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PEER REVIEW HISTORY

Gynecology and Obstetrics Clinical Medicine publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

ARTICLE DETAILS

TITLE (PROVISIONAL)	Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial
AUTHORS	Jackson, Hannah; Callander, Emily J.; McLachlan, Helen L.; Davey, Mary-Ann; Forster, Della A.

VERSION 1 - REVIEW

REVIEWER	***Xie, Junshu*** ***Peking University People's Hospital*** ***there is no competing interest.***
REVIEW RETURNED	26-Mar-2024

GENERAL COMMENTS	This article compares the pregnancy situation and cost between the caseload group and the standard care group, and predicts the cost of public funders in the later stage, which has good exploratory significance. 1. The Epidural rate in the Caseload group is lower and there is a statistical difference compared to the Standard care group. What is the reason for this? 2. Is the standard care group data in the Baby length of stay (hours) project in Table 2 correct? Please verify. 3. Is the CO for COmparing Standard Materiality care with One to one middleware support in Line 33 correct? Please verify. 4. Is the extra cost of the Caseload group paid by the pregnant women?

REVIEWER	***Wu, Shaowen*** ***The manuscript provided the balance between the pregnant women and midwives.***
REVIEW RETURNED	03-Apr-2024

GENERAL COMMENTS	The article provides a good balance between midwives and low-risk mothers in childbirth, and provides a certain basis for the human resource cost of midwives. But this study covers the entire country of Australia and should be targeted for stratification, such as urban and rural areas. In addition, it is recommended to pay attention to the comparison of the incidence of adverse events in pregnant and postpartum women under different care modes.

VERSION 1 – AUTHOR RESPONSE

Thank you for your response and encouraging feedback on our manuscript entitled "Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the cosmos randomised controlled trial". We thank you for the opportunity to strengthen our manuscript by incorporating the suggested changes and points for further consideration. Our responses to comments from the reviewers are included in the attached response to reviewer feedback document. We are confident that the revisions made have improved the overall quality of our manuscript and have addressed all points raised by the reviewers. We hope you find the revised version satisfactory.

VERSION 2 – REVIEW

REVIEWER	***Xie, Junshu*** ***Peking University People's Hospital*** ***There is no competing interest.***
REVIEW RETURNED	21-Apr-2024

GENERAL COMMENTS	Accept the revised draft of this manuscript.

REVIEWER	***Wu, Shaowen*** ***This study reveals the relationship between midwife manpower and maternal and infant outcomes, providing guidance for the distribution of midwife manpower in delivery rooms, especially applicable to the current situation in China***
REVIEW RETURNED	28-Apr-2024

GENERAL COMMENTS	Suggest the composition ratio of the number of deliveries and midwives for different high-risk mothers

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Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

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Keywords:	Maternal Health, Obstetrics

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Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

Running title: Cost analysis of caseload midwifery

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ABSTRACT

Introduction

Caseload midwifery (continuity of midwifery carer) offers benefits including lower caesarean section rates, lower risks of preterm birth and stillbirth, and improved maternal satisfaction of care. Despite these advantages, concerns about additional costs hinder widespread implementation. This study examines the cost of caseload midwifery compared to standard maternity care from the perspective of both public hospitals and public funders.

Methods

A cost analysis was conducted using data from a randomised controlled trial of 2,314 low-risk pregnant women in Melbourne, Australia. Women randomised to caseload care received antenatal, intrapartum, and postpartum care from a primary midwife, with some care provided by a 'back-up' midwife. Women in standard care received midwifery-led care with varying levels of continuity, junior obstetric care, or community-based medical care. The cost analysis compared differences in mean costs of health resources to public hospitals and to public funders. Additionally, a budget impact analysis estimated total costs to the health system between 2023 and 2027.

Results

For public hospitals, there was no significant difference in overall costs between women receiving caseload midwifery (n=1,146) versus standard care (n=1,151) ($12,363 [SD: $4,967] versus $12,323 [SD: $7,404]; P=0·85). Conversely, public funders incurred lower expenditures for women receiving caseload midwifery ($20,330, [SD: $8,312]) versus standard care ($21,637 [SD: $11,818]; P<0·001). The budget impact analysis estimated savings of $625 million to the health system over the next 5 years with expanded access to caseload midwifery in Australia.

Conclusion

Caseload midwifery in low-risk women is cost-neutral to public hospitals, and cost-saving to public funders.

Funding: Funding was received from the Australian National Health and Medical Research Council (Project Grant Number: 433040).

Acknowledgements: We gratefully acknowledge the National Health and Medical Research Council for trial funding, the women and midwives who participated in the study, other members of the research team, and members of the study Reference Group, the Safety Committee, and the Data Monitoring Committee. We acknowledge the dedicated research midwives and research assistants and the support of the study by hospital management, midwifery, and obstetric teams, as well as the Information Technology Department and Health Information Services. We also acknowledge Associate Professor Lisa Gold and Ms Bree Rankin for the health economic data collection design. Preliminary results from this study were presented at the Perinatal Society of Australia and New Zealand 2023 Conference.

Data availability: Data may be shared upon request in accordance with our ethics approvals.

Keywords: Caseload Midwifery; Caesarean Section; Costs and Cost Analysis; Pregnancy; Maternity Care

Tweetable abstract: Continuity of midwifery for low-risk women reduces costs to public funders, with no additional costs to hospitals

What is already known on this topic

- Continuity of care by a primary midwife (caseload midwifery) is associated with beneficial health outcomes and increased rates of maternal satisfaction.
- Despite positive effects, uncertainty regarding the economic consequences associated with this model of care remains a significant barrier to the uptake of this highly effective maternal health intervention.

What this study adds

- To drive changes in the uptake of caseload midwifery, this study assessed the cost implications of caseload midwifery in comparison to standard maternity care from the perspective of both public hospitals and public funders.

How this study might affect research, practice or policy

- Caseload midwifery was found to reduce costs to public funders for low-risk women without increasing costs for public hospitals.

INTRODUCTION

High-income countries are grappling with the concurrent challenges in maternity care of rapidly increasing intervention rates, particularly caesarean sections, and the imperative to prevent rare but catastrophic outcomes such as morbidity and death.[1, 2] This is set against a background of rapidly increasing health care costs and tightening government expenditure.[3] Caesarean section is a high-cost medical procedure that comes with an increased risk of adverse outcomes.[4,5] Consequently, reducing the need for caesarean section is an ongoing international priority.[6]

Whilst high income countries have very low rates of maternal and neonatal morbidity and mortality, some individual health services have recently been identified as service "failures", with clusters of catastrophic adverse events.[7-9] These incidents have highlighted the need for attention to maternal experience and maternal and neonatal safety.[10, 11] Furthermore, follow-up responses have also highlighted the need to prioritise the implementation of evidence-based responses both within these individual services, and across maternity care more broadly.[12]

Continuity of midwifery carer in women of low obstetric risk has been shown in the COmparing Standard Maternity care with One-to-one midwifery Support (COSMOS) randomised controlled trial (RCT) to reduce the risk of caesarean section, and admission to special or neonatal intensive care for the infant.[13] The model, called 'caseload midwifery', where women received antenatal, intrapartum and postpartum care from a primary midwife, also resulted in an improvement in birth experience for women,[14, 15] and has been associated with lower risk of preterm birth, stillbirth and neonatal death.[16] Other RCT evidence from all-risk women concluded that caseload midwifery is safe for women of any risk, and produces cost savings for hospital funders.[17] As such, increasing access to caseload midwifery should be a key strategy to concurrently address rising intervention rates, whilst improving experience and safety.

A key barrier to wider implementation or scale-up of caseload midwifery is the perceived additional costs to public hospitals associated with this model.[18] Comprehensive evidence of the costs of caseload midwifery and standard care is thus needed in order to inform decision-making about establishment or scale-up. The objective of this study was to identify the cost

and budget impact of caseload midwifery compared to standard care amongst women of low obstetric risk in Australia.

METHODS

Study setting and location

In Australia, caesarean section rates were 37% in 2020, which is above the Organisation for Economic Co-operation and Development (OECD) average.[19, 20] It is projected that 45% of births in Australia will be by caesarean section by 2030.[21] Maternity care is funded through a mix of public funding, out of pocket fees, and private health insurance funds.[22] Public hospitals are funded jointly by both the Federal and state governments through Public Hospital Funding Agreements on an activity based funding model. Each episode of inpatient, outpatient and emergency department care in public hospitals is funded at a set rate determined by the Independent Hospital Pricing Authority, with no out-of-pocket fees for Medicare-eligible patients.[23] Any care provided outside of public hospitals is partly subsidised through a different pool, Medicare, which is funded solely by the Federal government.

Public hospitals are owned and managed by state governments, with individual hospitals being operated by a board and executive responsible for the provision of services and financial sustainability. Once government funding reaches a hospital, the hospital is then responsible for providing the care, including payment of staff, consumables, and facility costs. This includes midwife and medical salaries associated with providing maternity care. Caseload midwifery in Australia is designed for implementation in the public hospital setting. As such, it will have cost implications to public funders as it will affect the types of activities or episodes of care being funded, and to individual hospitals as it involves different staff, consumable and facility costs.

Study population

COSMOS was a two-arm RCT designed to compare caseload midwifery to standard maternity care in women at low risk of obstetric complications. The trial design is described in detail elsewhere.[13, 24] Briefly, women at low risk of obstetric complication were recruited at the Royal Women's Hospital, a public tertiary women's hospital in Melbourne, Australia, between September 2007 and June 2010. Women were eligible for inclusion in the trial if they were able to speak, read and write English, if they had a singleton pregnancy of less than 24 weeks

gestation at recruitment and if they were considered low obstetric risk, with no complications during the current pregnancy and no precluding medical conditions (e.g., cardiac disease, diabetes, epilepsy, substance use, obesity or significantly underweight). Women with a previous caesarean section were excluded. Caseload midwifery was not available to women outside the trial.

Comparators

Caseload midwifery care

Women randomised to the intervention group received the majority of their antenatal, intrapartum and postnatal care from a primary caseload midwife at the hospital. If complications arose, the primary midwife collaborated with other health professionals (e.g., obstetricians) whilst continuing to provide caseload care. Caseload midwives provided 'back-up' care for each other, so that if a caseload midwife was sick, on personal leave or unavailable the back-up midwife would provide care for a woman. Women saw an obstetrician at booking, at 36 weeks of gestation and if the pregnancy lasted beyond 40 weeks' gestation. Intrapartum care was provided in the birth suite by the caseload midwife (89% of the time), or otherwise by a core hospital midwife. Postpartum, the caseload midwife saw women on most days in hospital to provide postnatal care and provided domiciliary care following discharge from hospital. All care was provided according to hospital guidelines and protocols. Full-time midwives had a caseload of 45 women per annum.

Standard maternity care

Women randomised to the control group could choose from the standard hospital options for low-risk women (referred to as "standard care"). These included midwifery-led care (78%), which generally meant women saw a different midwife at each visit, based upon who was rostered to work at the time of care; obstetric trainee care (2%); or shared care where antenatal care is shared between an accredited general medical practitioner (GP) and the hospital (15%). Five percent transferred their care elsewhere. As with caseload midwifery care, women in the standard care model saw an obstetrician at booking, and 36-weeks' gestation and at 41 weeks' gestation if required. Care was provided according to the same hospital guidelines and protocols as women in the caseload midwifery arm.

Study Design – cost analysis

We conducted a cost analysis using data from the COSMOS RCT to determine if there are differences in cost between caseload midwifery and standard care for individual public hospitals providing care, and public funders.

Time horizon, discount rate

The time horizon for the cost analysis was from booking at around 16 weeks' gestation, through to two months postpartum. Since the follow-up period was less than 12 months, discounting of costs was not required.

Measurement and valuation of resources

Public hospital costs

Use of public hospital resources was identified from a combination of self-reported health service use from a survey administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Health resources were costed from the hospital's perspective. These are described in detail in Appendix 1.

Expenditure by public funders

Expenditure by public funders was based upon all episodes of care, also identified from self-reported health service use survey data administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Funding per activity was based upon the Independent Hospital Pricing Authority National Efficient Price Determination (NEPD) for 2022/23,[25] with the Inlier weight per activity multiplied by the National Efficient Price.[25] These are described in detail in Appendix 1.

Study Design – budget impact analysis

The second analysis was a budget impact analysis including costs to the health system, comprising both public hospital costs and expenditure by public funders for caseload midwifery and standard care in women at low risk of obstetric complications. This was designed to capture the cost implications of hypothetical national implementation. We assumed that uptake of caseload would be 70% in women at low risk of obstetric complications, and that adherence would be 90%; this was considered more reflective of potential use in practice. The analysis was designed to represent the Australian population of births between 2023 – 2027. Full methodological details are provided in Appendix 2.

Time horizon

The model took a five-year time horizon, including all births and considering costs and outcomes between 2023 and 2027 (that is, for births in 2023 costs and outcomes will be

considered for up to five years postpartum, whereas those born in 2026 will only have costs and outcomes considered up to one year postpartum). No discounting was applied.

Currency, price date and conversion

All costs are presented in 2021/22 Australia dollars. For reference, at time of writing 1 Australian Dollar is equal to 0·56 Pounds sterling, 0·63 Euros, and 0·67 United States Dollars. When unit prices and funding amounts were not recorded in the original source in this price date, they were adjusted for inflation using the Reserve Bank of Australia inflation figures.[26]

Data analysis

Data were analysed on an intention to treat basis. Demographic characteristics of women receiving caseload midwifery and standard care were compared. Differences between groups were calculated using Pearson's chi-square test, and Student's t-test (p-values reported). The average number of, or frequency of access to, different resources was then compared, followed by costs to public hospitals and expenditure by public funders. A supplementary analysis was conducted that compared costs to public hospitals and expenditure by public hospitals for women receiving shared care (with a GP). For costs, generalised linear models were used to compare differences, with a gamma distribution and log link function to account for the skewed nature of the cost data. Health service use was analysed as count data with negative binomial distribution. All analysis was conducted using SAS 9.4.

RESULTS

There were 1,146 women allocated to caseload care and 1,151 women allocated to standard care. Of the 1,151 women allocated to standard care, 79.7% (917/1,151) received public antenatal care with either midwives or obstetric trainees; 15.1% (174/1,151) received shared care (with a GP); and 5.2% (60/1,151) transferred to care elsewhere. Of the 1,146 women allocated to caseload care, 3.3% (38/1,146) received other care either at the Royal Women's Hospital, or at a facility outside of Melbourne due to relocation. Table 1 demonstrates that the two groups were similar in terms of demographic characteristics.

Table 1: Demographic characteristics of women receiving caseload and standard care

	Caseload (n=1,146)	**Standard care (n=1,151)**	**p-value**
Model of care received within allocated group	Caseload only care - 1108 (96.7%)	Midwives or obstetrics trainees – 917 (79.7%)	n/a
	Transferred to care elsewhere – 38 (3.3%)	Share care with a GP – 174 (15.1%)	n/a
		Transferred to care elsewhere - 60 (5.2%)	n/a
Age at booking visit – mean (SD)	31·2 (4·6)	31·3 (4·7)	0·62
Body Mass Index (BMI) at booking visit – mean (SD)	24·1 (3·7)	23·8 (3·7)	0·13
Gestation at booking – mean (SD)	16·3 (2·8)	16·3 (2·9)	0·57
Nulliparous – n (%)	803 (70·1%)	799 (69.4%)	0·73
Married or de facto – n (%)	1076 (93·9%)	1062 (92.3%)	0·33
Post-secondary Education – n (%)	874 (76·3%)	828 (71.9%)	0·05
Born in Australia – n (%)	652 (56·9%)	644 (56.0%)	0·79

n/a=not applicable.

In terms of health resources utilised, women allocated to caseload midwifery accessed slightly more antenatal midwife appointments (6·7 versus 6·1; P<0·001) but were less likely to have an epidural (28·3% versus 30·8%; P=0·04) than women in the standard care group. They also were less likely to have a caesarean section birth (19·3% versus 24·8%; P=0·001), had a shorter length of labour (12·9 hours versus 14·0 hours; P=0.04), and a shorter postnatal ward stay (55·5 hours versus 60·2 hours; P<0.001). The babies of women allocated to caseload midwifery had fewer admissions to SCN or NICU (5·9% versus 9·2%; P=0·002) and had shorter lengths of stay post birth (68·2 hours versus 73·9 hours; P<0.001). Women in the caseload group also had slightly more postnatal home visits (2·1 visits versus 1·7 visits; P<0·001) (Table 2).

