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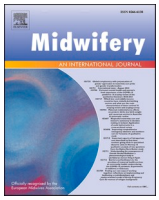

# A cost analysis of upscaling access to continuity of midwifery carer: Population-based microsimulation in Queensland, Australia

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ABSTRACT

*Objective:* To quantify the economic impact of upscaling access to continuity of midwifery carer, compared with current standard maternity care, from the perspective of the public health care system.
*Methods:* We created a static microsimulation model based on a whole-of-population linked administrative data set containing all public hospital births in one Australian state (Queensland) between July 2017 to June 2018 ($n$ = 37,701). This model was weighted to represent projected State-level births between July 2023 and June 2031. Woman and infant health service costs (inpatient, outpatient and emergency department) during pregnancy and birth were summed. The *base model* represented current standard maternity care and a *counterfactual model* represented two hypothetical scenarios where 50 % or 65 % of women giving birth would access continuity of midwifery carer. Costs were reported in 2021/22 AUD.
*Results:* The estimated cost savings to Queensland public hospital funders per pregnancy were $336 in 2023/24 and $546 with 50 % access. With 65 % access, the cost savings were estimated to be $534 per pregnancy in 2023/24 and $839 in 2030/31. A total State-level annual cost saving of $12 million in 2023/24 and $19 million in 2030/31 was estimated with 50 % access. With 65 % access, total State-level annual cost savings were estimated to be $19 million in 2023/24 and $30 million in 2030/31.
*Conclusion:* Enabling most childbearing women in Australia to access continuity of midwifery carer would realise significant cost savings for the public health care system by reducing the rate of operative birth.

**Statement of significance**

Problem or issue

Upscaling of continuity of midwifery carer in public health care system is slow, and the financial impact under-researched.

**What is already known**

Women randomised to continuity of midwifery carer experience numerous benefits without adverse effects, compared with other models of care.

**What this paper adds**

Enabling most childbearing women in Australia to access continuity of midwifery carer would realise significant cost savings for the public health care system by reducing the rate of operative vaginal birth.

## Introduction

Maternity care in high-income countries has been characterised by rapidly increasing intervention rates, yet without a commensurate improvement in health outcomes (e.g., maternal haemorrhage, stillbirth or neonatal admission) (E.J. Callander et al., 2023; Hu et al., 2024). In

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addition, there are concerns regarding inequitable access to quality care and limited involvement of women as maternity care consumers (Miller et al., 2016; Australian Institute of Health Welfare, Australia's mothers and babies 2022). Therefore, changes are needed to align maternity care with the best evidence, to normalise and humanise birth, and focus on woman-centred care (Australian Institute of Health Welfare, Australia's mothers and babies 2019; Australian Health Ministers' Conference, National maternity services plan 2011; Australian Health Ministers' Conference, National maternity services plan 2008; England, 2016). Increasing access to continuity of midwifery carer has been recommended as a complex intervention to address current failures in maternity care (J. Allen et al., 2022; Bryant, 2009).

Continuity of midwifery carer (also known as midwifery group practice, midwifery continuity of care or caseload midwifery care) provides care led by the same midwife from the first pregnancy booking visit, to labour and birth and the early postpartum period; in collaboration with other health care providers as clinically indicated. This continuum of relationship-based care facilitates trust between a woman and her midwife and contributes to greater engagement in maternity care (Allen et al., 2023), increased satisfaction across the entirety of the maternity experience (Forster et al., 2016) and achieved the lowest birth trauma rates as measured by women's experiences (Keedle and Dahlen, 2023). When compared with other models of care (e.g., medical-led care or shared care), women of any risk randomised to continuity of midwifery carer have a lower risk of preterm birth, less exposure to medical interventions (e.g., lower use of epidural analgesia and operative vaginal birth) with no adverse effects (Sandall et al., 2016) and reduced costs (Sandall et al., 2016; Donnellan-Fernandez et al., 2018; Gao et al., 2023). In the context of rapidly increasing intervention rates, unsustainable increases in costs and the urgent need to prioritise and improve women's outcomes and positive birth experiences (Kirkup, 2022; Duncombe et al., 2022; Ockenden and report, 2020), continuity of midwifery carer offers an evidence-based solution.

