical base population was created from the monthly number of births <30 weeks' gestation at our centre between January 2013 and September 2018. The actual number of babies exposed to antenatal magnesium sulphate each month was utilised. From reported individual participant data meta-analysis, the percentage of babies born at <30 weeks' gestation who would later develop CP was estimated to be 6.4% for those exposed to magnesium sulphate and 9.1% for those not exposed.[5] Monte Carlo simulation[11] was used to randomly assign babies in the study population to have CP or not. This estimated the number of babies expected to have CP with the actual rates of magnesium sulphate use from January 2013 to September 2018. The discounted lifetime costs associated with CP were then assigned to each baby predicted to have CP, obtained from a Danish registry study.[12] For this model, the costs of administering magnesium sulphate were estimated, and all costs were converted to 2019 Australian dollars. To model the counterfactual scenario, Monte Carlo simulation was used to assign the proportion of babies in this same period who would have been exposed to antenatal magnesium sulphate exposure if use had hypothetically been at post-QI program implementation rates. Again Monte Carlo simulation was used to randomly assign babies to have CP or not have CP based upon the percentages reported previously[5] and set costs as described earlier. All analysis was generated using SAS software (version 9.4 Copyright © 2020 SAS Institute Inc.).

Ethics approval

The study was approved by the Women's and Children's Hospital Network Human Research Ethics Committee (approval number: 1030A/6/2021).

RESULTS

The estimated total cost of magnesium sulphate treatment was $AU20 496 for the 501 babies born from January 2013 to September 2018. The total lifetime costs associated with the estimated 47 children with subsequent CP were $AU44 791 064; of this, $AU5 212 830 was incurred by hospitals and $AU720 001 in pharmaceutical costs. Under the counterfactual scenario, there would have been an estimated five fewer children with CP. In this scenario, the estimated total cost of the magnesium sulphate use was $AU28 020, whereas the lifetime costs associated with CP were estimated to be $AU40 026 058: $AU4 658 273 in hospital costs and $AU643 405 in pharmaceutical expenses (Table 1). Total savings would have been $AU4 765 006 if these five occurrences of CP were averted.

DISCUSSION

We found that if uptake of antenatal magnesium sulphate for CP prevention in the approximately six years before the QI program

TABLE 1 Outcomes and costs of prior rates of exposure to magnesium sulphate compared with increased exposure to magnesium sulphate through quality improvement

	Actual care: 2013–2018 62% coverage	Counterfactual scenario: 2013–2018 85% coverage equivalent to levels with active implementation
Babies born <30 weeks' gestation, *N*	501	501
Magnesium sulphate exposure (%)	62	85
Children with cerebral palsy, *N*	47	42
Cost of magnesium sulphate (AU$)	20 496	28 020
The total lifetime cost of cerebral palsy discounted (AU$)	44 791 064	40 026 058
Lifetime cost of hospitalisations associated with cerebral palsy discounted (AU$)	5 212 830	4 658 273
Lifetime cost of primary care associated with cerebral palsy discounted (AU$)	790 502	706 406
Lifetime cost of pharmaceuticals associated with cerebral palsy discounted (AU$)	720 001	643 405
Lifetime cost of specialised early intervention and pre-schooling support services associated with cerebral palsy discounted (AU$)	22 613 333	20 207 660
Lifetime cost of specialised education associated with cerebral palsy discounted (AU$)	7 234 234	6 464 635
Lifetime cost of housing associated with cerebral palsy discounted (AU$)	8 220 635	7 346 099

had been at post-program implementation rates, five children potentially would not have CP in our perinatal centre. The societal, economic and healthcare impacts of reducing this number of children with CP are substantial.[13] Continued implementation of evidence into practice is required, and healthcare workers must focus on active work. QI is one method of doing this through a systematic continuous approach that aims to solve problems in healthcare, improve service provision and ultimately provide better outcomes for patients and families.[14]

In 2011, the proportion of eligible pregnant women at our perinatal centre receiving antenatal magnesium sulphate increased from 30% (2010) to 73%. It was maintained across 2012–2013[15] and attributed to the centre participating in the Australian and New Zealand Working to Improve Survival and Health (WISH) for babies born very preterm implementation project.[16] However, once the WISH project was completed, we observed that exposure decreased to approximately 50–60% across 2016–2017, with no other notable changes occurring in the centre at this time. Without continued investment in resources to support frontline staff to use QI as part of routine healthcare delivery, the uptake of antenatal magnesium sulphate may decrease again. The cost of this QI program was approximately $AU151 060 across three years, primarily used to employ a midwifery lead at 0.5 full-time equivalent, with funds sourced externally. Without an ongoing commitment by the local healthcare system itself for QI, sustainability is likely to remain elusive.[6]

This study is unique, as no cost-effectiveness studies have been reported outside of North American settings to date,[3,4] nor have any reports of cost savings attributable to increased use of magnesium sulphate for CP prevention been published.

Our study is limited by its retrospective nature and our inability to identify actual numbers of children with CP with certainty. However, the South Australian (SA) CP Registry provides preliminary data that support our modelling estimates. Approximately 30% of children with CP in South Australia were born at <32 weeks' gestation.[17] Data from the SA CP Register reported nine (2013) and four (2014) children with a history of preterm birth at <32 weeks' gestation. Unfortunately, more detailed data regarding gestational age are not yet available on children with CP born during 2015–2018, as the register confirms a diagnosis of CP at age five years. However, with the assumption that approximately 30% of children with CP will have a history of birth at <30 weeks' gestation, using total numbers of children with known CP each year, it is plausible at least five of these 31 children (2015–2018) will fall into this group.

We require sustained implementation of evidence-based clinical practices in perinatal care to address known variations in care delivery that arise due to numerous factors (eg, workforce changes, time pressures, financial constraints and other system factors). Often, there is low awareness of gaps in care delivery. For example, in a survey of perinatal clinicians throughout Australia and New Zealand in 2015, clinicians estimated that 89% of eligible mothers received magnesium sulphate.[18] Based on ANZNN data, the reality was closer to 60–70%.[6] Our study suggests that without

ongoing implementation investment, for example, at a minimum of $AU50 353 per year to allow for a dedicated QI facilitation role, rates are unlikely to reach and be maintained at 90%. Awareness and dissemination of evidence-based clinical guidelines alone are unlikely to change practice in the most effective, sustainable and timely manner that active implementation potentially does,[19] such as our local QI program did.[20]

Furthermore, our approach and model can be extrapolated to a larger data set such as the ANZNN.[21] The potential impacts of increasing antenatal magnesium sulphate use bi-nationally from 67% of women at <30 weeks' gestation[6] to closer to 90% would be substantial, in terms of both improved quality of life of children avoiding CP and the considerable healthcare system cost savings. If realised across Australia, New Zealand and beyond, this would represent significant benefits for individuals, families and societies.

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