Table 2: Health service use of women

	n	**Caseload** Mean (SD) / n (%)	**n**	**Standard care** Mean (SD) / n (%)	**P-value**
Antenatal visits					
Antenatal visits - midwife	1,146	6·7 (0·7)	1,151	6·1 (1·7)	<0·001
Antenatal visits – GP*	1,146	0·0 (0·0)	1,151	0·6 (1·6)	n/a
Antenatal visits - obstetrician	1,146	2·3 (0·5)	1,151	2·2 (0·5)	0·42
Emergency department presentations	1,146	0·7 (0·9)	1,151	0·7 (1·0)	0·46
Induction – n (%)	1,146	351 (30·6%)	1,151	386 (33·5%)	0·54
Epidural – n (%)	1,146	324 (28·3%)	1,151	354 (30·8%)	0·04
Birth					
Caesarean Section - n (%)	1,146	221 (19·3%)	1,151	285 (24·8%)	0·001

Vaginal birth - instrumental - n (%)	1,146	202 (17·6%)	1,151	222 (19·3%)	0·31
Vaginal birth- unassisted – n (%)	1,146	719 (62·7%)	1,151	637 (55·3%)	<0·001
Length of labour (hours)	1,146	12.9 (30·1)	1,151	14·0 (27·9)	0·04
Postnatal - baby					
SCN or NICU admission	1,146	67 (5·9%)	1,151	106 (9·2%)	0·002
Baby length of stay (hours)	1,146	68.2 (45·7)	1,151	73·.9 (40·0)	<0·001
Postnatal ward – mother					
Mother length of stay (hours)	1,146	55·5 (31·2)	1,151	60·2 (24·9)	<0·001
Postnatal visits, after discharge (home visits)					
Postnatal home visits	1,146	2·1 (1·0)	1,151	1·7 (0·7)	<0·001

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; * 0 for those receiving caseload, as antenatal care by a GP was only provided for those receiving 'shared care' as a subset of those in standard care; n/a=not applicable.

Based upon annual caseload midwife salary and a caseload of 45 women, caseload midwives cost public hospitals $3,414 per woman to provide care through the antenatal, intrapartum, and postnatal time period. Women receiving caseload midwifery had lower mean costs associated with antenatal visits (which includes non-caseload midwife, obstetrician, and GP time) ($214 versus $316 P<0·001), epidural use ($94 versus $110; P=0·04), birth suite ($1,376 versus $3,729; P<0·001), and postnatal ward costs for mother ($2,993 versus $3,239; P<0·001) and baby ($3,731 versus $4,154; P<0·001). Women receiving caseload care had $0 for postnatal costs after discharge as these costs were included in caseload midwife salary costs. There was no significant difference in overall costs between women allocated to the caseload group compared with women allocated to standard care ($12,363 versus $12,323; P=0·85) (Table 3). There was also no significant difference in costs per woman for public hospitals for women receiving shared care (with a GP), and women receiving caseload midwifery (Appendix 3). In the scenario analysis where women received intrapartum care from their caseload or back-up midwife *and* the rostered hospital midwives as well, costs were $1,971 higher for women receiving caseload midwifery (Appendix 4).

Expenditure by public funders on midwife antenatal outpatient episodes ($1,380 versus $1,260; P<0.001) and obstetrician antenatal outpatient episodes ($597 versus $583; P=0·01) was higher for women receiving caseload midwifery care compared to women receiving standard care (Table 4). In contrast expenditure by public funders on labour, birth and postnatal inpatient episodes of care was lower for women receiving caseload midwifery care compared to women receiving standard care ($17,521 versus $18,967; P<0·001). In all, expenditure by public

funders was $1,307 less for women receiving caseload midwifery than women receiving standard care (P<0·001).

Table 3: Mean costs to public hospitals per woman

	Caseload	Standard care	p-value	Difference
	n=1,146	n=1,151		
Caseload midwife salary cost	$3,414	-	n/a	$3,414
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$316 ($63)	<0·001	-$102
Emergency department presentations*, mean (SD)	$487 ($659)	$508 ($699)	0·29	-$21
Induction*, mean (SD)	$35 ($53)	$39 ($55)	0·22	-$4
Epidural*, mean (SD)	$94 ($139)	$110 ($145)	0·04	-$16
Birth Suite, mean (SD)	$1,376 ($1,694)	$3,729 ($4,855)	<0·001	-$2,353
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,154 ($2,263)	<0·001	-$423
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,239 ($1,289)	<0·001	-$246
Postnatal costs, after discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($81)	n/a	-$197
Total costs for all services, mean (SD)	$12,363 ($4,967)	$12,323 ($7,404)	0·85	-$41
Midwife and obstetrician staff costs only				
Caseload midwife salary cost, mean (SD)	$3,414	-	n/a	$3,414
Hospital Midwife Staff Costs (excluding Caseload Midwives), mean (SD)	$2,877 ($1,619)	$5,627 ($4,670)	<0·001	-$2,749
Obstetric Staff Costs, mean (SD)	$521 ($245)	$561 ($251)	<0·001	-$41
Total, mean (SD)	$6,812 ($1,721)	$6,188 ($4,734)	<0·001	$624

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; *mean cost across all women in each group; n/a=not applicable

Table 4: Expenditure by public funders per woman

	Caseload	Standard care	p-value	Difference
	Mean (SD)	Mean (SD)		
Antenatal health service use				
Outpatient episodes - Midwife	$1,380 ($143)	$1,260 ($348)	<0·001	$119
Outpatient episodes - Obstetrician	$597 ($126)	$583 ($119)	0·01	$13
Outpatient episodes - General Practitioner	n/a no shared care	$47 ($128)	n/a	-$47
Emergency department episodes	$408 ($551)	$426 ($584)	0·62	-$17
Antenatal expenditure TOTAL	$2,384 ($588)	$2,316 ($665)	0·01	$68
Labour, birth, postnatal in-hospital service use				
Induction of labour	$1,676 ($2,522)	$1,835 ($2,583)	0·36	-$159
Labour and birth inpatient episodes - mother	$7,885 ($2,516)	$8,234 ($2,753)	<0·001	-$349
Neonatal inpatient episode - baby	$4,920 ($6,368)	$5,193 ($10,650)	0·02	-$273
Postnatal inpatient episode, prior to discharge	$3,041 ($2,509)	$3,707 ($2,281)	0·01	-$666
Labour, birth, postnatal in-hospital expenditure TOTAL	$17,521 ($8,361)	$18,967 ($11,811)	<0·001	-$1,447

Postnatal outpatient episode (home visits)	$424 ($181)	$348 ($143)	<0·001	$76
Total expenditure for all services	$20,330 ($8,312)	$21,637 ($11,818)	<0·001	-$1,307

Table 5: Modelled Budget Impact Analysis of caseload midwifery compared to standard care, assuming 70% uptake rate and 90% adherence

	2023	2024	2025	2026	2027
Australian population of women giving birth	300,680	298,056	298,160	296,603	296,645
Public hospital births	231,532	233,772	233,412	234,828	236,690
Low risk women (target population)	165,582	166,691	157,457	149,625	144,185
Uptake	104,317	105,015	99,198	94,264	90,837
Standard care					
Costs to public hospitals (A)	$1,285,494,201	$1,294,103,912	$1,222,415,845	$1,161,612,191	$1,119,378,806
Expenditure by public hospital funders (B)	$2,257,099,572	$2,272,216,695	$2,146,345,179	$2,039,584,759	$1,965,430,432
Net costs from health system's perspective	$3,542,593,774	$3,566,320,607	$3,368,761,024	$3,201,196,950	$3,084,809,238
Caseload midwifery					
Costs to public hospitals (A)	$1,289,666,868	$1,298,304,525	$1,226,383,761	$1,165,382,741	$1,123,012,268
Costs to public hospital funders (B)	$2,120,757,698	$2,134,961,659	$2,016,693,510	$1,916,382,038	$1,846,707,062
Net costs from health system's perspective	$3,410,424,565	$3,433,266,184	$3,243,077,272	$3,081,764,779	$2,969,719,329
Savings from caseload midwifery	-$132,169,208	-$133,054,423	-$125,683,752	-$119,432,171	-$115,089,909

The modelled budget impact analysis (Table 5) shows the overall cost implications of caseload midwifery compared to standard care for low-risk women in Australia, with hypothetical nationwide implementation. The overall number of eligible women (women of low obstetric risk, giving birth in a public hospital) is expected to initially rise, due to the increasing proportion of women giving birth in public hospitals, and then decline due to the decreasing proportion of women considered to be low obstetric risk. There would be net cost savings of $132 million to the public health system in year 1 (2023), and $115 million in year 5 (2027). Overall, there would be savings of $625 million to the health system over the next 5 years if 70% eligible women had access to caseload midwifery in Australia, with 90% adherence.

DISCUSSION

Main findings

Caseload midwifery for women at low obstetric risk was not associated with increased overall costs to public hospitals ($12,363 for women receiving caseload; $12,323 for women receiving standard care). Caseload midwifery was associated with a reduction in expenditure to public funders of $1,307 per woman compared to standard care. This was primarily by lower use of epidural, caesarean section, instrumental vaginal birth, fewer special care nursery and neonatal intensive care unit admissions, and shorter length of labour and length of stay post-birth for women receiving caseload midwifery compared to standard care. The lower use of these resources, and thus lower costs to public hospitals, offset the additional staffing costs for midwife and obstetric time. When considered at the national level from a health systems perspective (considering both costs to public hospitals and expenditure by public funders), caseload midwifery is cost saving. If implemented at a national level in Australia, caseload midwifery for low-risk women could save the system $625 million over the next five years.

Strengths and limitations

The primary limitation of the study was that it was based upon a single site, in an urban setting with strong leadership. This may mean that the findings may be different to those seen with wider implementation. Previous studies from this trial[13] have noted some differences in the characteristics of women participating in the trial compared to the overall population, notably the higher proportion of women who were married or living with their partner, nulliparous women, and women born overseas. The key strength of this study is that it is based on results directly collected during an RCT, and thus represents a balanced comparison between study

groups. Furthermore, the study took a comprehensive approach to cost measurement, capturing both public hospital costs and expenditure by public funders.

Interpretation

Few studies have assessed the costs of caseload midwifery relative to standard care, and the limited evidence base on costs of caseload midwifery is still considered a barrier to implementation. The M@NGO RCT of all risk women found cost savings to hospital funders associated with the birth event for women receiving caseload midwifery, compared to standard care.[17] A Cochrane review[16] published in 2016 compared midwife-led continuity of care models with other models of care and found a trend towards cost-saving for midwife-led continuity of care models. More recently, an observational study from Australia comparing the real-world costs of caseload midwifery and standard care demonstrated cost-savings of AU$5,208 per woman in the caseload model from the public funder's perspective, however this related to all-risk women.[27] Two modelling studies have also been conducted - one study from the United States demonstrated that a shift from obstetric-led to midwife-led care could be cost saving for low-risk pregnancies [28] and another Australian study identified that caseload midwifery in low-risk nulliparous women was cost-saving compared to standard care.[29] However, none of these previous studies have considered staffing costs to public hospitals.

Our study also highlighted a number of important factors that need to be considered as a part of implementation to ensure financial sustainability. Firstly, when considering only midwifery staffing costs, caseload midwifery is higher cost than standard care. It is also higher cost when the caseload midwife *and* rostered hospital midwives both provide intrapartum care. Cost savings to public hospitals are seen through a small reduction in obstetric staff time but also through a reduction in costs of anaesthetists for epidurals and caesarean sections, theatre costs for providing caesarean section, SCN and NICU admissions. Thus, for implementation within public hospitals there would need to be a redistribution of cost savings from other areas into midwifery salary to support the additional midwifery staffing costs required for caseload midwifery. Another crucial finding from this study is that caseload midwifery will result in higher costs to public hospital funders if the number of midwives rostered to birth suite to provide standard care are not proportionately reduced with caseload midwifery.

Our findings that demonstrated substantial cost savings for public hospital funders are also an important consideration for implementation. The cost-saving per woman receiving caseload midwifery to public funders ($1,307 per woman) is larger than the potential additional staffing costs for midwives incurred by public hospitals ($624 per woman). From a policy perspective, public hospital funders (in Australia, state and Federal governments) could fund individual hospitals to support start-up costs of caseload midwifery, given the previously noted need for hospitals to internally redistribute staff savings and reduce birth suite midwives providing standard care. This could still be cost saving to public funders given the reduction in expenditure associated with reduced numbers of caesarean section births, reduction in length of stay in birth suite and postnatal ward, and fewer neonatal admission to special care.

CONCLUSION

Amongst low-risk women, caseload midwifery is not associated with increased costs to public hospitals compared to standard care, and significantly reduces costs to public funders. Overall, to health systems, caseload midwifery reduces costs compared to standard care in low risk women and could result in substantial cost savings if fully implemented.

Contributors: HM, MAD and DF originally conceived the study and contributed to the initial grant application. EC led the design of, and conducted, the cost data analysis and led the drafting of the manuscript. HJ contributed to data analysis. All authors contributed to the analysis design, interpretation of the results, and made contributions to subsequent drafts. All authors had full access to the data, and all read and approved the final manuscript.

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Patient and public involvement: A consumer of maternity services was involved in the study design, conduct, and dissemination of this research via membership of the COSMOS trial reference group. Further, study participants were asked to provide their view and experiences of care by postal surveys. Additionally, midwives who conducted the intervention were invited to provide their views and experiences via interviews and surveys.

Provenance and peer review: Not commissioned; externally peer reviewed.

Ethics Approval: Ethics approval was obtained from the Royal Women's Hospital (07/01) and La Trobe University Human Research Ethics Committees (07/04).

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Figure and table legends

Table 3: Demographic characteristics of women receiving caseload and standard care

Table 4: Health service use of women

Table 3: Mean costs to public hospitals per woman

Table 4: Expenditure by public funders per woman

Table 5: Modelled Budget Impact Analysis of caseload midwifery compared to standard care, assuming 70% uptake rate and 90% adherence

Appendix Table 1.1: Caseload midwifery – costs to public hospitals

Appendix Table 1.2: Standard care – costs to public hospitals

Appendix Table 1.3: Expenditure by public funders, based upon health service use activities

Appendix 2: Budget Impact Analysis additional methodological details

Appendix Table 3.1 Costs to public hospitals per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 3.2: Expenditure by public funders per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 4.1: Costs to public hospitals in the scenario analysis where caseload midwives are not included in birth suite ratios (i.e. their time in birth suite is an additional cost)

SUPPLEMENTARY MATERIAL

Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

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Appendix 1: Measurement and valuation of resources

Public hospital costs

For women receiving caseload midwifery care, a single cost per woman was assigned for the caseload midwife's time to cover the costs of antenatal, intrapartum and postnatal care provided by this midwife (Appendix Table 1). This was calculated as an annual caseload midwife salary, taken from hospital payroll records, divided by 45 women in the caseload.

For women receiving antenatal care and standard care, antenatal visits occurred per the following schedule:

Visit	Provider
Booking clinic	Midwife and obstetric consultant/registrar
22 week consultation	Midwife (GP for women receiving shared care)
28 week consultation	Midwife
32 week consultation	Midwife (GP for women receiving shared care)
34 week consultation	Midwife (GP for women receiving shared care)
36 week consultation	Obstetric consultant/registrar
38 week consultation	Midwife (GP for women receiving shared care)
39/40 week consultation	Midwife (GP for women receiving shared care)
41 week consultation	Obstetric consultant/registrar

The average duration of each antenatal appointment was recorded as a part of trial data collection. Midwife and obstetrician salary time was multiplied by the length of each appointment and who the care provider was. No costs to public hospitals were incurred for GP appointments. For women receiving caseload midwifery, the antenatal care consultations with a midwife were provided by the caseload midwife, with additional costs for obstetric consultant/registrar (Appendix Table 1.1). For women in the standard care arm, the costs of each antenatal consultation is outlined in Appendix Table 1.2 (below).

For women in both arms of the study, emergency department presentations during the antenatal time period was identified based upon self-reported data. Costs were assigned based upon the Independent Hospital Pricing Authority National Hospital Cost Data Collection (NHCDC) Round 24,[1] and the mean costs to hospitals for pregnancy-related emergency department presentations. Induction of labour and epidural use by women was identified based upon hospital records. Costs of induction of labour was assumed to be staff time and consumables, and costs of epidural covered staff time and consumables.