Although attempts to implement continuity of midwifery carer are occurring across many high-income countries, the number of women who can access this model remains limited, largely confined to low-risk pregnancies, with wide variation across and within countries (e.g., Australia, Canada, Ireland, New Zealand and the United Kingdom) (J. Australian Health Ministers' Conference, National maternity services plan 2022; Donnellan-Fernandez et al., 2021; J. Australian Health Ministers' Conference, National maternity services plan 2022). According to the latest national report which grouped models of care in Australia into eleven major model categories, as defined by the Maternity Care Classification System (MaCCS) (Donnolley et al., 2016), traditional public hospital maternity care remains the most common category (40.4 %), followed by shared care (15.3 %) and continuity of midwifery carer (14.8 %) (J. Australian Health Ministers' Conference, National maternity services plan 2022). The recently developed *Normal Birth Strategy for Queensland, Australia* recommended universal access (minimum 50 % within three years and 80 % within five years) to continuity of midwifery carer (J. Allen et al., 2022). Achieving a target of universal access will require rapid and large-scale implementation.

Despite clear evidence of benefits regarding maternal and neonatal outcomes, and women's childbirth experience and satisfaction; evidence of the economic impact on the public health system of continuity of midwifery carer is scant. No previous studies have examined the financial impact of continuity of midwifery carer on the likelihood of different modes of birth, particularly operative vaginal birth, which has the potential for cost savings to public hospital funders. Also, no Statewide cost analysis covering the full spectrum of health service use (inpatient, outpatient and emergency department) throughout the full episode of care (antepartum, intrapartum and postpartum) associated with expanding access to continuity of midwifery carer has been explored to date.

To inform faster scale-up of continuity of midwifery carer, this study aimed to quantify the potential cost savings to public health care funders if 50 % or 65 % of women who gave birth in public hospitals of one Australian state (Queensland) had access to continuity of midwifery carer, in relation to the relative risks of modes of birth associated with models of care.

## Methods

### *Maternity services in Australia – context*

Australia's health care system is broadly comprised of a publicly funded universal scheme and a supplementary private system. Publicly funded care is subsidized by the Federal Government through the Medicare scheme, which covers care outside of public hospitals, and Federal and State governments co-fund the public hospital system. Individuals may be required to pay out-of-pocket fees outside of public hospitals. Private health insurance, which is voluntary, covers part costs for inpatient care accessed in private hospitals.

In terms of maternity care, a woman may access different health care providers across the pregnancy and birth journey, mostly determined by whether she intends to give birth in a public or private hospital. This study focuses on public hospital births, which comprise around 75 % of births in Australia (Australian Institute of Health Welfare, Australia's mothers and babies 2022). In public hospitals, women primarily receive standard maternity care from public hospital employed midwives and obstetricians during the antenatal, intrapartum and postnatal periods. Antenatal care may also be shared with general practitioners in place of midwives. Staffing of public hospitals has traditionally been based on a roster system, whereby women receive care from staff rostered to work at the time of presentation. Continuity of midwifery carer offers a value-based model to the traditional model, whereby each midwife provides care for a caseload of approximately 40 women per year during pregnancy, labour and birth, and postpartum (via 24/7 availability on rostered days on-call).

### *Economic model*

In brief, we created a static microsimulation model of woman and infant health service costs associated with pregnancy and birth, using individual-level data from a population-based linked administrative data set to estimate the impact of moving towards universal access to continuity of midwifery carer. It comprises two parts: the *base model* containing details of the status quo (i.e., standard public hospital maternity care) and the *counterfactual model* that estimates change under hypothetical scenarios (Brown and Harding, 2002): in this study, continuity of midwifery carer was accessible to 50 % or 65 % women who gave birth in public hospitals (Fig. 1).

### *Data sets*

This study utilised a whole-of-population routine administrative data set including all public hospital births in one Australian state (Queensland), Australia between July 2017 and June 2018 (Callander and Fox, 2018). Women and their infants were identified using the Queensland Perinatal Data Collection, a mandatory repository for details of all births in Queensland. Variables used in this study included women's sociodemographic and clinical characteristics before and during pregnancy and birth, and birth details including medical interventions performed during labour and birth. These data were then linked to the Queensland Hospital Admitted Patient Data Collection, Queensland Health Non-Admitted Patient Data Collection and Queensland Emergency Department Information System, which records all inpatient, outpatient and emergency department events in Queensland public hospitals.

