Title Effect of an innovative care model, The MONARCH Centre, on decreasing postpartum length of stay: an interrupted time series study

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Short title Innovative postpartum care decreases hospital length of stay

ABSTRACT

Background Reductions in length of postnatal hospital stays have been advocated within a context of reducing health system costs and maintaining quality of care. We assessed changes in postpartum length of stay (LOS) for vaginal and cesarean deliveries at an academic hospital in Ottawa, Canada before and after the implementation of a novel, community-based postpartum outpatient clinic, the MONARCH Centre, which has been demonstrated to support high quality of care for newborns and mothers.

Methods Interrupted time series regression models were used to assess changes in postpartum LOS at the Ottawa Hospital over a five-year period between January 2012-December 2016 covering 16,023 deliveries (16,515 babies).

Results The mean length of postpartum stay over the study period was 46 hours (66 for cesarean deliveries and 36 for vaginal deliveries). At 1.5 years following the introduction of the community-based postpartum clinic, the average length of stay following a cesarean birth was reduced by 20 hours or a 27% relative reduction (95% CI: 9.5 to 30.4); for vaginal deliveries LOS was reduced by 6 hours overall (18% relative reduction, 95% CI: 5.2 to 31.1) and 12 hours among typical cases (28% relative reduction, 95% CI: 19.2 to 36.6).

Interpretation A strong association was found between declines in postpartum LOS during and following the introduction of a community-based multidisciplinary postpartum centre. This alternative model of postpartum care is safe, has high patient satisfaction and should be considered for further implantation at provincial and national levels.

INTRODUCTION

The Canadian health care system continues to evolve and faces serious economic challenges to meet the demands of an aging population. Health care services are the largest component in every provincial and territorial budget in Canada. For example, in 2016 Ontario dedicated 43.2% of its total program spending to health care which was the largest share in Canada.[1] Growth in total health expenditure has been relatively stable in the past decade and in 2017 was estimated to be $242 billion or 11.5% of gross domestic product (GDP).[2] Within health care expenses, hospital and in-patient care represents the largest proportion and giving birth is the most frequent reason for inpatient hospitalization.[3] In 2015-2016, there were 368,676 inpatient hospital admissions attributed to childbirth with an average length of stay of 2.3 days.[3] Therefore, new models of obstetrical patient care that promote shorter patient length of stay (LOS), high quality care and patient satisfaction have been strongly considered to improve patient experience and outcomes along with decreasing postpartum care costs. Postpartum care following hospital discharge is of utmost importance for mothers and their newborns as it helps lead to a smooth transition from hospital care back to home life and contributes to improving health outcomes. Available outpatient postpartum support for many mothers appears to be limited in Canada which can present numerous challenges. For instance, new mothers may experience difficulties in establishing breastfeeding which may lead to neonatal jaundice, poor weight gain, dehydration resulting in increased visits to the emergency room, longer hospital stays and breastfeeding cessation.[4,5]

The optimal model of postpartum care for new mothers remains an under-researched area and debates continue among different health care providers (postpartum

nurses, family physicians, lactation specialists, and obstetricians) to determine the most effective way to deliver maternal and infant care postnatally.[6,7] There has been a trend toward discharge within 72 hours for mothers and their newborns following a vaginal birth in a number of countries and the current average postpartum LOS in Canada is 55 hours.[3] A recent study in England demonstrated that early discharge from hospital might bring significant saving over a high-volume service.[8] However, that study and others have shown that earlier discharge results in more frequent morbidity and readmission for neonatal jaundice[9,10] and may require additional postnatal follow-up to ensure recognition of medical problems.[11] Therefore, maintaining the quality and safety of care in the context of shorter postpartum LOS would require corresponding increases in follow-up options including home visits and community-based postpartum care resources.

Early discharge in combination with an individualized follow-up program has demonstrated safe outcomes for both the neonate and postpartum mothers.[12,13] Certain programs which often involve frequent postpartum home visits by nurses or other health care professionals have been shown to improve family outcomes, patient satisfaction and decrease infant emergency care episodes and hospitalisation. However, these types of care models are often not always accessible in every community, require substantial human resources and are typically very costly.[14]

An innovative post-partum community based clinical care service was introduced and evaluated in our obstetrical center in Ottawa. This new program, the MONARCH Centre, consisted of mothers and babies receiving multi-disciplinary postpartum care in an outpatient clinic during their first month following hospital discharge after delivery. In a randomized controlled trial evaluating mother-baby dyads receiving this model of care

we demonstrated a high sense of satisfaction among mothers (OR = 1.96, 95% CI: 3.50-6.88), along with a modest increase in breastfeeding rates at 12 weeks (66% vs 61%), and no difference in rates of emergency room visits compared to a control group receiving standard therapy (11% vs 15%), which support this new model of postpartum care.[15]

The objective of the present study is to further evaluate the effect of referral to the MONARCH postpartum centre on postpartum LOS at the Ottawa Hospital. We present trends in postpartum LOS at the Civic Campus of the Ottawa Hospital prior to and following the introduction of the MONARCH centre in July 2014. Separate analyses are conducted for trends in LOS following vaginal deliveries and caesarian sections and by other maternal characteristics.