For women in the caseload arm who had a vaginal birth, it was assumed that the caseload midwife provided intrapartum care. Additional costs for ward supplies and hotel costs (i.e. accommodation costs) were identified from NHCDC, for disaggregated costs of vaginal birth. In a scenario analysis, the assumption was made that caseload midwives provide intrapartum care in addition to the cost of the birth suite midwives who had to be rostered to provide that care, as per the required ratios, regardless of whether they also provided care to the woman, and this was tested. For women in the standard care arm who had a vaginal birth, the length of labour recorded in hospital records was multiplied by midwife time, and salary costs. Midwife time in birth suite was calculated based upon midwife to woman ratios of two midwives per three women in birth suite[2]. Additional costs for ward supplies and hotel costs were identified from NHCDC, for disaggregated costs of vaginal birth. For women in the caseload arm and standard care arm who had a vaginal birth with forceps or vacuum it was assumed that an obstetric registrar or trainee also attended for 1.5 hours. For women in the caseload arm and standard care arm

who had a caesarean section, additional staff time was identified during the study, and the additional costs for operating room, ward supplies and hotel costs were identified from the NHCDC, for disaggregated costs of caesarean section.

For women in the caseload and standard care arms postnatal ward use was based upon maternal time in hospital from birth to discharge. Costs were based upon midwife time for providing care in postnatal ward, and salary cots. Midwife time in the postnatal ward was calculated based upon midwife to woman ratios of 1:4 in am and pm shifts, and 1:6 in night shifts.[2] It was assumed that core midwifery staff provided the care. For the baby, staff time for the provision of care was based upon the length of admitted time from birth obtained from hospital records, and multiplied by midwife salary to identify costs. For babies admitted to the special care nursery (SCN) or neonatal intensive care unit (NICU), it was assumed that they were admitted to these units for 4.8 days, based upon national average for length of stay identified from the NHCDC. This was then multiplied by nurse staff time, based upon SCN and NICU ratios of 1:2,[2] plus neonatologist time, pathology, critical care, consumables and hotel costs identified from the NHCDC.[1]

For women in the standard care arm, the number of postnatal home visits were identified based upon women's self-reported data at two months postpartum, the length of visit assumed to be 1.5 hours, including travel time and costed based upon midwife salary. For women in the caseload arm, postnatal home visits are provided by caseload midwife and thus included in the caseload midwife cost per woman.

Expenditure by public hospital funders

Outpatient episodes were categorised into activities for funding purposes based upon Tier-2 codes and whether the episode was provided by a midwife, or obstetrician. GP-services for women receiving shared care were based upon Medicare Benefits Schedule item numbers. Emergency department episodes were assumed to be presentations for pregnancy related conditions and were categorised as such based upon Australian Emergency Classification Codes. Inpatient episodes were categorised based upon Australian Refined-Diagnostic Related Groups (AR-DRG) codes and if a woman had a caesarean section or vaginal birth.

For women receiving caseload midwifery and standard care, activities were costed the same, with only the type and volume of activities varying between the groups (Appendix Table 1.3, below). Funding for antenatal care followed the standard schedule of antenatal visits, based upon whether the appointment was provided by a midwife, an obstetric consultant/registrar or a GP (for women receiving shared care); the number of visits was dependant on the duration of the pregnancy. Emergency department presentations during the antenatal time period was identified based upon self-reported data, and assigned the cost to funders of the corresponding AECC codes. Induction of labour was assumed to be associated with an obstetrician outpatient consultation, and then an antenatal admission. Epidural use does not have a specific activity code and so did not attract a cost to funders.

Funding for vaginal birth and caesarean section birth was assigned based upon the weighted average of AR-DRG codes relating to type of birth from the NEPD.[3] Funding for the baby was based upon the AR-DRG code assigned to the baby for the birth. If maternal length of stay was longer than 48 hours, then a separate postnatal admission activity was assumed. For domiciliary visits post birth, each home visit was funded as a midwife outpatient activity.

Appendix Table 1.1: Caseload midwifery – costs to public hospitals

Resource	Units consumed	Cost per unit
Caseload midwife time	= 1/45 One full-time caseload midwife cares for 45 women per year	$153,648 Based upon hospital payroll records.
Antenatal care		
Booking clinic – obstetric consultant/registrar	40 minutes All women	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
36 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 35 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
41 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 40 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
Emergency department use	Use identified self-reported data for each woman at 2 months postpartum	$736 Cost to public hospitals identified from AECC Code E1420A and B (average) NHCDC
Labour and birth		
Induction of labour	Use of induction identified from hospital records for each woman 20 minutes Obstetric consultant/registrar's time - assumption	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Consumables $80
Epidural	Use of epidural identified from hospital records for each woman	$301.10 Based on Medicare item number 18226, which covers costs of anaesthetist's time and consumables
Vaginal birth	Identified from hospital records for each woman Maternal length of stay from admission to birth – based on hospital records	Ward supplies - $294 Hotel costs - $3.8 per hour Based on NHCDC
Vaginal birth with forceps or vacuum	Identified from hospital records for each woman 1.5 hours Obstetric consultant/registrar's time – assumption Maternal length of stay post-birth – based on hospital records	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Caesarean section	Identified from hospital records for each woman 2 hours Obstetric registrar's time – based on trial data 1 hour Obstetric resident's time – based on trial data 1 hour paediatrician's time – based on trial data 1 hour anaesthetist's time – based on trial data	Obstetric consultant/registrar: $210/hour Obstetric resident: $126/hour Paediatrician: $210/hour Anaesthetist: $210/hour Anaesthetic nurse: $78/hour Scrub nurse: $78/hour Theatre technician: $78/hour Recovery nurse: $78/hour Based upon hospital payroll records.

	1 hour anaesthetic nurse's time – based on trial data 1 hour scrub nurse's time – based on trial data 1.5 hour operating theatre technician's time – based on trial data 1 hour recovery nurse's time – based on trial data Maternal length of stay post-birth – based on hospital records	Operating room costs - $2,748 Ward supplies - $402 Hotel costs post birth - $3.8 per hour Based on NHCDC
Postnatal ward - mother	Identified from hospital records for each woman Maternal length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm, 1:6 night Midwife salary: $78/hour Based upon hospital payroll records.
Postnatal ward - baby	Identified from hospital records for each baby Baby's length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm, 1:6 night Midwife salary: $78/hour Based upon hospital payroll records.
Special care nursery or neonatal intensive care unit admission	Admission identified from hospital records for each baby Length of stay assumed to be 4.8 days per average reported in NHCDC	Nurse time based upon ratio of 1:2 Intensive care nurse: $78/hour Neonatologist: $210/hour Based upon hospital payroll records. Critical care costs - $2,748 Pathology - $249 Consumables - $271 Hotel costs post birth - $1.9 per hour Based on NHCDC

Appendix Table 1.2: Standard care – costs to public hospitals

Resource	Units consumed	Cost per unit
Booking clinic – midwife and obstetric consultant/registrar	40 minutes – midwife 20 - minutes obstetric consultant/registrar All women	Midwife: $78/hour Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
22 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 21 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
28 week consultation with midwife	20 minutes - midwife All women whose pregnancy progressed beyond 27 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
32 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 31 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.

34 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 33 weeks gestation	Midwife: $78/hour Based upon hospital payroll records.
36 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 35 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
38 week consultation with midwife	30 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 37+6 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
39/40 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 38 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
41 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 40 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
Emergency department use	Use identified self-reported data for each woman at 2 months postpartum	$736 Cost to public hospitals identified from AECC Code E1420A and B (average) NHCDC
Labour and birth		
Induction of labour	Use of induction identified from hospital records for each woman 20 minutes Obstetric consultant/registrar's time – assumption	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Consumables $80
Epidural	Use of epidural identified from hospital records for each woman	$301.10 Based on Medicare item number 18226, which covers costs of anaesthetist's time ad consumables
Vaginal birth	Identified from hospital records for each woman Maternal length of time in birth suite based on length of time from admission to labour to birth – based on hospital records Maternal length of stay post-birth – based on hospital records	Midwife time on birth suite, based upon ratio of 2:3 Midwife salary: $78/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Vaginal birth with forceps or vacuum	Identified from hospital records for each woman 1.5 hours Obstetric consultant/registrar's time – assumption Maternal length of stay post-birth – based on hospital records	Obstetric consultant/registrar: $210/hour Midwife salary: $78/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Caesarean section	Identified from hospital records for each woman	Obstetric consultant/registrar: $210/hour

	2 hours Obstetric registrar's time – based on trial data 1 hour Obstetric resident's time – based on trial data 1 hour paediatrician's time – based on trial data 1 hour anaesthetist's time – based on trial data 1 hour anaesthetic nurse's time – based on trial data 1 hour scrub nurse's time – based on trial data 1.5 hour operating theatre technician's time – based on trial data 1 hour recover nurse's time – based on trial data Maternal length of stay post-birth – based on hospital records	Obstetric resident: $126/hour Paediatrician: $210/hour Anaesthetist: $210/hour Anaesthetic nurse: $78/hour Scrub nurse: $78/hour Theatre technician: $78/hour Recovery nurse: $78/hour Based upon hospital payroll records. Operating room costs - $2,748 Ward supplies - $402 Hotel costs post birth - $3.8 per hour Based on NHCDC
Postnatal ward - mother	Identified from hospital records for each woman Maternal length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm shift, 1:6 night shift Midwife salary: $77.76/hour Based upon hospital payroll records.
Postnatal ward - baby	Identified from hospital records for each baby Baby's length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm shift, 1:6 night shift Midwife salary: $77.76/hour Based upon hospital payroll records.
Special care nursery or neonatal intensive care unit admission	Admission identified from hospital records for each baby Length of stay assumed to be 4.8 days per average reported in NHCDC	Nurse time based upon ratio of 1:2 Intensive care nurse: $78/hour Neonatologist: $210/hour Based upon hospital payroll records. Critical care costs - $2,748 Pathology - $249 Consumables - $271 Hotel costs post birth - $1.9 per hour Based on NHCDC
Postnatal		
Postnatal home visits	Number of visits based upon women's self-reported data at 2 months Length of visit assumed to be 1.5 hours, including travel time	Midwife salary: $78/hour Based upon hospital payroll records.

Appendix Table 1.3: Expenditure by public funders, based upon health service use activities

Health service activity	Units consumed	Cost to funders per activity
Antenatal care		
Booking clinic – midwife and obstetric consultant/registrar	Tier 2 code 40.28 Midwifery and Maternity Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$205.21 $265.5 Based upon NEPD
22 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500 and 16591	$205.21 Based upon the NEPD $49.85 $150.75 Based on Medicare benefits Schedule
28 week consultation with midwife	Tier 2 code 40.28 Midwifery and Maternity	$205.21 Based upon the NEPD
32 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
34 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
36 week consultation with obstetric consultant/registrar	Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$265.50 Based upon the NEPD
38 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
39/40 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
41 week consultation with obstetric consultant/registrar	Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$265.50 Based upon the NEPD
Emergency Department	AECC Code E1420A and B (average)	$615.35 Based upon the NEPD
Labour and birth		
Induction of labour	Obstetrician consultation: Tier 2 code 20.40 Obstetrics - management of pregnancy without complications Antenatal admission: AR-DRG code O66A.	$265.50 $5,203.39 Based upon the NEPD
Epidural	-	-

Vaginal birth	Weighted average of AR-DRG codes O60A, O60B, O60C	$6,655.73 Based upon the NEPD, Round 24
Caesarean section	Weighted average of AR-DRG codes O01A, O01B, O01C	$13,030.89 Based upon the NEPD, 24
Postnatal ward – mother, if length of stay >48 hours	Weighted average of AR-DRG codes O61A, O61B	$5,108.61 Based upon the NEPD, Round 24
Postnatal ward - baby	AR-DRG: P03Z P04Z P06A P60A P61Z P62Z P64Z P65B P65C P65D P66A P66B P66C P66D P67A P67B P67C P67D	 $129,748.45 $98,240.31 $121,033.82 $8,403.33 $269,055.58 $187,168.03 $49,064.94 $43,771.41 $35,841.68 $26,744.46 $32,750.73 $21,043.69 $14,136.56 $7,159.30 if gestation<37 weeks then $31,075.98 if gestation>37 weeks then $17,770.72 if gestation<37 weeks then $18,282 if gestation>37 weeks then $7,943.02 if gestation<37 weeks then $14,914.52 if gestation>37 weeks then $5,778.45 if gestation<37 weeks then $9,073.46 if gestation>37 weeks then $3,927.47 Based upon the NEPD, Round 24
Postnatal		
Postnatal home visits	Tier 2 code 40.28 Midwifery and Maternity	$205.21 Based upon the NEPD, Round 24

Appendix 2: Budget Impact Analysis additional methodological details

To identify the size of the future eligible population, data were drawn from the *Queensland Perinatal Data Collection* (PDC), containing all pregnancies and births (n=365,138) between 01/07/2012 and 30/06/2018 in Queensland (QLD), Australia.[4] The PDC contains the details of all births regardless of location (private hospital, public hospital), information on maternal demographics, maternal clinical characteristics, medical interventions performed in pregnancy and childbirth, and infant outcomes. This was considered the most current source of whole of population, individual level data containing obstetric risk status of women, which was required to identify eligibility for caseload midwifery.

We reweighted the data of births over 20 weeks' gestation between 01/07/2013 and 30/06/2018 (n=302,169) to reflect the Australian population of women giving birth between 01/01/2023 and 31/12/2027. Reweighting was conducted using GREGWT, a generalised regression reweighting algorithm developed by the Australian Bureau of Statistics (ABS).[5] Weighting was conducted using national benchmarks for mother's age by First Nations identification, private hospital births, mother's age by parity, and age by caesarean section using data from the Australian Institute of Health and Welfare's (AIHW) Mothers and Babies 2012 - 2020 reports.[6] Linear trends were fitted to extrapolate benchmarking figures between 2023 and 2027.

Appendix 3: Comparison of costs to public hospitals and public funders for caseload midwifery, standard care and shared care.

Appendix Table 3.1 Costs to public hospitals per woman – Caseload midwifery, Standard Care, Shared Care

	Caseload	Control	
		Standard care	Shared care
	n=1,146	n=1,151	n=141
Caseload midwife salary cost	$3,414	-	-
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$337 ($30)	$166 ($17)
Emergency department presentations*, mean (SD)	$487 ($659)	$528 ($718)	$369 ($524)
Induction*, mean (SD)	$35 ($53)	$40 ($55)	$38 ($54)
Epidural*, mean (SD)	$94 ($139)	$113 ($146)	$97 ($141)
Birth Suite, mean (SD)	$1,376 ($1,694)	$3,665 ($3,899)	$4,184 ($9,141)
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,202 ($2,142)	$4,075 ($3,401)
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,242 ($1,285)	$3,217 ($1,318)
Postnatal costs, after to discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($77)	$195 ($110)
Total costs for all services, mean (SD)	$12,363 ($4,967)	$12,320 ($6,299)	$12,341 ($12,801)

Grey shaded cells indicate statistically significant difference with caseload

Appendix Table 3.2: Expenditure by public funders per woman – Caseload midwifery, Standard Care, Shared Care

	Caseload		Control			
			Standard care		Shared care	
Antenatal health service use	Mean	SD	Mean	SD	Mean	SD
Outpatient episodes - Midwife	$1,379.71	$142.91	$1,378.97	$151.47	$410.42	$0.00
Outpatient episodes - Obstetrician	$596.80	$126.42	$580.95	$117.09	$600.67	$129.47
Outpatient episodes - General Practitioner	$0.00	$0.00	$0.00	$0.00	$387.63	$34.31
Emergency department episodes	$407.40	$550.78	$441.07	$600.39	$308.85	$438.44
Antenatal costs TOTAL	$2,383.95	$588.31	$2,401.37	$644.20	$1,707.57	$469.52
Labour, birth, postnatal in-hospital service use						
Induction of labour	$7,885.15	$2,516.30	$8,208.49	$2,737.78	$8,419.07	$2,861.87
Labour and birth inpatient episodes - mother	$1,675.03	$2,521.98	$1,846.43	$2,587.52	$1,745.39	$2,558.39
Neonatal inpatient episode - baby	$4,920.13	$6,367.80	$5,178.16	$10,900.87	$5,296.50	$8,673.57
Postnatal inpatient episode, prior to discharge	$3,040.20	$2,508.76	$3,722.71	$2,272.54	$3,586.90	$2,344.61
Labour, birth, postnatal in-hospital costs TOTAL	$17,520.51	$8,360.82	$18,955.79	$11,982.59	$19,047.86	$10,541.75
Postnatal outpatient episode (home visits)	$410.42	$0.00	$410.42	$0.00	$410.42	$0.00
Total costs for all services	$20,320.51	$8,333.33	$21,774.43	$12,006.87	$21,165.85	$10,452.46

Grey shaded cells indicate statistically significant difference with caseload

Appendix 4:

Appendix Table 4.1 : Costs to public hospitals in the scenario analysis where caseload midwives are not included in birth suite ratios (i.e. their time in birth suite is an additional cost)

	Caseload	Standard care	p-value	Difference
	n=1,146	n=1,151		
Caseload midwife salary cost	$3,414	-	n/a	$3,414
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$316 ($63)	<0.001	-$102
Emergency department presentations*, mean (SD)	$487 ($659)	$508 ($699)	0.29	-$21
Induction*, mean (SD)	$35 ($53)	$39 ($55)	0.22	-$4
Epidural*, mean (SD)	$94 ($139)	$110 ($145)	0.04	-$16
Birth Suite, mean (SD)	$3,306 ($5,145)	$3,729 ($4,855)	<0.001	-$423
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,154 ($2,263)	<0.001	-$423
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,239 ($1,289)	<0.001	-$246
Postnatal costs, after to discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($81)	n/a	-$197
Total costs for all services, mean (SD)	$14,294 ($8,120)	$12,323 ($7,404)	<0.001	$1,971
Midwife and obstetrician staff costs only				
Caseload midwife salary cost, mean (SD)	$3,414	-	n/a	$3,414
Hospital Midwife Staff Costs (ex Caseload Midwives), mean (SD)	$4,829 ($5,104)	$5,627 ($4,670)	<0.001	-$798
Obstetric Staff Costs, mean (SD)	$521 ($245)	$561 ($251)	<0.001	-$41
Total, mean (SD)	$8,764 ($5,168)	$6,188 ($4,734)	<0.001	$2,576

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Response to reviewer feedback from submission to Gynecology and Obstetrics Clinical Medicine

Manuscript reference number: gocm-2024-000008

Thank you for your response and encouraging feedback on our manuscript entitled “Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the cosmos randomised controlled trial”. We thank you for the opportunity to strengthen our manuscript by incorporating the suggested changes and points for further consideration. Our responses to comments from the reviewers are detailed below.