### *Identification of health service costs*

Costs were assigned based upon the Australian Refined Diagnosis

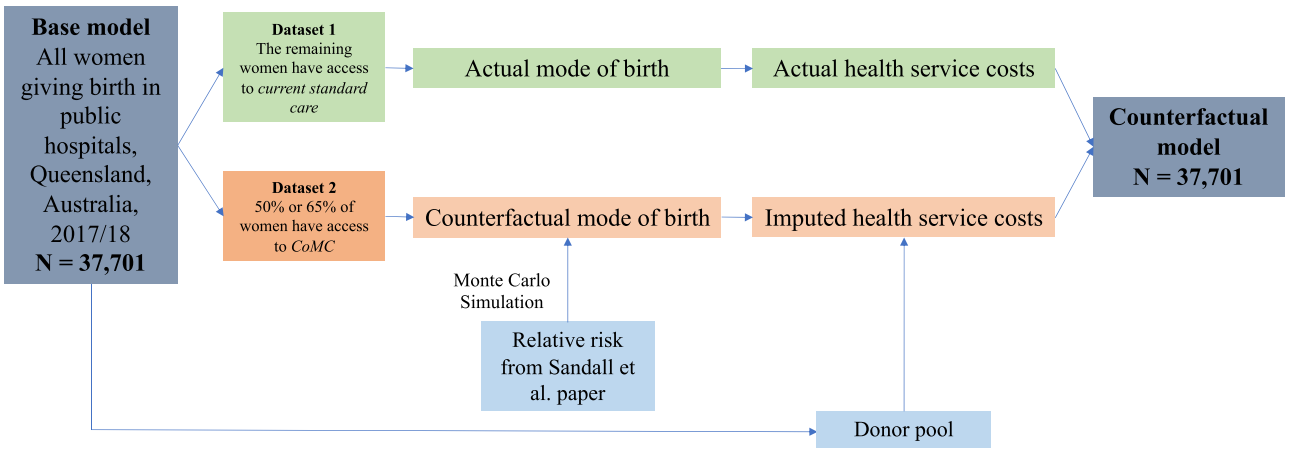


**Fig. 1.** Generation of the microsimulation models using linked administrative data – all women giving birth in public hospitals, Queensland, Australia, 2017/18. Abbreviation: CoMC = Continuity of midwifery carer.

Related Groups (AR-DRG) code for each admission (adjusted for patient remoteness, Indigenous identification, intensive care and private patient admissions), Tier-2 codes for outpatient services and Urgency Related Group (URG) codes for emergency department presentations, as reported on the National Efficient Price Determination (NEP) produced by the Independent Health and Aged Care Pricing Authority (IHACPA). We used the NEP version corresponding to the time the service was accessed.

For each pregnancy, the costs were summed for the mother and baby/babies (if twins or triplets) of their health service use (inpatient, outpatient and emergency department) accessed during pregnancy and birth (up to one month after birth for births occurred at the beginning of the month due to the services' dates and birth dates being provided in MM/YYYY format in our data set in an effort to maintain privacy).

All costs were inflated to 2021/22 Australian dollars based on the Reserve Bank of Australia Inflation Calculator (Reserve Bank of Australia. Inflation Calculator, 2024). Australian dollars are presented throughout. All costs were calculated and presented from the perspective of public hospital funders in the Australian state of Queensland.

### *Process of simulation*

The simulation estimated the health service costs to public hospital funders that would be incurred in two hypothetical scenarios (Fig. 1). Two data sets were created from the base data set. The first, contained randomly selected women who would continue to receive current standard care (i.e., 50 % or 35 %), whose health resource use remained as it was recorded on the base data set. The second, comprised 50 % or 65 % of women who would receive continuity of midwifery carer in public hospitals. For these women and their babies, we imputed health resource use based on the assigned mode of birth.

To hypothetically assign the mode of birth, firstly, the actual rates of caesarean section, instrumental vaginal birth (vacuum or forceps), and spontaneous vaginal birth (without vacuum or forceps) were identified (Table 2). The relative risks (RR) of spontaneous vaginal birth (RR = 1.05) and instrumental vaginal birth (RR = 0.9) were applied to give a counterfactual proportion, in accordance with findings from a systematic review and meta-analysis (Sandall et al., 2016). Monte Carlo simulation was then used to randomly assign the mode of birth to these women who would receive continuity of midwifery carer (Li and O'Donoghue, 2012).