Methods

Data

Data originated with the Ottawa Hospital Data Warehouse (TOHDW). The TOHDW is a relational database that contains administrative and clinical data for all patients at the Ottawa Hospital (TOH). For this study, data from the TOH patient registration system (SMS), DAD and NACRS were extracted from the TOHDW for the period between 2012 and 2016. SMS contains demographic information on patients along with dates and times of admissions and discharges. The study was approved by the Ottawa Health Science Network Research Ethics Board (# 20170169-01H).

Intervention and implementation period

The MONARCH postpartum model of care consists of pre-booked appointments at the postpartum clinic, scheduled within 48 hours of hospital discharge with additional follow-ups for missed appointments. The clinic visits include maternal assessment

including mode assessment and care (e.g., wound care, prescriptions), neonatal care (e.g., weight gain assessment, jaundice screening using transcutaneous bilirubinometer), blood work including total serum bilirubin (TSB), and breastfeeding assessment and support. Family physicians, lactation consultants, and registered nurses are also available for consultations at the appointment and there is coordination with institutional care (e.g. hospital postpartum wards and NICU), community partners (e.g. public health), and primary care providers (family physicians and pediatricians) to assist families in establishing post discharge care.[15] This study covers a five-year period between January 1, 2012 and December 31, 2016. The MONARCH centre was launched at the Ottawa Hospital in January 2014 as a 6-month trial program and fully implemented over the following year. Therefore, to properly evaluate the impact of the MONARCH centre on postpartum LOS, the period between January 1, 2014 and July 31, 2015 was treated as the implementation period for the analysis, with a pre-implementation period between January 1, 2012 and December 31, 2013 and a post-implementation follow-up between June 1, 2015 and December 31, 2016.

Outcome

The primary outcome was postpartum LOS in hours. Record-level data was aggregated to four week intervals (which accounts for differing number of days in months) for time-series analyses (over a total study duration of 48 months). As a secondary outcome, we examined the proportion of mothers having a postpartum LOS of greater than 48 hours.

Statistical analyses

Descriptive analyses were carried out on mothers and babies to look at distribution of demographic factors, type of delivery, and procedures, and mean changes in LOS across study periods. The main analyses used an interrupted time series (ITS) segmented regression design. This is a robust, quasi-experimental approach for evaluating the longitudinal effects of interventions.[16] Further, the use of segmented analysis of interrupted time series data allows for the assessment of change in LOS as a result of the MONARCH centre immediately and over time which is different from the underlying trend.[17]

ITS models were specified to estimate level and trend in postpartum length of stay in the pre-implementation (January 1, 2012 – December 31, 2014) segment and changes in level and trend after MONARCH implementation (August 1, 2015 – December 31, 2016). The following model was specified:

$$y=\beta_0+\beta_1\times time+\beta_2\times implementation+\beta_3\times time\ after+e,$$

where β_0 represents baseline average postpartum LOS, β_1 is the trend in the average postpartum LOS before the implementation period, β_2 estimates the change in the average postpartum LOS immediately after the implementation period, β_3 estimates the change in the trend in the average postpartum LOS after the implementation period compared to the trend before the implementation period, and e represents the random error.

All analyses were stratified by cesarean and vaginal deliveries. We considered all deliveries and a subset of 'typical' deliveries defined as admissions through the birthing resulting in a routine discharge as an obstetrics patient from mother/baby. This group excluded women who are admitted to other units during the hospitalization (e.g. ICU,

PACU, admitted to the hospital through the Emergency Department, etc.) and those transferred back and forth from the birthing unit and the mother/baby unit while waiting for the start of the delivery. In addition, we conducted ITS analyses of 2 control outcomes which were not targeted and unlikely to be affected by MONARCH; gestational age at admission and LOS following hysterectomy. The analysis stratified the hysterectomy cohort by three subgroups: inpatients, same-day admissions and day surgeries.

RESULTS

There were 16,023 deliveries with 16,515 babies born during the study period between January 1, 2012 and December 31, 2016 (Table 1). Mean LOS across the overall study period was 46 hours and was longer in cesarean compared to vaginal deliveries (66 h vs 37 h). Rates of 30-day readmission were 2.0% and 1.1% for mothers and 1.0% and 1.8% for babies among cesarean and vaginal births, respectively. Maternal characteristics including maternal age at admission and parity among vaginal and cesarean deliveries were similar across study periods (Supplemental Appendix). Among vaginal deliveries, there was a reduction in mean postpartum LOS from 40.2 hours in the pre-intervention period to 30.2 hours in the post-intervention period (P <0.001) in descriptive analyses. Similarly, in the cesarean delivery group, there was a significant reduction in postpartum LOS from 71.4 h to 55.8 h between the pre-intervention and post-intervention periods, respectively (P <0.001). Rates of readmission varied over the study period and in the post-intervention period were 2.4% and 1.1% for mothers and 1.5% and 2.2% for babies among cesarean and vaginal births, respectively.