Reviewer	Reviewer’s comments	Response	Manuscript section
1	This article compares the pregnancy situation and cost between the caseload group and the standard care group, and predicts the cost of public funders in the later stage, which has good exploratory significance.	Thank you for your encouraging feedback.	No changes made
	1. The Epidural rate in the Caseload group is lower and there is a statistical difference compared to the Standard care group. What is the reason for this?	It is well-established that caseload midwifery is associated with lower rates of medical interventions overall. This includes reduced caesarean section rates, episiotomy, induction of labour, and epidural anaesthesia. The results found in the COSMOS trial have been reported previously (DOI: 10.1111/j.1471-0528.2012.03446.x.) It is possible that the observed difference is because women who chose Caseload midwifery were also strongly committed to minimising medical interventions that might interfere with the natural process of labour and birth. Since these factors were discussed in the initial results of the published trial, we have focused on costs in this manuscript.	No changes made
	2. Is the standard care group data in the Baby length of stay (hours) project in Table 2 correct? Please verify.	The correct length of stay for this cell is 73.9hours as reported in text, this has been corrected.	Table 2
	3. Is the CO for COmparing Standard Materiality care with One to one middleware support in Line 33 correct? Please verify.	The CO is uppercase in “comparing” to highlight how the acronym for the COSMOS RCT was created. COSMOS: COmparing Standard Maternity care with One-to-one midwifery Support: a randomised controlled trial.	No changes made

	4. Is the extra cost of the Caseload group paid by the pregnant women?	There is no extra cost to women in the caseload group; all women had care delivered at no charge in the public hospital system. We have further highlighted in the manuscript that public hospital episodes of care are not associated with patient out of pocket fees. The cost analysis conducted is from the perspective of 1) public hospitals, and 2) public funders. Therefore, any differences in costs between groups for each analysis are incurred by those funders. Patient out-of-pocket costs were not analysed in the cost analyses included in this study.	Page 5
2	The article provides a good balance between midwives and low-risk mothers in childbirth, and provides a certain basis for the human resource cost of midwives.	Thank you for your feedback.	
	But this study covers the entire country of Australia and should be targeted for stratification, such as urban and rural areas.	The study was conducted at a single site as detailed on page 5. As such, stratification of results was not possible.	No changes made
	In addition, it is recommended to pay attention to the comparison of the incidence of adverse events in pregnant and postpartum women under different care modes.	The COSMOS RCT only recruited women of low obstetric risk. With regards to varying modes of care, Appendix 3 shows a sensitivity analysis that was conducted to separate out women in the GP shared care group within the control population.	No changes made
Editor	1.Try to keep all numbers in the same format, such as keep one decimal place;	The reported figures have been edited for consistency in reporting of decimal places between text and tables.	Page 8
	2.Please check all the rate%, some of them seems incorrectly calculated.	These have been checked throughout and corrected where needed.	Page 9, page 10, Table 1, Table 2
	3.Make sure all the figures are in the text and tables(tables andAppendix talbes) are consistent with the tables.	Missing figures regarding models of care received have been added.	Table 1
	4.Others see attached (i.e., comments included on manuscript).	All other comments have been addressed – please see responses within the manuscript.	

1

Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

Running title: Cost analysis of caseload midwifery

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Please check all the rate%, some of them seems incorrectly calculated.
Make sure all the figures are in the text and tables(tables andAppendix talbes) are consistent with the tables.

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ABSTRACT

Introduction

Caseload midwifery (continuity of midwifery carer) offers benefits including lower ~~reduces~~ caesarean section rates, ~~and~~ lower risks of preterm birth and stillbirth, ~~admission to special care nurseries,~~and improveds maternal satisfaction of care, ~~, and lowers risks of preterm birth, stillbirth and neonatal death.~~ Despite these ~~positive effects~~advantages, concerns about ~~uncertainty regarding~~ additional costs ~~remains a key barrier to~~hinder ~~wider~~ widespread implementation. This study~~e objective of this study was to~~ examines ~~determine~~ the cost of caseload midwifery ~~in~~ comparedison to standard maternity care from the perspective of both ~~two different payers in public hospital systems -~~ public hospitals and public funders.

Methods

~~We conducted a~~A cost analysis was conducted using data from a randomised controlled trial of 2,314 low-risk pregnant women ~~at low risk of obstetric complications~~ in Melbourne, Australia. Women randomised to caseload care received antenatal, intrapartum, and postpartum care from a primary midwife, with some care provided by a 'back-up' midwife. Women in standard care received midwifery-led care with varying levels of continuity, junior obstetric care, or community-based medical care. The cost analysis compared ~~the~~ differences in mean costs of health resources to public hospitals and to public funders. Additionally, a~~A~~ budget impact analysis ~~was also carried out, which~~ estimated total costs to the health system between 2023 and 2027.

Results

For public hospitals, there was no significant difference in overall costs ~~overall~~ between women ~~in the~~receiving caseload ~~group~~ midwifery (n=1,146) ~~and women receiving~~versus standard care (n=1,151) ($12,363 [SD: $4,967] versus $12,323 [SD: $7,404]; P=0·854). ~~In contrast~~Conversely, ~~expenditure for~~ public funders incurred lower expenditures ~~was lower~~ for women receiving caseload midwifery ($20,330, [SD: $8,312]) ~~compared to women receiving~~versus standard care ($21,637 [SD: $11,818]; P<0·001). ~~Based on a~~The budget impact analysis estimated savings of ~~, there was estimated to be savings of~~ $~~645~~ 625 million to the health system over the next 5 years ~~if there was wider~~with expanded access to caseload midwifery in Australia.

Conclusion

Caseload midwifery in low-risk women is cost-neutral to public hospitals, and cost-saving to public funders.

Funding: Funding was received from the Australian National Health and Medical Research Council (Project Grant Number: 433040).

Acknowledgements: We gratefully acknowledge the National Health and Medical Research Council for trial funding, the women and midwives who participated in the study, other members of the research team, and members of the study Reference Group, the Safety Committee, and the Data Monitoring Committee. We acknowledge the dedicated research midwives and research assistants and the support of the study by hospital management, midwifery, and obstetric teams, as well as the Information Technology Department and Health Information Services. We also acknowledge Associate Professor Lisa Gold and Ms Bree Rankin for the health economic data collection design. Preliminary results from this study were presented at the Perinatal Society of Australia and New Zealand 2023 Conference.

Data availability: Data may be shared upon request in accordance with our ethics approvals.

Keywords: Caseload Midwifery; Caesarean Section; Costs and Cost Analysis; Pregnancy; Maternity Care

Tweetable abstract: Continuity of midwifery for low-risk women reduces costs to public funders, with no additional costs to hospitals

What is already known on this topic

- Continuity of care by a primary midwife (caseload midwifery) is associated with beneficial health outcomes and increased rates of maternal satisfaction.
- Despite positive effects, uncertainty regarding the economic consequences associated with this model of care remains a significant barrier to the uptake of this highly effective maternal health intervention.

What this study adds

- To drive changes in the uptake of caseload midwifery, this study assessed the cost implications of caseload midwifery in comparison to standard maternity care from the perspective of both public hospitals and public funders.

How this study might affect research, practice or policy

- Caseload midwifery was found to reduce costs to public funders for low-risk women without increasing costs for public hospitals.

INTRODUCTION

High-income countries are grappling with the concurrent challenges in maternity care of rapidly increasing intervention rates, particularly caesarean sections, and the imperative to prevent rare but catastrophic outcomes such as morbidity and death.[1, 2] This is set against a background of rapidly increasing health care costs and tightening government expenditure.[3] Caesarean section is a high-cost medical procedure that comes with an increased risk of adverse outcomes.[4,–5] Consequently, reducing the need for caesarean section is an ongoing international priority.[6]

Whilst high income countries have very low rates of maternal and neonatal morbidity and mortality, some individual health services have recently been identified as service "failures", with clusters of catastrophic adverse events.[7-9] These incidents have highlighted the need for attention to maternal experience and maternal and neonatal safety.[10, 11] Furthermore, follow-up responses have also highlighted the need to prioritise the implementation of evidence-based responses both within these individual services, and across maternity care more broadly.[12]

Continuity of midwifery carer in women of low obstetric risk has been shown in the COmparing Standard Maternity care with One-to-one midwifery Support (COSMOS) randomised controlled trial (RCT) to reduce the risk of caesarean section, and admission to special or neonatal intensive care for the infant.[13] The model, called 'caseload midwifery', where women received antenatal, intrapartum and postpartum care from a primary midwife, also resulted in an improvement in birth experience for women,[14, 15] and has been associated with lower risk of preterm birth, stillbirth and neonatal death.[16] Other RCT evidence from all-risk women concluded that caseload midwifery is safe for women of any risk, and produces cost savings for hospital funders.[17] As such, increasing access to caseload midwifery should be a key strategy to concurrently address rising intervention rates, whilst improving experience and safety.

A key barrier to wider implementation or scale-up of caseload midwifery is the perceived additional costs to public hospitals associated with this model.[18] Comprehensive evidence of the costs of caseload midwifery and standard care is thus needed in order to inform decision-making about establishment or scale-up. The objective of this study was to identify the cost

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and budget impact of caseload midwifery compared to standard care amongst women of low obstetric risk in Australia.

METHODS

Study setting and location

In Australia, caesarean section rates were 37% in 2020, which is above the Organisation for Economic Co-operation and Development (OECD) average.[19, 20] It is projected that 45% of births in Australia will be by caesarean section by 2030.[21] Maternity care is funded through a mix of public funding, out of pocket fees, and private health insurance funds.[22] Public hospitals are funded jointly by both the Federal and state governments through Public Hospital Funding Agreements on an activity based funding model. Each episode of inpatient, outpatient and emergency department care in public hospitals is funded at a set rate determined by the Independent Hospital Pricing Authority, with no out-of-pocket fees for Medicare-eligible patients.[23] Any care provided outside of public hospitals is partly subsidised through a different pool, Medicare, which is funded solely by the Federal government.

Public hospitals are owned and managed by state governments, with individual hospitals being operated by a board and executive responsible for the provision of services and financial sustainability. Once government funding reaches a hospital, the hospital is then responsible for providing the care, including payment of staff, consumables, and facility costs. This includes midwife and medical salaries associated with providing maternity care. Caseload midwifery in Australia is designed for implementation in the public hospital setting. As such, it will have cost implications to public funders as it will affect the types of activities or episodes of care being funded, and to individual hospitals as it involves different staff, consumable and facility costs.

Study population

COSMOS was a two-arm RCT designed to compare caseload midwifery to standard maternity care in women at low risk of obstetric complications. The trial design is described in detail elsewhere.[13, 24] Briefly, women at low risk of obstetric complication were recruited at the Royal Women's Hospital, a public tertiary women's hospital in Melbourne, Australia, between September 2007 and June 2010. Women were eligible for inclusion in the trial if they were able to speak, read and write English, if they had a singleton pregnancy of less than 24 weeks

gestation at recruitment and if they were considered low obstetric risk, with no complications during the current pregnancy and no precluding medical conditions (e.g., cardiac disease, diabetes, epilepsy, substance use, obesity or significantly underweight). Women with a previous caesarean section were excluded. Caseload midwifery was not available to women outside the trial.

Comparators

Caseload midwifery care

Women randomised to the intervention group received the majority of their antenatal, intrapartum and postnatal care from a primary caseload midwife at the hospital. If complications arose, the primary midwife collaborated with other health professionals (e.g., obstetricians) whilst continuing to provide caseload care. Caseload midwives provided 'back-up' care for each other, so that if a caseload midwife was sick, on personal leave or unavailable the back-up midwife would provide care for a woman. Women saw an obstetrician at booking, at 36 weeks of gestation and if the pregnancy lasted beyond 40 weeks' gestation. Intrapartum care was provided in the birth suite by the caseload midwife (89% of the time), or otherwise by a core hospital midwife. Postpartum, the caseload midwife saw women on most days in hospital to provide postnatal care and provided domiciliary care following discharge from hospital. All care was provided according to hospital guidelines and protocols. Full-time midwives had a caseload of 45 women per annum.

Standard maternity care

Women randomised to the control group could choose from the standard hospital options for low-risk women (referred to as "standard care"). These included midwifery-led care (78%), which generally meant women saw a different midwife at each visit, based upon who was rostered to work at the time of care; obstetric trainee care (2%); or shared care where antenatal care is shared between an accredited general medical practitioner (GP) and the hospital (15%). Five percent transferred their care elsewhere. As with caseload midwifery care, women in the standard care model saw an obstetrician at booking, and 36-weeks' gestation and at 41 weeks' gestation if required. Care was provided according to the same hospital guidelines and protocols as women in the caseload midwifery arm.

Study Design – cost analysis

We conducted a cost analysis using data from the COSMOS RCT to determine if there are differences in cost between caseload midwifery and standard care for individual public hospitals providing care, and public funders.

Time horizon, discount rate

The time horizon for the cost analysis was from booking at around 16 weeks' gestation, through to two months postpartum. Since the follow-up period was less than 12 months, discounting of costs was not required.

Measurement and valuation of resources

Public hospital costs

Use of public hospital resources was identified from a combination of self-reported health service use from a survey administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Health resources were costed from the hospital's perspective. These are described in detail in Appendix 1.

Expenditure by public funders

Expenditure by public funders was based upon all episodes of care, also identified from self-reported health service use survey data administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Funding per activity was based upon the Independent Hospital Pricing Authority National Efficient Price Determination (NEPD) for 2022/23,[25] with the Inlier weight per activity multiplied by the National Efficient Price.[25] These are described in detail in Appendix 1.

Study Design – budget impact analysis

The second analysis was a budget impact analysis including costs to the health system, comprising both public hospital costs and expenditure by public funders for caseload midwifery and standard care in women at low risk of obstetric complications. This was designed to capture the cost implications of hypothetical national implementation. We assumed that uptake of caseload would be 70% in women at low risk of obstetric complications, and that adherence would be 90%; this was considered more reflective of potential use in practice. The analysis was designed to represent the Australian population of births between 2023 – 2027. Full methodological details are provided in Appendix 2.

Time horizon

The model took a five-year time horizon, including all births and considering costs and outcomes between 2023 and 2027 (that is, for births in 2023 costs and outcomes will be

considered for up to five years postpartum, whereas those born in 2026 will only have costs and outcomes considered up to one year postpartum). No discounting was applied.

Currency, price date and conversion

All costs are presented in 2021/22 Australia dollars. For reference, at time of writing 1 Australian Dollar is equal to 0·56 Pounds sterling, 0·63 Euros, and 0·67 United States Dollars. When unit prices and funding amounts were not recorded in the original source in this price date, they were adjusted for inflation using the Reserve Bank of Australia inflation figures.[26]

Data analysis

Data were analysed on an intention to treat basis. Demographic characteristics of women receiving caseload midwifery and standard care were compared. Differences between groups were calculated using Pearson's chi-square test, and Student's t-test (p-values reported). The average number of, or frequency of access to, different resources was then compared, followed by costs to public hospitals and expenditure by public funders. A supplementary analysis was conducted that compared costs to public hospitals and expenditure by public hospitals for women receiving shared care (with a GP). For costs, generalised linear models were used to compare differences, with a gamma distribution and log link function to account for the skewed nature of the cost data. Health service use was analysed as count data with negative binomial distribution. All analysis was conducted using SAS 9.4.