Secondly, subsequent health service use for the records of women who would receive continuity of midwifery carer ('recipient' records) was then imputed by matching to similar women who had the same sociodemographic characteristics and mode of birth ('donor' records), which were drawn from all public hospital births in 2017/18. This recreates the actual observed dynamics in health states and service costs captured in the real-world data (Leombruni and Mosca, 2016). To match the recipient and donor records, radius matching was used due to its performance with real-world data (Huber et al., 2013). Matching was based on the woman's age, if it was the woman's first pregnancy, smoking status before 20 weeks of gestation, Indigenous identification (Aboriginal and/or Torres Strait Islander), socioeconomic status (Socio-Economic Indexes for Areas (SEIFA) (Australian Health Ministers' Conference, National maternity services plan 2016)) and rurality of residence (Accessibility/Remoteness Index of Australia (ARIA+) (Government, 2018)). These variables were chosen as they have previously been shown to be associated with total health care costs (Callander et al., 2019) – an outcome of primary importance (Cohen et al., 1991) – but not influenced by the mode of birth. Recipient and donor records were matched if their score fell within 0.02 standard deviations of the logit of the matching score, using the greedy matching technique.

After the simulation, the two data sets containing women who received current standard care and continuity of midwifery carer were combined to compare with those in the base model (where all women continue to receive current standard care).

The *Normal Birth Strategy for Queensland* recommended at least 80 % access to continuity of midwifery carer within five years, however, we were unable to simulate this 80 % hypothetical scenario due to many unmatched cases ($n$ = 1043) during the matching process.

### *Weighting to forecast future population size*

Weighting to reflect the population of women giving birth in Queensland between financial year 2023/24 and 2030/31 was conducted using GREGWT, a generalised regression weighting algorithm developed by the Australian Bureau of Statistics (Bell, 2000). Weighting was conducted using Queensland state benchmarks for mothers' age by Indigenous identification (Aboriginal and/or Torres Strait Islander), mothers' age by gravidity and mothers' age by caesarean section using the whole linked data set (public hospital births between 2012/13 and 2017/18 ($n$ = 230,551). Linear trends were fitted to extrapolate benchmarking figures between 2023/24 and 2030/31. Separate weights were created for each financial year.

Total costs per year and mean costs per pregnancy were then calculated to show the State-level impact between 2023/24 and 2030/31.

## Results

There were 37,701 records of women who gave birth in Queensland public hospitals during 2017/18. Women had a mean age of 29.4 years,

8 % were in the 5th quintile of socioeconomic status, 57.7 % lived in a major city, 29.1 % were in their first pregnancy, 14.9 % smoked before 20 weeks of gestation, and 8.2 % identified as Aboriginal and/or Torres Strait Islander (Table 1).

In our two hypothetical scenarios, if 50 % ($n$ = 18,851) of women would access continuity of midwifery, after applying the relative risk of mode of birth, 65 % of these randomly selected women would hypothetically have spontaneous vaginal births in the counterfactual model, compared with 61.2 % in the base model (i.e., as recorded in the data set) (Table 2). If 65 % ($n$ = 24,506) of women would access continuity of midwifery, 64.1 % of them would have spontaneous vaginal births in the counterfactual model, compared with 60.8 % in the base model (Table 2). A detailed proportion of the mode of birth for *all* women who gave birth is available in Table 3.

After weighting, in 2023/24, the mean costs (including inpatient, outpatient and emergency department events of woman and infant during pregnancy and birth) to public hospital funders per pregnancy was $32,953 in the base model (Fig. 2). If continuity of midwifery carer was accessed by 50 % of women giving birth in public hospitals in Queensland, the mean cost per pregnancy would have reduced to $32,617 per pregnancy (difference compared to standard care: -$336) and the total costs for health services utilised in Queensland would have reduced from $1225 million to $1213 million (difference: -$12 million) to public hospital funders (Fig. 3). By expanding the proportion of access to 65 % a cost reduction of $535 per pregnancy to public hospital funders could have been achieved compared to standard maternity care. The corresponding annual cost saving in Queensland to public hospital funders would have been more than $19 million in 2023/24.

When costs were projected through to 2030/31, the mean cost per pregnancy in Queensland public hospitals would be $32,490 to public hospital funders, if continuity of midwifery carer was accessed by 50 % of women; $32,197 per pregnancy to public hospital funders if accessed by 65 % of women (Fig. 2). This calculated to annual expenditure by public hospital funders would reduce by more than $19 or $30 million in 2030/31. The components of costs (inpatient, outpatient and ED costs) for each scenario over time are presented in Figures S1 and S2.

**Table 1**
Sociodemographic and obstetric characteristics of women who gave birth in public hospitals, Queensland, Australia, 2017/18.

| Variables | N,% |
|---|---|
| **Total** | 37,701 |
| **Woman's age** (years) | |
| Mean ± SD | 29.4 ± 5.6 |
| **Socioeconomic status** (SEIFA) | |
| 1st quintile (the most disadvantaged) | 8357, 22.2 % |
| 2nd quintile | 7340, 19.5 % |
| 3rd quintile | 10,148, 26.9 % |
| 4th quintile | 8842, 23.5 % |
| 5th quintile (the least disadvantaged) | 3014, 8 % |
| **Rurality of residence** (ARIA+) | |
| Major city | 21,743, 57.7 % |
| Inner regional | 8239, 21.9 % |
| Outer regional | 6535, 17.3 % |
| Remote and very remote | 1184, 3.1 % |
| **First pregnancy** | |
| Yes | 10,953, 29.1 % |
| No/Not stated | 26,748, 71 % |
| **Smoking status before 20 weeks of gestation** | |
| Yes | 5626, 14.9 % |
| No/Not stated | 32,075, 85.1 % |
| **Indigenous Status** (Aboriginal and/or Torres Strait Islander) | |
| Yes | 3080, 8.2 % |
| No/Not stated | 34,621, 91.8 % |

Abbreviation: SEIFA = Socio-Economic Indexes for Areas; ARIA+ = Accessibility/Remoteness Index of Australia.

**Table 2**
Mode of birth in base model and counterfactual model – women who would access continuity of midwifery carer and gave birth in public hospitals, Queensland, Australia, 2017/18.

| Mode of birth | 50 % access N,% | | 65 % access N,% | |
|---|---|---|---|---|
| | Base model – current care | Counterfactual model – increased access to continuity of midwifery carer | Base model – current care | Counterfactual model – increased access to continuity of midwifery carer |
| **Spontaneous vaginal birth** | 11,544, 61.2 % | 12,258, 65 % | 14,907, 60.8 % | 15,718, 64.1 % |
| **Instrumental vaginal birth** | 1822, 9.7 % | 1599, 8.5 % | 2424, 9.9 % | 2149, 8.8 % |
| **Caesarean section** | 5485, 29.1 % | 4994, 26.5 % | 7175, 29.3 % | 6639, 27.1 % |

**Table 3**
Mode of birth in base model and counterfactual model – *all* women giving birth in public hospitals, Queensland, Australia, 2017/18.

| Mode of birth | Base model – current care N,% | Counterfactual model – increased access to continuity of midwifery carer | |
|---|---|---|---|
| | | 50 % access N,% | 65 % access N,% |
| **Spontaneous vaginal birth** | 23,000, 61 % | 23,714, 62.9 % | 23,811, 63.2 % |
| **Instrumental vaginal birth** | 3641, 9.7 % | 3418, 9.1 % | 3366, 8.9 % |
| **Caesarean section** | 11,060, 29.3 % | 10,659, 28 % | 10,524, 27.9 % |

## Discussion

Results of our analysis demonstrated that upscaling the proportion of women accessing continuity of midwifery carer in Queensland from 2023/24 onwards would provide considerable cost savings to public hospital funders. As the proportion of access to this model of care increased, greater cost savings could be achieved. Cumulatively from 2023/24 to 2030/31, if 50 % or 65 % of women giving birth in public hospitals had access to continuity of midwifery carer, more than $131 or $204 million could have been saved to Queensland public hospital funders by 2030/31.