RESULTS

There were 1,146 women allocated to caseload care and 1,151 women allocated to standard care. Of the 1,151 women allocated to standard care, 79.67%~~80%~~ (917/1,151) received public antenatal care with either midwives or obstetric trainees; 15.12%~~15%~~ (174/1,151) received shared care (with a GP); and 5.21% (60/1,151) transferred to care elsewhere. Of the 1,146 women allocated to caseload care, 3.32% (38/1,146) received other care either at the Royal Women's Hospital, or at a facility outside of Melbourne due to relocation. Table 1 demonstrates that the two groups were similar in terms of demographic characteristics.

Table 1: Demographic characteristics of women receiving caseload and standard care

	Caseload (n=1,146)	Standard care (n=1,151)	p-value
Model of care received within allocated group	Caseload only care - 1108 (96.7%)	Midwives or obstetrics trainees – 917 (79.7%)	n/a
	Transferred to care elsewhere – 38 (3.3%)	Share care with a GP – 174 (15.1%)	n/a
		Transferred to care elsewhere - 60 (5.2%)	n/a
Age at booking visit – mean (SD)	31·2 (4·6)	31·3 (4·7)	0·62
Body Mass Index (BMI) at booking visit – mean (SD)	24·1 (3·7)	23·8 (3·7)	0·13
Gestation at booking – mean (SD)	16·3 (2·8)	16·3 (2·9)	0·57
Nulliparous – n (%)	803 (70·1%)	799 (69.4%)	0·73
Married or de facto – n (%)	1076 (9593·92%)	1062 (9492.3%)	0·33
Post-secondary Education – n (%)	874 (7776·3%)	828 (7371.9%)	0·05
Born in Australia – n (%)	652 (5856·59%)	644 (5756.90%)	0·79

n/a=not applicable.

In terms of health resources utilised, women allocated to caseload midwifery accessed slightly more antenatal midwife appointments (6·7 versus 6·1; P<0·001) but were less likely to have an epidural (2928·93% versus 3430·28%; P=0·04) than women in the standard care group. They also were less likely to have a caesarean section birth (19·43% versus 24·98%; P=0·001), had a shorter length of labour (12·89 hours versus 1314·09 hours; P=0.04<0·001), and a shorter postnatal ward stay (55·5 hours versus 60·2 hours; P<0.001). The babies of women allocated to caseload midwifery had fewer admissions to SCN or NICU (5·9% versus 9·2%; P=0·002) and had shorter lengths of stay post birth (68·2 hours versus 73·9 hours; P<0.001). Women in the caseload midwifery group also had slightly more postnatal home visits (2·1 visits versus 1·7 visits; P<0·001) (Table 2).

Table 2: Health service use of women

	n	Caseload Mean (SD) / n (%)	n	Standard care Mean (SD) / n (%)	P-value
Antenatal visits					
Antenatal visits - midwife	1,146	6·7 (0·7)	1,151	6·1 (1·7)	<0·001
Antenatal visits – GP*	1,146	0·0 (0·0)	1,151	0·6 (1·6)	n/a
Antenatal visits - obstetrician	1,146	2·3 (0·5)	1,151	2·2 (0·5)	0·42
Emergency department presentations	1,146	0·7 (0·9)	1,151	0·7 (1·0)	0·46
Induction – n (%)	1,146	351 (30·6%)	1,151	386 (33·5%)	0·54

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Epidural – n (%)	1,146	324 (2928·93%)	1,151	354 (3430·82%)	0·04
Birth					
Caesarean Section - n (%)	1,146	221 (19·53%)	1,151	285 (24·89%)	0·001
Vaginal birth - instrumental - n (%)	1,146	202 (17·67%)	1,151	222 (19·43%)	0·31
Vaginal birth- unassisted – n (%)	1,146	719 (6362·07%)	1,151	637 (55·73%)	<0·001
Length of labour (hours)	1,146	12.9 (30·1)	1,151	14·0 (27·9)	0·04
Postnatal - baby					
SCN or NICU admission	1,146	67 (5·9%)	1,151	106 (9·2%)	0·002
Baby length of stay (hours)	1,146	68.2 (45·7)	1,151	73·.9 (40·0)	<0·001
Postnatal ward – mother					
Mother length of stay (hours)	1,146	55·5 (31·2)	1,151	60·2 (24·9)	<0·001
Postnatal visits, after discharge (home visits)					
Postnatal home visits	1,146	2·1 (1·0)	1,151	1·7 (0·7)	<0·001

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; * 0 for those receiving caseload, as antenatal care by a GP was only provided for those receiving 'shared care' as a subset of those in standard care; n/a=not applicable.

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Based upon annual caseload midwife salary and a caseload of 45 women, caseload midwives cost public hospitals $3,414 per woman to provide care through the antenatal, intrapartum, and postnatal time period. Women receiving caseload midwifery had lower mean costs associated with antenatal visits (which includes non-caseload midwife, obstetrician, and GP time) ($214 versus $316 P<0·001), epidural use ($94 versus $110; P=0·04), birth suite ($1,376 versus $3,729; P<0·001), and postnatal ward costs for mother ($2,993 versus $3,239; P<0·001) and baby ($3,7531 versus $4,187154; P<0·001). Women receiving caseload care had $0 for postnatal costs after discharge as these costs were included in caseload midwife salary costs. There was no significant difference in overall costs between women allocated to the caseload group compared with women allocated to standard care ($12,3634 versus $12,323; P=0·85) (Table 3). There was also no significant difference in costs per woman for public hospitals for women receiving shared care (with a GP), and women receiving caseload midwifery (Appendix 3). In the scenario analysis where women received intrapartum care from their caseload or back-up midwife *and* the rostered hospital midwives as well, costs were $1,971 higher for women receiving caseload midwifery (Appendix 4).

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Expenditure by public funders on midwife antenatal outpatient episodes ($1,380 versus $1,260; P<0.001) and obstetrician antenatal outpatient episodes ($597 versus $583; P=0·01) was higher for women receiving caseload midwifery care compared to women receiving standard care (Table 4). In contrast expenditure by public funders on labour, birth and postnatal inpatient episodes of care was lower for women receiving caseload midwifery care compared to women

receiving standard care ($17,521 versus $18,967; P<0·001). In all, expenditure by public funders was $1,307 less for women receiving caseload midwifery than women receiving standard care (P<0·001).

Table 3: Mean costs to public hospitals per woman

	Caseload	Standard care	p-value	Difference
	n=1,146	n=1,151		
Caseload midwife salary cost	$3,414	-	n/a	$3,414
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$316 ($63)	<0·001	-$102
Emergency department presentations*, mean (SD)	$487 ($659)	$508 ($699)	0·29	-$21
Induction*, mean (SD)	$35 ($53)	$39 ($55)	0·22	-$4
Epidural*, mean (SD)	$94 ($139)	$110 ($145)	0·04	-$16
Birth Suite, mean (SD)	$1,376 ($1,694)	$3,729 ($4,855)	<0·001	-$2,353
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,154 ($2,263)	<0·001	-$423
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,239 ($1,289)	<0·001	-$246
Postnatal costs, after discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($81)	n/a	-$197
Total costs for all services, mean (SD)	$12,363 ($4,967)	$12,323 ($7,404)	0·85	-$41
Midwife and obstetrician staff costs only				
Caseload midwife salary cost, mean (SD)	$3,414	-	n/a	$3,414
Hospital Midwife Staff Costs (excluding Caseload Midwives), mean (SD)	$2,877 ($1,619)	$5,627 ($4,670)	<0·001	-$2,749
Obstetric Staff Costs, mean (SD)	$521 ($245)	$561 ($251)	<0·001	-$41
Total, mean (SD)	$6,812 ($1,721)	$6,188 ($4,734)	<0·001	$624

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; *mean cost across all women in each group; n/a=not applicable.

Table 4: Expenditure by public funders per woman

	Caseload	Standard care	p-value	Difference
	Mean (SD)	Mean (SD)		
Antenatal health service use				
Outpatient episodes - Midwife	$1,380 ($143)	$1,260 ($348)	<0·001	$119
Outpatient episodes - Obstetrician	$597 ($126)	$583 ($119)	0·01	$13
Outpatient episodes - General Practitioner	n/a no shared care	$47 ($128)	n/a	-$47
Emergency department episodes	$408 ($551)	$426 ($584)	0·62	-$17
Antenatal expenditure TOTAL	$2,384 ($588)	$2,316 ($665)	0·01	$68
Labour, birth, postnatal in-hospital service use				
Induction of labour	$1,676 ($2,522)	$1,835 ($2,583)	0·36	-$159
Labour and birth inpatient episodes - mother	$7,885 ($2,516)	$8,234 ($2,753)	<0·001	-$349
Neonatal inpatient episode - baby	$4,920 ($6,368)	$5,193 ($10,650)	0·02	-$273
Postnatal inpatient episode, prior to discharge	$3,041 ($2,509)	$3,707 ($2,281)	0·01	-$666
Labour, birth, postnatal in-hospital expenditure TOTAL	$17,521 ($8,361)	$18,967 ($11,811)	<0·001	-$1,447
Postnatal outpatient episode (home visits)	$424 ($181)	$348 ($143)	<0·001	$76
Total expenditure for all services	$20,330 ($8,312)	$21,637 ($11,818)	<0·001	-$1,307

Table 5: Modelled Budget Impact Analysis of caseload midwifery compared to standard care, assuming 70% uptake rate and 90% adherence

	2023	2024	2025	2026	2027
Australian population of women giving birth	300,680	298,056	298,160	296,603	296,645
Public hospital births	231,532	233,772	233,412	234,828	236,690
Low risk women (target population)	165,582	166,691	157,457	149,625	144,185
Uptake	104,317	105,015	99,198	94,264	90,837
Standard care					
Costs to public hospitals (A)	$1,285,494,201	$1,294,103,912	$1,222,415,845	$1,161,612,191	$1,119,378,806
Expenditure by public hospital funders (B)	$2,257,099,572	$2,272,216,695	$2,146,345,179	$2,039,584,759	$1,965,430,432
Net costs from health system's perspective	$3,542,593,774	$3,566,320,607	$3,368,761,024	$3,201,196,950	$3,084,809,238
Caseload midwifery					
Costs to public hospitals (A)	$1,289,666,868	$1,298,304,525	$1,226,383,761	$1,165,382,741	$1,123,012,268
Costs to public hospital funders (B)	$2,120,757,698	$2,134,961,659	$2,016,693,510	$1,916,382,038	$1,846,707,062
Net costs from health system's perspective	$3,410,424,565	$3,433,266,184	$3,243,077,272	$3,081,764,779	$2,969,719,329
Savings from caseload midwifery	-$132,169,208	-$133,054,423	-$125,683,752	-$119,432,171	-$115,089,909

The modelled budget impact analysis (Table 5) shows the overall cost implications of caseload midwifery compared to standard care for low-risk women in Australia, with hypothetical nationwide implementation. The overall number of eligible women (women of low obstetric risk, giving birth in a public hospital) is expected to initially rise, due to the increasing proportion of women giving birth in public hospitals, and then decline due to the decreasing proportion of women considered to be low obstetric risk. There would be net cost savings of $~~136~~ 132 million to the public health system in year 1 (2023), and $~~119~~ 115 million in year 5 (2027). Overall, there would be savings of $~~645~~ 625 million to the health system over the next 5 years if 70% eligible women had access to caseload midwifery in Australia, with 90% adherence.

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DISCUSSION

Main findings

Caseload midwifery for women at low obstetric risk was not associated with increased overall costs to public hospitals ($12,363 for women receiving caseload; $12,323 for women receiving standard care). Caseload midwifery was associated with a reduction in expenditure to public funders of $1,307 per woman compared to standard care. This was primarily by lower use of epidural, caesarean section, instrumental vaginal birth, fewer special care nursery and neonatal intensive care unit admissions, and shorter length of labour and length of stay post-birth for women receiving caseload midwifery compared to standard care. The lower use of these resources, and thus lower costs to public hospitals, offset the additional staffing costs for midwife and obstetric time. When considered at the national level from a health systems perspective (considering both costs to public hospitals and expenditure by public funders), caseload midwifery is cost saving. If implemented at a national level in Australia, caseload midwifery for low-risk women could save the system $~~645~~ 625 million over the next five years.

Strengths and limitations

The primary limitation of the study was that it was based upon a single site, in an urban setting with strong leadership. This may mean that the findings may be different to those seen with wider implementation. Previous studies from this trial[13] have noted some differences in the characteristics of women participating in the trial compared to the overall population, notably the higher proportion of women who were married or living with their partner, nulliparous women, and women born overseas. The key strength of this study is that it is based on results

directly collected during an RCT, and thus represents a balanced comparison between study groups. Furthermore, the study took a comprehensive approach to cost measurement, capturing both public hospital costs and expenditure by public funders.

Interpretation

Few studies have assessed the costs of caseload midwifery relative to standard care, and the limited evidence base on costs of caseload midwifery is still considered a barrier to implementation. The M@NGO RCT of all risk women found cost savings to hospital funders associated with the birth event for women receiving caseload midwifery, compared to standard care.[17] A Cochrane review[16] published in 2016 compared midwife-led continuity of care models with other models of care and found a trend towards cost-saving for midwife-led continuity of care models. More recently, an observational study from Australia comparing the real-world costs of caseload midwifery and standard care demonstrated cost-savings of AU$5,208 per woman in the caseload model from the public funder's perspective, however this related to all-risk women.[27] Two modelling studies have also been conducted - one study from the United States demonstrated that a shift from obstetric-led to midwife-led care could be cost saving for low-risk pregnancies [28] and another Australian study identified that caseload midwifery in low-risk nulliparous women was cost-saving compared to standard care.[29] However, none of these previous studies have considered staffing costs to public hospitals.

Our study also highlighted a number of important factors that need to be considered as a part of implementation to ensure financial sustainability. Firstly, when considering only midwifery staffing costs, caseload midwifery is higher cost than standard care. It is also higher cost when the caseload midwife *and* rostered hospital midwives both provide intrapartum care. Cost savings to public hospitals are seen through a small reduction in obstetric staff time but also through a reduction in costs of anaesthetists for epidurals and caesarean sections, theatre costs for providing caesarean section, SCN and NICU admissions. Thus, for implementation within public hospitals there would need to be a redistribution of cost savings from other areas into midwifery salary to support the additional midwifery staffing costs required for caseload midwifery. Another crucial finding from this study is that caseload midwifery will result in higher costs to public hospital funders if the number of midwives rostered to birth suite to provide standard care are not proportionately reduced with caseload midwifery.

Our findings that demonstrated substantial cost savings for public hospital funders are also an important consideration for implementation. The cost-saving per woman receiving caseload midwifery to public funders ($1,307 per woman) is larger than the potential additional staffing costs for midwives incurred by public hospitals ($624 per woman). From a policy perspective, public hospital funders (in Australia, state and Federal governments) could fund individual hospitals to support start-up costs of caseload midwifery, given the previously noted need for hospitals to internally redistribute staff savings and reduce birth suite midwives providing standard care. This could still be cost saving to public funders given the reduction in expenditure associated with reduced numbers of caesarean section births, reduction in length of stay in birth suite and postnatal ward, and fewer neonatal admission to special care.

CONCLUSION

Amongst low-risk women, caseload midwifery is not associated with increased costs to public hospitals compared to standard care, and significantly reduces costs to public funders. Overall, to health systems, caseload midwifery reduces costs compared to standard care in low risk women and could result in substantial cost savings if fully implemented.

Contributors: HM, MAD and DF originally conceived the study and contributed to the initial grant application. EC led the design of, and conducted, the cost data analysis and led the drafting of the manuscript. HJ contributed to data analysis. All authors contributed to the analysis design, interpretation of the results, and made contributions to subsequent drafts. All authors had full access to the data, and all read and approved the final manuscript.

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Competing Interests: None declared.

Patient and public involvement: A consumer of maternity services was involved in the study design, conduct, and dissemination of this research via membership of the COSMOS trial reference group. Further, study participants were asked to provide their view and experiences of care by postal surveys. Additionally, midwives who conducted the intervention were invited to provide their views and experiences via interviews and surveys.

Provenance and peer review: Not commissioned; externally peer reviewed.

Ethics Approval: Ethics approval was obtained from the Royal Women's Hospital (07/01) and La Trobe University Human Research Ethics Committees (07/04).