To date, limited research has been undertaken to assess the economic implications of continuity of midwifery carer compared with other models of care (E. Callander et al., 2023). Overall, there is a trend towards cost-saving, which aligns with our findings (Sandall et al., 2016; Donnellan-Fernandez et al., 2018; Gao et al., 2023). Three previous economic analysis studies conducted in Australia reported that the costs of providing continuity of midwifery carer were lower compared to standard maternity care, from a public hospital perspective (i.e., service provider): one study published in 2001 (a randomised trial conducted in St George Hospital, New South Wales) calculated costs per woman for all antenatal, intrapartum and postnatal care (Homer et al., 2001); one study published in 2013 (a randomized controlled trial M@NGO conducted in Royal Hospital for Women, New South Wales and Mater Mother's Hospital, Queensland) measured costs per woman (both direct and indirect) for the full episode of maternity care (from booking visit to six weeks postnatally) (Tracy et al., 2013); and one study published in 2023 (a prospective cohort study of a Birthing on Country Service including continuity of midwifery carer with birth at Mater Mother's Public Hospital, Brisbane, Queensland) estimated direct costs for First Nation women from first presentation in pregnancy up to six weeks after


**Fig. 2.** Mean total costs per pregnancy to public hospital funders if increase access to continuity of midwifery carer – all projected women giving birth in public hospitals, Queensland, Australia, 2023/24 – 2030/31.
Abbreviation: CoMC = Continuity of midwifery carer. $ = AUD 2021/22.

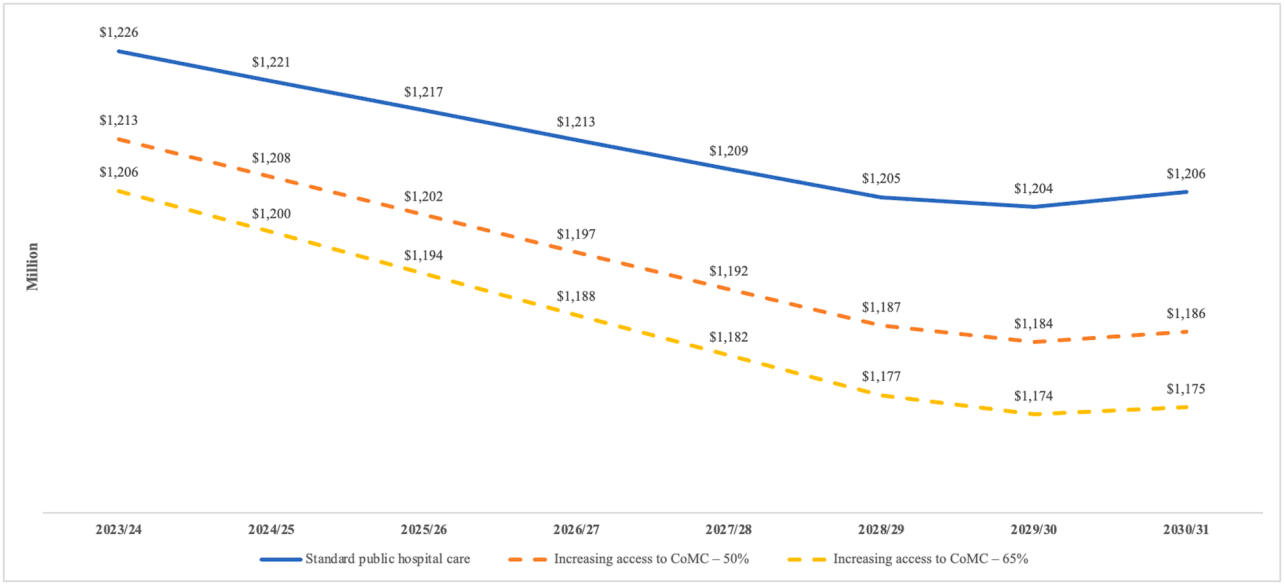


**Fig. 3.** Summed total costs per year to public hospital funders if increase access to continuity of midwifery carer – all projected women giving birth in public hospitals, Queensland, Australia, 2023/24 – 2030/31.
Abbreviation: CoMC = Continuity of midwifery carer. $ = AUD 2021/22.

birth and 28 days for infants, or until discharged from hospital (Gao et al., 2023). To our knowledge, our study is the first to examine the economic benefits of continuity of midwifery carer at the population level by constructing a costing microsimulation based on its effect on maternal outcome (i.e., mode of birth) and calculating inpatient, outpatient and emergency department service costs for woman and infant during pregnancy and birth.

Benefits of continuity of midwifery carer are well researched, including fewer medical interventions without higher risk of adverse clinical outcomes for women and infants, and increased women's satisfaction, compared to other models of care (Sandall et al., 2016). Despite the strong evidence of benefit, redesigning current service models towards continuity of midwifery carer has not been successfully implemented at a national level in any country around the world except New Zealand (Bradford et al., 2022). Without resourced implementation strategies to achieve sustainable scale-up at a state level, there will be a continuation of unnecessary costs (World Health Organization ExpandNet, Nine steps for developing a scaling-up strategy 2010).

Transitioning and scaling up continuity of midwifery carer will address many of the current challenges in maternity care delivery in high-income countries, by providing high-quality care, reducing medical intervention rates and improving women's satisfaction (Forster et al., 2016; Hodnett et al., 2012), as well as the potential cost-savings demonstrated in this study. In addition to our findings, the resource costs of implementing continuity of midwifery carer require further exploration to support feasible service redesign. Future efforts are

suggested to identify the enablers and barriers (e.g., maternity culture and leadership) of expanding women's access to continuity of midwifery carer (Styles et al., 2020; McKellar et al., 2019; McLachlan et al., 2022) in order to realise the economic benefits demonstrated in this study. Although continuity of midwifery carer has been identified as a key model of care for several years, its definition and measurement vary widely. Therefore, further efforts need to be made to standardize the approaches of cost estimation, so that comparative analysis of scaled expansion can be performed to better assist the decision-making of policymakers (Sandall et al., 2016).

### *Strengths and limitations*

The strength of our analyses is that we drew on data from a whole-of-population routine administrative data set, linking with inpatient, outpatient and emergency department health service use, to measure the economic value of upscaling continuity of midwifery carer. Interpretation of our findings was based on the Australian public health care system and factors included in our modelling (i.e., the relative risk of modes of birth), which may limit generalisability in other health care settings and measurement of the economic impact of other clinical outcomes. Results were simulated based on women who gave birth in 2017/18 rather than the current financial year (2023/24), although this was the most recent data available to the researchers due to delays in the collection and release of administrative data, whilst it is possible that the utilisation of services and related costs have changed over time, especially due to the COVID-19 pandemic (Aranda et al., 2022). Furthermore, our analysis did not consider trends in costs over time, with previous studies showing large increases in costs between 2012 and 2018 that will likely continue (Callander et al., 2024). This demonstrates the need to be able to monitor use and costs at the service level where data is more readily available. As the datasets are updated over time, this will enable future updates on this topic.

## Conclusion

Continuity of midwifery carer represents value-based maternity care by providing better outcomes and consumer experiences, at a lower cost. A trend towards a reduction in the cost of care could be achieved by expanding the proportion of women who are able to access continuity of midwifery carer in the public health care system. Other potential economic benefits of improved outcomes need to be further explored and measured to support the decision-making of policymakers on changes in models of maternity care.

## CRediT authorship contribution statement

**Yanan Hu:** Formal analysis, Methodology, Writing – original draft. **Jenny Gamble:** Writing – review & editing, Methodology. **Jyai Allen:** Writing – review & editing, Methodology. **Debra K. Creedy:** Writing – review & editing, Methodology. **Jocelyn Toohill:** Conceptualization, Methodology, Writing – review & editing. **Emily Callander:** Conceptualization, Data curation, Methodology, Writing – review & editing, Supervision.

## Declaration of competing interest

We have no conflict of interest to declare.

### *Ethical statement*

The data used in this study were de-identified before its use. All methods were performed in accordance with the Declaration of Helsinki. The Townsville Hospital and Health Service Human Research Ethics Committee (HREC/16/QTHS/223) and the Australian Institute of Health and Welfare HREC (EO2017–1–338) granted permission to access the raw data used in this study.

### *Consent for publication*

Not applicable.

### *Data availability*

Individual-level data from this study cannot be shared by the research team, due to ethics and access approvals granted. Requests for access to individual-level data may be made directly to the data custodians via the Queensland Health, Statistical Services Branch with appropriate ethics and relevant approvals. The authors can share the Data Dictionary upon request.

### *Code availability*

SAS V9.4. The code used for this study is available from the corresponding author on reasonable request.

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### *Contribution to authorship*

YH led the data analysis and drafting of the manuscript. EC conceived the original study idea, led the study design, and contributed to the interpretation of the results and editing of the final manuscript. JG, JA, DC and JT contributed to the interpretation of the results and editing of the final manuscript. All authors read and approved the final manuscript.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.midw.2024.103998.

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