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Figure and table legends

Table 3: Demographic characteristics of women receiving caseload and standard care

Table 4: Health service use of women

Table 3: Mean costs to public hospitals per woman

Table 4: Expenditure by public funders per woman

Table 5: Modelled Budget Impact Analysis of caseload midwifery compared to standard care, assuming 70% uptake rate and 90% adherence

Appendix Table 1.1: Caseload midwifery – costs to public hospitals

Appendix Table 1.2: Standard care – costs to public hospitals

Appendix Table 1.3: Expenditure by public funders, based upon health service use activities

Appendix 2: Budget Impact Analysis additional methodological details

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Appendix Table 3.1 Costs to public hospitals per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 3.2: Expenditure by public funders per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 4.1: Costs to public hospitals in the scenario analysis where caseload midwives are not included in birth suite ratios (i.e. their time in birth suite is an additional cost)

SUPPLEMENTARY MATERIAL

Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

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Contents

Appendix 1: Measurement and valuation of resources

Public hospital costs

For women receiving caseload midwifery care, a single cost per woman was assigned for the caseload midwife's time to cover the costs of antenatal, intrapartum and postnatal care provided by this midwife (Appendix Table 1). This was calculated as an annual caseload midwife salary, taken from hospital payroll records, divided by 45 women in the caseload.

For women receiving antenatal care and standard care, antenatal visits occurred per the following schedule:

Visit	**Provider**
Booking clinic	Midwife and obstetric consultant/registrar
22 week consultation	Midwife (GP for women receiving shared care)
28 week consultation	Midwife
32 week consultation	Midwife (GP for women receiving shared care)
34 week consultation	Midwife (GP for women receiving shared care)
36 week consultation	Obstetric consultant/registrar
38 week consultation	Midwife (GP for women receiving shared care)
39/40 week consultation	Midwife (GP for women receiving shared care)
41 week consultation	Obstetric consultant/registrar

The average duration of each antenatal appointment was recorded as a part of trial data collection. Midwife and obstetrician salary time was multiplied by the length of each appointment and who the care provider was. No costs to public hospitals were incurred for GP appointments. For women receiving caseload midwifery, the antenatal care consultations with a midwife were provided by the caseload midwife, with additional costs for obstetric consultant/registrar (Appendix Table 1.1). For women in the standard care arm, the costs of each antenatal consultation is outlined in Appendix Table 1.2 (below).

For women in both arms of the study, emergency department presentations during the antenatal time period was identified based upon self-reported data. Costs were assigned based upon the Independent Hospital Pricing Authority National Hospital Cost Data Collection (NHCDC) Round 24,[1] and the mean costs to hospitals for pregnancy-related emergency department presentations. Induction of labour and epidural use by women was identified based upon hospital records. Costs of induction of labour was assumed to be staff time and consumables, and costs of epidural covered staff time and consumables.

For women in the caseload arm who had a vaginal birth, it was assumed that the caseload midwife provided intrapartum care. Additional costs for ward supplies and hotel costs (i.e. accommodation costs) were identified from NHCDC, for disaggregated costs of vaginal birth. In a scenario analysis, the assumption was made that caseload midwives provide intrapartum care in addition to the cost of the birth suite midwives who had to be rostered to provide that care, as per the required ratios, regardless of whether they also provided care to the woman, and this was tested. For women in the standard care arm who had a vaginal birth, the length of labour recorded in hospital records was multiplied by midwife time, and salary costs. Midwife time in birth suite was calculated based upon midwife to woman ratios of two midwives per three women in birth suite[2]. Additional costs for ward supplies and hotel costs were identified from NHCDC, for disaggregated costs of vaginal birth. For women in the caseload arm and standard care arm who had a vaginal birth with forceps or vacuum it was assumed that an obstetric registrar or trainee also attended for 1.5 hours. For women in the caseload arm and standard care arm

who had a caesarean section, additional staff time was identified during the study, and the additional costs for operating room, ward supplies and hotel costs were identified from the NHCDC, for disaggregated costs of caesarean section.

For women in the caseload and standard care arms postnatal ward use was based upon maternal time in hospital from birth to discharge. Costs were based upon midwife time for providing care in postnatal ward, and salary cots. Midwife time in the postnatal ward was calculated based upon midwife to woman ratios of 1:4 in am and pm shifts, and 1:6 in night shifts.[2] It was assumed that core midwifery staff provided the care. For the baby, staff time for the provision of care was based upon the length of admitted time from birth obtained from hospital records, and multiplied by midwife salary to identify costs. For babies admitted to the special care nursery (SCN) or neonatal intensive care unit (NICU), it was assumed that they were admitted to these units for 4.8 days, based upon national average for length of stay identified from the NHCDC. This was then multiplied by nurse staff time, based upon SCN and NICU ratios of 1:2,[2] plus neonatologist time, pathology, critical care, consumables and hotel costs identified from the NHCDC.[1]

For women in the standard care arm, the number of postnatal home visits were identified based upon women's self-reported data at two months postpartum, the length of visit assumed to be 1.5 hours, including travel time and costed based upon midwife salary. For women in the caseload arm, postnatal home visits are provided by caseload midwife and thus included in the caseload midwife cost per woman.

Expenditure by public hospital funders

Outpatient episodes were categorised into activities for funding purposes based upon Tier-2 codes and whether the episode was provided by a midwife, or obstetrician. GP-services for women receiving shared care were based upon Medicare Benefits Schedule item numbers. Emergency department episodes were assumed to be presentations for pregnancy related conditions and were categorised as such based upon Australian Emergency Classification Codes. Inpatient episodes were categorised based upon Australian Refined-Diagnostic Related Groups (AR-DRG) codes and if a woman had a caesarean section or vaginal birth.

For women receiving caseload midwifery and standard care, activities were costed the same, with only the type and volume of activities varying between the groups (Appendix Table 1.3, below). Funding for antenatal care followed the standard schedule of antenatal visits, based upon whether the appointment was provided by a midwife, an obstetric consultant/registrar or a GP (for women receiving shared care); the number of visits was dependant on the duration of the pregnancy. Emergency department presentations during the antenatal time period was identified based upon self-reported data, and assigned the cost to funders of the corresponding AECC codes. Induction of labour was assumed to be associated with an obstetrician outpatient consultation, and then an antenatal admission. Epidural use does not have a specific activity code and so did not attract a cost to funders.

Funding for vaginal birth and caesarean section birth was assigned based upon the weighted average of AR-DRG codes relating to type of birth from the NEPD.[3] Funding for the baby was based upon the AR-DRG code assigned to the baby for the birth. If maternal length of stay was longer than 48 hours, then a separate postnatal admission activity was assumed. For domiciliary visits post birth, each home visit was funded as a midwife outpatient activity.

Appendix Table 1.1: Caseload midwifery – costs to public hospitals

Resource	Units consumed	Cost per unit
Caseload midwife time	= 1/45 One full-time caseload midwife cares for 45 women per year	$153,648 Based upon hospital payroll records.
Antenatal care		
Booking clinic – obstetric consultant/registrar	40 minutes All women	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
36 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 35 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
41 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 40 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
Emergency department use	Use identified self-reported data for each woman at 2 months postpartum	$736 Cost to public hospitals identified from AECC Code E1420A and B (average) NHCDC
Labour and birth		
Induction of labour	Use of induction identified from hospital records for each woman 20 minutes Obstetric consultant/registrar's time - assumption	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Consumables $80
Epidural	Use of epidural identified from hospital records for each woman	$301.10 Based on Medicare item number 18226, which covers costs of anaesthetist's time and consumables
Vaginal birth	Identified from hospital records for each woman Maternal length of stay from admission to birth – based on hospital records	Ward supplies - $294 Hotel costs - $3.8 per hour Based on NHCDC
Vaginal birth with forceps or vacuum	Identified from hospital records for each woman 1.5 hours Obstetric consultant/registrar's time – assumption Maternal length of stay post-birth – based on hospital records	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Caesarean section	Identified from hospital records for each woman 2 hours Obstetric registrar's time – based on trial data 1 hour Obstetric resident's time – based on trial data 1 hour paediatrician's time – based on trial data 1 hour anaesthetist's time – based on trial data	Obstetric consultant/registrar: $210/hour Obstetric resident: $126/hour Paediatrician: $210/hour Anaesthetist: $210/hour Anaesthetic nurse: $78/hour Scrub nurse: $78/hour Theatre technician: $78/hour Recovery nurse: $78/hour Based upon hospital payroll records.

	1 hour anaesthetic nurse's time – based on trial data 1 hour scrub nurse's time – based on trial data 1.5 hour operating theatre technician's time – based on trial data 1 hour recovery nurse's time – based on trial data Maternal length of stay post-birth – based on hospital records	Operating room costs - $2,748 Ward supplies - $402 Hotel costs post birth - $3.8 per hour Based on NHCDC
Postnatal ward - mother	Identified from hospital records for each woman Maternal length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm, 1:6 night Midwife salary: $78/hour Based upon hospital payroll records.
Postnatal ward - baby	Identified from hospital records for each baby Baby's length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm, 1:6 night Midwife salary: $78/hour Based upon hospital payroll records.
Special care nursery or neonatal intensive care unit admission	Admission identified from hospital records for each baby Length of stay assumed to be 4.8 days per average reported in NHCDC	Nurse time based upon ratio of 1:2 Intensive care nurse: $78/hour Neonatologist: $210/hour Based upon hospital payroll records. Critical care costs - $2,748 Pathology - $249 Consumables - $271 Hotel costs post birth - $1.9 per hour Based on NHCDC

Appendix Table 1.2: Standard care – costs to public hospitals

Resource	Units consumed	Cost per unit
Booking clinic – midwife and obstetric consultant/registrar	40 minutes – midwife 20 - minutes obstetric consultant/registrar All women	Midwife: $78/hour Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
22 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 21 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
28 week consultation with midwife	20 minutes - midwife All women whose pregnancy progressed beyond 27 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
32 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 31 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.

34 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 33 weeks gestation	Midwife: $78/hour Based upon hospital payroll records.
36 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 35 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
38 week consultation with midwife	30 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 37+6 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
39/40 week consultation with midwife	20 minutes - midwife All women not receiving shared care, whose pregnancy progressed beyond 38 weeks' gestation	Midwife: $78/hour Based upon hospital payroll records.
41 week consultation with obstetric consultant/registrar	15 minutes All women whose pregnancy progressed beyond 40 weeks' gestation	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records.
Emergency department use	Use identified self-reported data for each woman at 2 months postpartum	$736 Cost to public hospitals identified from AECC Code E1420A and B (average) NHCDC
Labour and birth		
Induction of labour	Use of induction identified from hospital records for each woman 20 minutes Obstetric consultant/registrar's time – assumption	Obstetric consultant/registrar: $210/hour Based upon hospital payroll records. Consumables $80
Epidural	Use of epidural identified from hospital records for each woman	$301.10 Based on Medicare item number 18226, which covers costs of anaesthetist's time ad consumables
Vaginal birth	Identified from hospital records for each woman Maternal length of time in birth suite based on length of time from admission to labour to birth – based on hospital records Maternal length of stay post-birth – based on hospital records	Midwife time on birth suite, based upon ratio of 2:3 Midwife salary: $78/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Vaginal birth with forceps or vacuum	Identified from hospital records for each woman 1.5 hours Obstetric consultant/registrar's time – assumption Maternal length of stay post-birth – based on hospital records	Obstetric consultant/registrar: $210/hour Midwife salary: $78/hour Based upon hospital payroll records. Ward supplies - $294 Hotel costs post birth - $3.8 per hour Based on NHCDC
Caesarean section	Identified from hospital records for each woman	Obstetric consultant/registrar: $210/hour

	2 hours Obstetric registrar's time – based on trial data 1 hour Obstetric resident's time – based on trial data 1 hour paediatrician's time – based on trial data 1 hour anaesthetist's time – based on trial data 1 hour anaesthetic nurse's time – based on trial data 1 hour scrub nurse's time – based on trial data 1.5 hour operating theatre technician's time – based on trial data 1 hour recover nurse's time – based on trial data Maternal length of stay post-birth – based on hospital records	Obstetric resident: $126/hour Paediatrician: $210/hour Anaesthetist: $210/hour Anaesthetic nurse: $78/hour Scrub nurse: $78/hour Theatre technician: $78/hour Recovery nurse: $78/hour Based upon hospital payroll records. Operating room costs - $2,748 Ward supplies - $402 Hotel costs post birth - $3.8 per hour Based on NHCDC
Postnatal ward - mother	Identified from hospital records for each woman Maternal length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm shift, 1:6 night shift Midwife salary: $77.76/hour Based upon hospital payroll records.
Postnatal ward - baby	Identified from hospital records for each baby Baby's length of stay post-birth – based on hospital records	Midwife time on postnatal ward, based upon ratio of 1:4 am and pm shift, 1:6 night shift Midwife salary: $77.76/hour Based upon hospital payroll records.
Special care nursery or neonatal intensive care unit admission	Admission identified from hospital records for each baby Length of stay assumed to be 4.8 days per average reported in NHCDC	Nurse time based upon ratio of 1:2 Intensive care nurse: $78/hour Neonatologist: $210/hour Based upon hospital payroll records. Critical care costs - $2,748 Pathology - $249 Consumables - $271 Hotel costs post birth - $1.9 per hour Based on NHCDC
Postnatal		
Postnatal home visits	Number of visits based upon women's self-reported data at 2 months Length of visit assumed to be 1.5 hours, including travel time	Midwife salary: $78/hour Based upon hospital payroll records.

Appendix Table 1.3: Expenditure by public funders, based upon health service use activities

Health service activity	Units consumed	Cost to funders per activity
Antenatal care		
Booking clinic – midwife and obstetric consultant/registrar	Tier 2 code 40.28 Midwifery and Maternity Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$205.21 $265.5 Based upon NEPD
22 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500 and 16591	$205.21 Based upon the NEPD $49.85 $150.75 Based on Medicare benefits Schedule
28 week consultation with midwife	Tier 2 code 40.28 Midwifery and Maternity	$205.21 Based upon the NEPD
32 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
34 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
36 week consultation with obstetric consultant/registrar	Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$265.50 Based upon the NEPD
38 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
39/40 week consultation with midwife (GP for women receiving shared care)	Tier 2 code 40.28 Midwifery and Maternity MBS Item number 16500	$205.21 Based upon the NEPD $49.85 Based on Medicare benefits Schedule
41 week consultation with obstetric consultant/registrar	Tier 2 code 20.40 Obstetrics - management of pregnancy without complications	$265.50 Based upon the NEPD
Emergency Department	AECC Code E1420A and B (average)	$615.35 Based upon the NEPD
Labour and birth		
Induction of labour	Obstetrician consultation: Tier 2 code 20.40 Obstetrics - management of pregnancy without complications Antenatal admission: AR-DRG code O66A.	$265.50 $5,203.39 Based upon the NEPD
Epidural	-	-

Vaginal birth	Weighted average of AR-DRG codes O60A, O60B, O60C	$6,655.73 Based upon the NEPD, Round 24
Caesarean section	Weighted average of AR-DRG codes O01A, O01B, O01C	$13,030.89 Based upon the NEPD, 24
Postnatal ward – mother, if length of stay >48 hours	Weighted average of AR-DRG codes O61A, O61B	$5,108.61 Based upon the NEPD, Round 24
Postnatal ward - baby	AR-DRG: P03Z P04Z P06A P60A P61Z P62Z P64Z P65B P65C P65D P66A P66B P66C P66D P67A P67B P67C P67D	 $129,748.45 $98,240.31 $121,033.82 $8,403.33 $269,055.58 $187,168.03 $49,064.94 $43,771.41 $35,841.68 $26,744.46 $32,750.73 $21,043.69 $14,136.56 $7,159.30 if gestation<37 weeks then $31,075.98 if gestation>37 weeks then $17,770.72 if gestation<37 weeks then $18,282 if gestation>37 weeks then $7,943.02 if gestation<37 weeks then $14,914.52 if gestation>37 weeks then $5,778.45 if gestation<37 weeks then $9,073.46 if gestation>37 weeks then $3,927.47 Based upon the NEPD, Round 24
Postnatal		
Postnatal home visits	Tier 2 code 40.28 Midwifery and Maternity	$205.21 Based upon the NEPD, Round 24

Appendix 2: Budget Impact Analysis additional methodological details

To identify the size of the future eligible population, data were drawn from the *Queensland Perinatal Data Collection* (PDC), containing all pregnancies and births (n=365,138) between 01/07/2012 and 30/06/2018 in Queensland (QLD), Australia.[4] The PDC contains the details of all births regardless of location (private hospital, public hospital), information on maternal demographics, maternal clinical characteristics, medical interventions performed in pregnancy and childbirth, and infant outcomes. This was considered the most current source of whole of population, individual level data containing obstetric risk status of women, which was required to identify eligibility for caseload midwifery.

We reweighted the data of births over 20 weeks' gestation between 01/07/2013 and 30/06/2018 (n=302,169) to reflect the Australian population of women giving birth between 01/01/2023 and 31/12/2027. Reweighting was conducted using GREGWT, a generalised regression reweighting algorithm developed by the Australian Bureau of Statistics (ABS).[5] Weighting was conducted using national benchmarks for mother's age by First Nations identification, private hospital births, mother's age by parity, and age by caesarean section using data from the Australian Institute of Health and Welfare's (AIHW) Mothers and Babies 2012 - 2020 reports.[6] Linear trends were fitted to extrapolate benchmarking figures between 2023 and 2027.

Appendix 3: Comparison of costs to public hospitals and public funders for caseload midwifery, standard care and shared care.

Appendix Table 3.1 Costs to public hospitals per woman – Caseload midwifery, Standard Care, Shared Care

	Caseload	Control	
		Standard care	Shared care
	n=1,146	n=1,151	n=141
Caseload midwife salary cost	$3,414	-	-
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$337 ($30)	$166 ($17)
Emergency department presentations*, mean (SD)	$487 ($659)	$528 ($718)	$369 ($524)
Induction*, mean (SD)	$35 ($53)	$40 ($55)	$38 ($54)
Epidural*, mean (SD)	$94 ($139)	$113 ($146)	$97 ($141)
Birth Suite, mean (SD)	$1,376 ($1,694)	$3,665 ($3,899)	$4,184 ($9,141)
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,202 ($2,142)	$4,075 ($3,401)
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,242 ($1,285)	$3,217 ($1,318)
Postnatal costs, after to discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($77)	$195 ($110)
Total costs for all services, mean (SD)	$12,363 ($4,967)	$12,320 ($6,299)	$12,341 ($12,801)

Grey shaded cells indicate statistically significant difference with caseload

Appendix Table 3.2: Expenditure by public funders per woman – Caseload midwifery, Standard Care, Shared Care

	Caseload		Control			
			Standard care		Shared care	
Antenatal health service use	Mean	SD	Mean	SD	Mean	SD
Outpatient episodes - Midwife	$1,379.71	$142.91	$1,378.97	$151.47	$410.42	$0.00
Outpatient episodes - Obstetrician	$596.80	$126.42	$580.95	$117.09	$600.67	$129.47
Outpatient episodes - General Practitioner	$0.00	$0.00	$0.00	$0.00	$387.63	$34.31
Emergency department episodes	$407.40	$550.78	$441.07	$600.39	$308.85	$438.44
Antenatal costs TOTAL	$2,383.95	$588.31	$2,401.37	$644.20	$1,707.57	$469.52
Labour, birth, postnatal in-hospital service use						
Induction of labour	$7,885.15	$2,516.30	$8,208.49	$2,737.78	$8,419.07	$2,861.87
Labour and birth inpatient episodes - mother	$1,675.03	$2,521.98	$1,846.43	$2,587.52	$1,745.39	$2,558.39
Neonatal inpatient episode - baby	$4,920.13	$6,367.80	$5,178.16	$10,900.87	$5,296.50	$8,673.57
Postnatal inpatient episode, prior to discharge	$3,040.20	$2,508.76	$3,722.71	$2,272.54	$3,586.90	$2,344.61
Labour, birth, postnatal in-hospital costs TOTAL	$17,520.51	$8,360.82	$18,955.79	$11,982.59	$19,047.86	$10,541.75
Postnatal outpatient episode (home visits)	$410.42	$0.00	$410.42	$0.00	$410.42	$0.00
Total costs for all services	$20,320.51	$8,333.33	$21,774.43	$12,006.87	$21,165.85	$10,452.46

Grey shaded cells indicate statistically significant difference with caseload

Appendix 4:

Appendix Table 4.1 : Costs to public hospitals in the scenario analysis where caseload midwives are not included in birth suite ratios (i.e. their time in birth suite is an additional cost)

	Caseload	Standard care	p-value	Difference
	n=1,146	n=1,151		
Caseload midwife salary cost	$3,414	-	n/a	$3,414
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$316 ($63)	<.001	-$102
Emergency department presentations*, mean (SD)	$487 ($659)	$508 ($699)	0.29	-$21
Induction*, mean (SD)	$35 ($53)	$39 ($55)	0.22	-$4
Epidural*, mean (SD)	$94 ($139)	$110 ($145)	0.04	-$16
Birth Suite, mean (SD)	$3,306 ($5,145)	$3,729 ($4,855)	<.001	-$423
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,154 ($2,263)	<.001	-$423
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,239 ($1,289)	<.001	-$246
Postnatal costs, after to discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($81)	n/a	-$197
Total costs for all services, mean (SD)	$14,294 ($8,120)	$12,323 ($7,404)	<.001	$1,971
Midwife and obstetrician staff costs only				
Caseload midwife salary cost, mean (SD)	$3,414	-	n/a	$3,414
Hospital Midwife Staff Costs (ex Caseload Midwives), mean (SD)	$4,829 ($5,104)	$5,627 ($4,670)	<.001	-$798
Obstetric Staff Costs, mean (SD)	$521 ($245)	$561 ($251)	<.001	-$41
Total, mean (SD)	$8,764 ($5,168)	$6,188 ($4,734)	<.001	$2,576

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Continuity of care by a primary midwife (caseload midwifery): A cost analysis using results from the COSMOS randomised controlled trial

Running title: Cost analysis of caseload midwifery

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ABSTRACT

Introduction

Caseload midwifery (continuity of midwifery carer) offers benefits including lower caesarean section rates, lower risks of preterm birth and stillbirth, and improved maternal satisfaction of care. Despite these advantages, concerns about additional costs hinder widespread implementation. This study examines the cost of caseload midwifery compared to standard maternity care from the perspective of both public hospitals and public funders.

Methods

A cost analysis was conducted using data from a randomised controlled trial of 2,314 low-risk pregnant women in Melbourne, Australia. Women randomised to caseload care received antenatal, intrapartum, and postpartum care from a primary midwife, with some care provided by a 'back-up' midwife. Women in standard care received midwifery-led care with varying levels of continuity, junior obstetric care, or community-based medical care. The cost analysis compared differences in mean costs of health resources to public hospitals and to public funders. Additionally, a budget impact analysis estimated total costs to the health system between 2023 and 2027.

Results

For public hospitals, there was no significant difference in overall costs between women receiving caseload midwifery (n=1,146) versus standard care (n=1,151) ($12,363 [SD: $4,967] versus $12,323 [SD: $7,404]; P=0·85). Conversely, public funders incurred lower expenditures for women receiving caseload midwifery ($20,330, [SD: $8,312]) versus standard care ($21,637 [SD: $11,818]; P<0·001). The budget impact analysis estimated savings of $625 million to the health system over the next 5 years with expanded access to caseload midwifery in Australia.

Conclusion

Caseload midwifery in low-risk women is cost-neutral to public hospitals, and cost-saving to public funders.

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Data availability: Data may be shared upon request in accordance with our ethics approvals.

Keywords: Caseload Midwifery; Caesarean Section; Costs and Cost Analysis; Pregnancy; Maternity Care

Tweetable abstract: Continuity of midwifery for low-risk women reduces costs to public funders, with no additional costs to hospitals

What is already known on this topic

- Continuity of care by a primary midwife (caseload midwifery) is associated with beneficial health outcomes and increased rates of maternal satisfaction.
- Despite positive effects, uncertainty regarding the economic consequences associated with this model of care remains a significant barrier to the uptake of this highly effective maternal health intervention.

What this study adds

- To drive changes in the uptake of caseload midwifery, this study assessed the cost implications of caseload midwifery in comparison to standard maternity care from the perspective of both public hospitals and public funders.

How this study might affect research, practice or policy

- Caseload midwifery was found to reduce costs to public funders for low-risk women without increasing costs for public hospitals.

INTRODUCTION

High-income countries are grappling with the concurrent challenges in maternity care of rapidly increasing intervention rates, particularly caesarean sections, and the imperative to prevent rare but catastrophic outcomes such as morbidity and death.[1, 2] This is set against a background of rapidly increasing healthcare costs and tightening government expenditure.[3] Caesarean section is a high-cost medical procedure that comes with an increased risk of adverse outcomes.[4,5] Consequently, reducing the need for caesarean section is an ongoing international priority.[6]

Whilst high-income countries have very low rates of maternal and neonatal morbidity and mortality, some individual health services have recently been identified as service "failures", with clusters of catastrophic adverse events.[7-9] These incidents have highlighted the need for attention to maternal experience and maternal and neonatal safety.[10, 11] Furthermore, follow-up responses have also highlighted the need to prioritize the implementation of evidence-based responses both within these individual services, and across maternity care more broadly.[12]

Continuity of midwifery carer in women of low obstetric risk has been shown in the COmparing Standard Maternity care with One-to-one midwifery Support (COSMOS) randomised controlled trial (RCT) to reduce the risk of caesarean section, and admission to special or neonatal intensive care for the infant.[13] The model, called 'caseload midwifery', where women received antenatal, intrapartum, and postpartum care from a primary midwife, also resulted in an improvement in birth experience for women,[14, 15] and has been associated with a lower risk of preterm birth, stillbirth and neonatal death.[16] Other RCT evidence from all-risk women concluded that caseload midwifery is safe for women of any risk, and produces cost savings for hospital funders.[17] As such, increasing access to caseload midwifery should be a key strategy to concurrently address rising intervention rates, whilst improving experience and safety.

A key barrier to wider implementation or scale-up of caseload midwifery is the perceived additional costs to public hospitals associated with this model.[18] Comprehensive evidence of the costs of caseload midwifery and standard care is thus needed in order to inform decision-making about establishment or scale-up. The objective of this study was to identify the cost

and budget impact of caseload midwifery compared to standard care amongst women of low obstetric risk in Australia.

METHODS

Study setting and location

In Australia, caesarean section rates were 37% in 2020, which is above the Organisation for Economic Co-operation and Development (OECD) average.[19, 20] It is projected that 45% of births in Australia will be by caesarean section by 2030.[21] Maternity care is funded through a mix of public funding, out-of-pocket fees, and private health insurance funds.[22] Public hospitals are funded jointly by both the Federal and state governments through Public Hospital Funding Agreements on an activity-based funding model. Each episode of inpatient, outpatient, and emergency department care in public hospitals is funded at a set rate determined by the Independent Hospital Pricing Authority, with no out-of-pocket fees for Medicare-eligible patients.[23] Any care provided outside of public hospitals is partly subsidized through a different pool, Medicare, which is funded solely by the Federal government.

Public hospitals are owned and managed by state governments, with individual hospitals being operated by a board and executive responsible for the provision of services and financial sustainability. Once government funding reaches a hospital, the hospital is then responsible for providing the care, including payment of staff, consumables, and facility costs. This includes midwives and medical salaries associated with providing maternity care. Caseload midwifery in Australia is designed for implementation in the public hospital setting. As such, it will have cost implications to public funders as it will affect the types of activities or episodes of care being funded, and to individual hospitals as it involves different staff, consumable, and facility costs.

Study population

COSMOS was a two-arm RCT designed to compare caseload midwifery to standard maternity care in women at low risk of obstetric complications. The trial design is described in detail elsewhere.[13, 24] Briefly, women at low risk of obstetric complications were recruited at the Royal Women's Hospital, a public tertiary women's hospital in Melbourne, Australia, between September 2007 and June 2010. Women were eligible for inclusion in the trial if they were able to speak, read, and write English, if they had a singleton pregnancy of less than 24 weeks

gestation at recruitment, and if they were considered a low obstetric risk, with no complications during the current pregnancy and no precluding medical conditions (e.g., cardiac disease, diabetes, epilepsy, substance use, obesity or significantly underweight). Women with a previous caesarean section were excluded. Caseload midwifery was not available to women outside the trial.

Comparators

Caseload midwifery care

Women randomised to the intervention group received the majority of their antenatal, intrapartum, and postnatal care from a primary caseload midwife at the hospital. If complications arose, the primary midwife collaborated with other health professionals (e.g., obstetricians) whilst continuing to provide caseload care. Caseload midwives provided 'back-up' care for each other, so that if a caseload midwife was sick, on personal leave, or unavailable the back-up midwife would provide care for a woman. Women saw an obstetrician at booking, at 36 weeks of gestation and if the pregnancy lasted beyond 40 weeks' gestation. Intrapartum care was provided in the birth suite by the caseload midwife (89% of the time), or otherwise by a core hospital midwife. Postpartum, the caseload midwife saw women on most days in the hospital to provide postnatal care and provided domiciliary care following discharge from the hospital. All care was provided according to hospital guidelines and protocols. Full-time midwives had a caseload of 45 women per annum.

Standard maternity care

Women randomized to the control group could choose from the standard hospital options for low-risk women (referred to as "standard care"). These included midwifery-led care (78%), which generally meant women saw a different midwife at each visit, based upon who was rostered to work at the time of care; obstetric trainee care (2%); or shared care where antenatal care is shared between an accredited general medical practitioner (GP) and the hospital (15%). Five percent transferred their care elsewhere. As with caseload midwifery care, women in the standard care model saw an obstetrician at booking, 36 weeks' gestation and 41 weeks gestation if required. Care was provided according to the same hospital guidelines and protocols as women in the caseload midwifery arm.

Study Design – cost analysis

We conducted a cost analysis using data from the COSMOS RCT to determine if there are differences in cost between caseload midwifery and standard care for individual public hospitals providing care, and public funders.

Time horizon, discount rate

The time horizon for the cost analysis was from booking at around 16 weeks' gestation, through to two months postpartum. Since the follow-up period was less than 12 months, discounting of costs was not required.

Measurement and valuation of resources

Public hospital costs

The use of public hospital resources was identified from a combination of self-reported health service use from a survey administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Health resources were costed from the hospital's perspective. These are described in detail in Appendix 1.

Expenditure by public funders

Expenditure by public funders was based upon all episodes of care, also identified from self-reported health service use survey data administered to women at 2 months postpartum, data collected from hospital records by the study team, and administrative data. Funding per activity was based upon the Independent Hospital Pricing Authority National Efficient Price Determination (NEPD) for 2022/23, with the Inlier weight per activity multiplied by the National Efficient Price.[25] These are described in detail in Appendix 1.

Study Design – budget impact analysis

The second analysis was a budget impact analysis including costs to the health system, comprising both public hospital costs and expenditure by public funders for caseload midwifery and standard care in women at low risk of obstetric complications. This was designed to capture the cost implications of hypothetical national implementation. We assumed that uptake of caseload would be 70% in women at low risk of obstetric complications and that adherence would be 90%; this was considered more reflective of potential use in practice. The analysis was designed to represent the Australian population of births between 2023 – 2027. Full methodological details are provided in Appendix 2.

Time horizon

The model took a five-year time horizon, including all births and considering costs and outcomes between 2023 and 2027 (that is, for births in 2023 costs and outcomes will be

considered for up to five years postpartum, whereas those born in 2026 will only have costs and outcomes considered up to one year postpartum). No discounting was applied.

Currency, price date, and conversion

All costs are presented in 2021/22 Australian dollars. For reference, at the time of writing 1 Australian Dollar is equal to 0·56 Pounds sterling, 0·63 Euros, and 0·67 United States Dollars. When unit prices and funding amounts were not recorded in the original source on this price date, they were adjusted for inflation using the Reserve Bank of Australia inflation figures.[26]

Data analysis

Data were analyzed on an intention-to-treat basis. Demographic characteristics of women receiving caseload midwifery and standard care were compared. Differences between groups were calculated using Pearson's chi-square test, and Student's t-test (p-values reported). The average number of, or frequency of access to, different resources was then compared, followed by costs to public hospitals and expenditure by public funders. A supplementary analysis was conducted that compared costs to public hospitals and expenditure by public hospitals for women receiving shared care (with a GP). For costs, generalized linear models were used to compare differences, with a gamma distribution and log link function to account for the skewed nature of the cost data. Health service use was analyzed as count data with the negative binomial distribution. All analysis was conducted using SAS 9.4.

RESULTS

There were 1,146 women allocated to caseload care and 1,151 women allocated to standard care. Of the 1,151 women allocated to standard care, 79.7% (917/1,151) received public antenatal care with either midwives or obstetric trainees; 15.1% (174/1,151) received shared care (with a GP); and 5.2% (60/1,151) transferred to care elsewhere. Of the 1,146 women allocated to caseload care, 3.3% (38/1,146) received other care either at the Royal Women's Hospital, or at a facility outside of Melbourne due to relocation. Table 1 demonstrates that the two groups were similar in terms of demographic characteristics.

Table 1: Demographic characteristics of women receiving caseload and standard care

	Caseload (n=1,146)	**Standard care (n=1,151)**	***p*-value**
Model of care received within the allocated group	Caseload only care - 1108 (96.7%)	Midwives or obstetrics trainees – 917 (79.7%)	n/a
	Transferred to care elsewhere – 38 (3.3%)	Share care with a GP – 174 (15.1%)	n/a
		Transferred to care elsewhere - 60 (5.2%)	n/a
Age at booking visit – mean (SD)	31·2 (4·6)	31·3 (4·7)	0·62
Body Mass Index (BMI) at booking visit – mean (SD)	24·1 (3·7)	23·8 (3·7)	0·13
Gestation at booking – mean (SD)	16·3 (2·8)	16·3 (2·9)	0·57
Nulliparous – n (%)	803 (70·1%)	799 (69.4%)	0·73
Married or de facto – n (%)	1076 (93·9%)	1062 (92.3%)	0·33
Post-secondary Education – n (%)	874 (76·3%)	828 (71.9%)	0·05
Born in Australia – n (%)	652 (56·9%)	644 (56.0%)	0·79

n/a=not applicable.

In terms of health resources utilized, women allocated to caseload midwifery accessed slightly more antenatal midwife appointments (6·7 versus 6·1; P<0·001) but were less likely to have an epidural (28·3% versus 30·8%; P=0·04) than women in the standard care group. They also were less likely to have a caesarean section birth (19·3% versus 24·8%; P=0·001), had a shorter length of labour (12·9 hours versus 14·0 hours; P=0.04), and had a shorter postnatal ward stay (55·5 hours versus 60·2 hours; P<0.001). The babies of women allocated to caseload midwifery had fewer admissions to SCN or NICU (5·9% versus 9·2%; P=0·002) and had shorter lengths of stay post-birth (68·2 hours versus 73·9 hours; P<0.001). Women in the caseload group also had slightly more postnatal home visits (2·1 visits versus 1·7 visits; P<0·001) (Table 2).

Table 2: Health service use of women

	n	**Caseload** Mean (SD) / n (%)	**n**	**Standard care** Mean (SD) / n (%)	***p* -value**
Antenatal visits					
Antenatal visits - midwife(SD)	1,146	6·7 (0·7)	1,151	6·1 (1·7)	<0·001
Antenatal visits – GP*(SD)	1,146	0·0 (0·0)	1,151	0·6 (1·6)	n/a
Antenatal visits - obstetrician(SD)	1,146	2·3 (0·5)	1,151	2·2 (0·5)	0·42
Emergency department presentations(SD)	1,146	0·7 (0·9)	1,151	0·7 (1·0)	0·46
Induction – n (%)	1,146	351 (30·6%)	1,151	386 (33·5%)	0·54
Epidural – n (%)	1,146	324 (28·3%)	1,151	354 (30·8%)	0·04
Birth					
Caesarean Section - n (%)	1,146	221 (19·3%)	1,151	285 (24·8%)	0·001

Vaginal birth - instrumental - n (%)	1,146	202 (17·6%)	1,151	222 (19·3%)	0·31
Vaginal birth- unassisted – n (%)	1,146	719 (62·7%)	1,151	637 (55·3%)	<0·001
Length of labour (hours) (SD)	1,146	12.9 (30·1)	1,151	14·0 (27·9)	0·04
Postnatal - baby					
SCN or NICU admission	1,146	67 (5·9%)	1,151	106 (9·2%)	0·002
Baby length of stay (hours) (SD)	1,146	68.2 (45·7)	1,151	73·.9 (40·0)	<0·001
Postnatal ward – mother					
Mother's length of stay (hours) (SD)	1,146	55·5 (31·2)	1,151	60·2 (24·9)	<0·001
Postnatal visits, after discharge (home visits)					
Postnatal home visits(SD)	1,146	2·1 (1·0)	1,151	1·7 (0·7)	<0·001

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; * 0 for those receiving caseload, as antenatal care by a GP, was only provided for those receiving 'shared care' as a subset of those in standard care; n/a=not applicable.

Based on annual caseload midwife salary and a caseload of 45 women, caseload midwives cost public hospitals $3,414 per woman to provide care through the antenatal, intrapartum, and postnatal period. Women receiving caseload midwifery had lower mean costs associated with antenatal visits (which includes non-caseload midwife, obstetrician, and GP time) ($214 versus $316 P<0·001), epidural use ($94 versus $110; P=0·04), birth suite ($1,376 versus $3,729; P<0·001), and postnatal ward costs for mother ($2,993 versus $3,239; P<0·001) and baby ($3,731 versus $4,154; P<0·001). Women receiving caseload care had $0 for postnatal costs after discharge as these costs were included in caseload midwife salary costs. There was no significant difference in overall costs between women allocated to the caseload group compared with women allocated to standard care ($12,363 versus $12,323; P=0·85) (Table 3). There was also no significant difference in costs per woman for public hospitals for women receiving shared care (with a GP), and women receiving caseload midwifery (Appendix 3). In the scenario analysis where women received intrapartum care from their caseload or back-up midwife *and* the rostered hospital midwives as well, costs were $1,971 higher for women receiving caseload midwifery (Appendix 4).

Expenditure by public funders on midwife antenatal outpatient episodes ($1,380 versus $1,260; P<0.001) and obstetrician antenatal outpatient episodes ($597 versus $583; P=0·01) was higher for women receiving caseload midwifery care compared to women receiving standard care (Table 4). In contrast, expenditure by public funders on labour, birth, and postnatal inpatient episodes of care was lower for women receiving caseload midwifery care compared to women receiving standard care ($17,521 versus $18,967; P<0·001). In all, expenditure by public funders was $1,307 less for women receiving caseload midwifery than women receiving standard care (P<0·001).

Table 3: Mean costs to public hospitals per woman

	Caseload	Standard care	*p*-value	Difference
	n=1,146	n=1,151		
Caseload midwife salary cost	$3,414	-	n/a	$3,414
Antenatal visits (non-caseload midwife, obstetrician), mean (SD)	$214 ($55)	$316 ($63)	<0·001	-$102
Emergency department presentations*, mean (SD)	$487 ($659)	$508 ($699)	0·29	-$21
Induction*, mean (SD)	$35 ($53)	$39 ($55)	0·22	-$4
Epidural*, mean (SD)	$94 ($139)	$110 ($145)	0·04	-$16
Birth Suite, mean (SD)	$1,376 ($1,694)	$3,729 ($4,855)	<0·001	-$2,353
Postnatal (ward, SCN or NICU) - baby, mean (SD)	$3,731 ($2,557)	$4,154 ($2,263)	<0·001	-$423
Postnatal ward - mother, mean (SD)	$2,993 ($1,619)	$3,239 ($1,289)	<0·001	-$246
Postnatal costs, after discharge (home visits), mean (SD)	n/a included in caseload midwife salary cost	$198 ($81)	n/a	-$197
Total costs for all services, mean (SD)	$12,363 ($4,967)	$12,323 ($7,404)	0·85	-$41
Midwife and obstetrician staff costs only				
Caseload midwife salary cost, mean (SD)	$3,414	-	n/a	$3,414
Hospital Midwife Staff Costs (excluding Caseload Midwives), mean (SD)	$2,877 ($1,619)	$5,627 ($4,670)	<0·001	-$2,749
Obstetric Staff Costs, mean (SD)	$521 ($245)	$561 ($251)	<0·001	-$41
Total, mean (SD)	$6,812 ($1,721)	$6,188 ($4,734)	<0·001	$624

SCN= Special Care Nursery; NICU=Neonatal Intensive Care Unit; *mean cost across all women in each group; n/a=not applicable

Table 4: Expenditure by public funders per woman

	Caseload	Standard care	*p*-value	Difference
	Mean (SD)	Mean (SD)		
Antenatal health service use				
Outpatient episodes - Midwife	$1,380 ($143)	$1,260 ($348)	<0·001	$119
Outpatient episodes - Obstetrician	$597 ($126)	$583 ($119)	0·01	$13
Outpatient episodes - General Practitioner	n/a no shared care	$47 ($128)	n/a	-$47
Emergency department episodes	$408 ($551)	$426 ($584)	0·62	-$17
Antenatal expenditure TOTAL	$2,384 ($588)	$2,316 ($665)	0·01	$68
Labour, birth, postnatal in-hospital service use				
Induction of labour	$1,676 ($2,522)	$1,835 ($2,583)	0·36	-$159
Labour and birth inpatient episodes - mother	$7,885 ($2,516)	$8,234 ($2,753)	<0·001	-$349
Neonatal inpatient episode - baby	$4,920 ($6,368)	$5,193 ($10,650)	0·02	-$273
Postnatal inpatient episode, prior to discharge	$3,041 ($2,509)	$3,707 ($2,281)	0·01	-$666
Labour, birth, postnatal in-hospital expenditure TOTAL	$17,521 ($8,361)	$18,967 ($11,811)	<0·001	-$1,447
Postnatal outpatient episode (home visits)	$424 ($181)	$348 ($143)	<0·001	$76

Total expenditure for all services	$20,330 ($8,312)	$21,637 ($11,818)	<0·001	-$1,307

Table 5: Modelled budget impact analysis of caseload midwifery compared to standard care, assuming a 70% uptake rate and 90% adherence

	2023	2024	2025	2026	2027
Australian population of women giving birth	300,680	298,056	298,160	296,603	296,645
Public hospital births	231,532	233,772	233,412	234,828	236,690
Low-risk women (target population)	165,582	166,691	157,457	149,625	144,185
Uptake	104,317	105,015	99,198	94,264	90,837
Standard care					
Costs to public hospitals (A)	$1,285,494,201	$1,294,103,912	$1,222,415,845	$1,161,612,191	$1,119,378,806
Expenditure by public hospital funders (B)	$2,257,099,572	$2,272,216,695	$2,146,345,179	$2,039,584,759	$1,965,430,432
Net costs from the health system's perspective (A+B)	$3,542,593,774	$3,566,320,607	$3,368,761,024	$3,201,196,950	$3,084,809,238
Caseload midwifery					
Costs to public hospitals (A)	$1,289,666,868	$1,298,304,525	$1,226,383,761	$1,165,382,741	$1,123,012,268
Costs to public hospital funders (B)	$2,120,757,698	$2,134,961,659	$2,016,693,510	$1,916,382,038	$1,846,707,062
Net costs from the health system's perspective (A+B)	$3,410,424,565	$3,433,266,184	$3,243,077,272	$3,081,764,779	$2,969,719,329
Savings from caseload midwifery	-$132,169,208	-$133,054,423	-$125,683,752	-$119,432,171	-$115,089,909

The modelled budget impact analysis (Table 5) shows the overall cost implications of caseload midwifery compared to standard care for low-risk women in Australia, with hypothetical nationwide implementation. The overall number of eligible women (women of low obstetric risk, giving birth in a public hospital) is expected to initially rise, due to the increasing proportion of women giving birth in public hospitals, and then decline due to the decreasing proportion of women considered to be low obstetric risk. There would be net cost savings of $132 million to the public health system in year 1 (2023), and $115 million in year 5 (2027). Overall, there would be savings of $625 million to the health system over the next 5 years if 70% of eligible women had access to caseload midwifery in Australia, with 90% adherence.

DISCUSSION

Main findings

Caseload midwifery for women at low obstetric risk was not associated with increased overall costs to public hospitals ($12,363 for women receiving caseload; $12,323 for women receiving standard care). Caseload midwifery was associated with a reduction in expenditure to public funders of $1,307 per woman compared to standard care. This was primarily by lower use of the epidural, caesarean section, instrumental vaginal birth, fewer special care nursery and neonatal intensive care unit admissions, and shorter length of labour and length of stay post-birth for women receiving caseload midwifery compared to standard care. The lower use of these resources, and thus lower costs to public hospitals, offset the additional staffing costs for midwives and obstetric time. When considered at the national level from a health systems perspective (considering both costs to public hospitals and expenditure by public funders), caseload midwifery is cost-saving. If implemented at a national level in Australia, caseload midwifery for low-risk women could save the system $625 million over the next five years.

Strengths and limitations

The primary limitation of the study was that it was based upon a single site, in an urban setting with strong leadership. This may mean that the findings may be different from those seen with wider implementation. Previous studies from this trial[13] have noted some differences in the characteristics of women participating in the trial compared to the overall population, notably the higher proportion of women who were married or living with their partner, nulliparous women, and women born overseas. The key strength of this study is that it is based on results directly collected during an RCT, and thus represents a balanced comparison between study

groups. Furthermore, the study took a comprehensive approach to cost measurement, capturing both public hospital costs and expenditures by public funders.

Interpretation

Few studies have assessed the costs of caseload midwifery relative to standard care, and the limited evidence base on the costs of caseload midwifery is still considered a barrier to implementation. The M@NGO RCT of all risk women found cost savings to hospital funders associated with the birth event for women receiving caseload midwifery, compared to standard care.[17] A Cochrane review[16] published in 2016 compared midwife-led continuity of care models with other models of care and found a trend towards cost-saving for midwife-led continuity of care models. More recently, an observational study from Australia comparing the real-world costs of caseload midwifery and standard care demonstrated cost-savings of AU$5,208 per woman in the caseload model from the public funder's perspective, however, this related to all-risk women.[27] Two modelling studies have also been conducted - one study from the United States demonstrated that a shift from obstetric-led to midwife-led care could be cost-saving for low-risk pregnancies [28] and another Australian study identified that caseload midwifery in low-risk nulliparous women was cost-saving compared to standard care.[29] However, none of these previous studies have considered staffing costs in public hospitals.

Our study also highlighted a number of important factors that need to be considered as a part of implementation to ensure financial sustainability. Firstly, when considering only midwifery staffing costs, caseload midwifery is a higher cost than standard care. It is also a higher cost when the caseload midwife *and* rostered hospital midwives both provide intrapartum care. Cost savings to public hospitals are seen through a small reduction in obstetric staff time but also through a reduction in costs of anaesthetists for epidurals and caesarean sections, theatre costs for providing caesarean sections, SCN, and NICU admissions. Thus, for implementation within public hospitals, there would need to be a redistribution of cost savings from other areas into midwifery salary to support the additional midwifery staffing costs required for caseload midwifery. Another crucial finding from this study is that caseload midwifery will result in higher costs to public hospital funders if the number of midwives rostered to birth suite to provide standard care is not proportionately reduced with caseload midwifery.

Our findings that demonstrated substantial cost savings for public hospital funders are also an important consideration for implementation. The cost-saving per woman receiving caseload midwifery to public funders ($1,307 per woman) is larger than the potential additional staffing costs for midwives incurred by public hospitals ($624 per woman). From a policy perspective, public hospital funders (in Australia, state, and Federal governments) could fund individual hospitals to support start-up costs of caseload midwifery, given the previously noted need for hospitals to internally redistribute staff savings and reduce birth suite midwives providing standard care. This could still be cost-saving to public funders given the reduction in expenditure associated with reduced numbers of caesarean section births, reduction in length of stay in birth suite and postnatal ward, and fewer neonatal admission to special care.

CONCLUSION

Amongst low-risk women, caseload midwifery is not associated with increased costs to public hospitals compared to standard care, and significantly reduces costs to public funders. Overall, to health systems, caseload midwifery reduces costs compared to standard care in low-risk women and could result in substantial cost savings if fully implemented.

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Patient and public involvement: A consumer of maternity services was involved in the study design, conduct, and dissemination of this research via membership of the COSMOS trial reference group. Further, study participants were asked to provide their views and experiences of care by postal surveys. Additionally, midwives who conducted the intervention were invited to provide their views and experiences via interviews and surveys.

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Ethics Approval: Ethics approval was obtained from the Royal Women's Hospital (07/01) and La Trobe University Human Research Ethics Committees (07/04).

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Figure and table legends

Table 3: Demographic characteristics of women receiving caseload and standard care

Table 4: Health service use of women

Table 3: Mean costs to public hospitals per woman

Table 4: Expenditure by public funders per woman

Table 5: Modelled budget impact analysis of caseload midwifery compared to standard care, assuming a 70% uptake rate and 90% adherence

Appendix Table 1.1: Caseload midwifery – costs to public hospitals

Appendix Table 1.2: Standard care – costs to public hospitals

Appendix Table 1.3: Expenditure by public funders, based upon health service use activities

Appendix 2: Budget impact analysis additional methodological details

Appendix Table 3.1 Costs to public hospitals per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 3.2: Expenditure by public funders per woman – Caseload midwifery, Standard Care, Shared Care

Appendix Table 4.1: Costs to public hospitals in the scenario analysis where caseload midwives are not included in birth suite ratios (i.e. their time in a birth suite is an additional cost)