ITS analyses of change in postpartum length of stay due to MONARCH

Among all cases of vaginal delivery, postpartum LOS decreased over the pre-

implementation period (Figure 1) and implementation of the MONARCH centre was associated with a 3.6 h reduction in LOS although this effect was not statistically significant (p=0.17, Table 2). The resulting post-implementation slope was a decrease of 10.9 min/month in LOS after the implementation period (p=0.049). Among typical cases of vaginal delivery, the magnitude of the implementation effect was larger (5.7 h reduction, p=0.025). In this population, the post-implementation slope was a reduction of 10.6 min/month for typical vaginal deliveries (p=0.035). Among all cesarean deliveries, MONARCH was associated with a decrease of 7.2 h in average postpartum LOS, although this was not statistically significant (p=0.16) and the combined post-implementation slope was a reduction of 18.6 min/month (p=0.08). For typical cesarean deliveries, MONARCH was associated with a 9.5 h reduction in average LOS (p=0.0013) and the average postpartum LOS decreased by 16.5 min/month after the implementation period (p=0.005).

We performed additional analyses on the percentage of deliveries with PP LOS greater than 48 hours. It shows that 91.3% of typical cesarean deliveries had postpartum LOS greater than 48 hours at the start of the study period and immediately after the implementation period, 65.6% of deliveries had postpartum LOS greater than 48 hours. The MONARCH centre was associated with a 25.7% decrease in the number exceeding 48 hours (p=0.003). In addition, 33.5% of typical vaginal deliveries had a postpartum LOS greater than 48 hours at the start of the study period, decreasing to 23.1% indicating the implementation of MONARCH was associated with a 10.3% reduction in typical vaginal deliveries exceeding 48 hours, although the association was not significant (p=0.06).

Control analyses

We conducted ITS analyses of 2 control outcomes which were not targeted and unlikely to be affected by MONARCH if the association with postpartum LOS is causal, but are also subject to the same confounding structure as the outcome of interest. The first set of analyses on gestational age at admission indicated that only the intercept parameters from the models were statistically significant suggesting that the average gestational age at admission remained at approximately 38-39 weeks at throughout the study period (Table 3). The second control analysis considered another procedure (hysterectomy) performed on a similar patient population. The analysis looked at a hysterectomy cohort stratified by three subgroups with varying LOS: inpatients, same-day admissions and day surgeries (Supplemental Appendix). From all three models, implementation and time after parameters were not statistically significant, indicating that any changes over time in average post-hysterectomy LOS were not associated with the MONARCH centre and thus strengthening our interpretation that the MONARCH centre had a specific effect on postpartum LOS (Table 4).

Long-term impact of MONARCH

The ITS model was used to estimate the long-term effect of the MONARCH centre on postpartum LOS (Figure 4). These estimates were expressed as absolute and relative differences in observed mean LOS at 1.5 years following the implementation of MONARCH and a predicted LOS assuming constant change from the pre-implantation period (Table 5). The average length of stay following a vaginal birth among all cases was predicted to be 35 hours without MONARCH compared to 28.6 hours after implementing MONARCH (an absolute reduction of 6.3 hours, 95% confidence interval [CI]: 0.9 to 11.8), equivalent to an 18% relative reduction. The absolute reduction increased to 12 hours (95% CI: 7.2 to 17.2)

among typical cases. Among all cesarean births, the implementation of MONARCH was associated with a reduction in postpartum LOS of 20 hours (equivalent to a 27% relative reduction) and this was consistent or the subset of typical cesarean deliveries.

DISCUSSION

The salient finding of this study was that the introduction of a novel community-based postpartum clinic was associated was associated with a significant reduction in the postpartum LOS for vaginal and cesarean deliveries in a large academic teaching hospital. At 1.5 years following the introduction of the MONARCH centre, the average length of stay following a cesarean birth was reduced by 20 hours or a 27% relative reduction; for vaginal deliveries LOS was reduced by 6 hours overall (18% relative reduction) and 12 hours among typical cases (28% relative reduction). No changes were observed in our control analyses on gestational age at delivery and post-hysterectomy LOS which are assumed to have a similar confounding structure but not be directly impacted by the implementation of the MONARCH centre.

The postpartum period is known to be a period associated with important physiological and psychological changes in the mother and extends for at least 6 weeks after childbirth. According to the World Health Organization (WHO), this intense period is the most critical and yet the most neglected phase in the lives of mothers and babies.[18] Different postpartum management models have been studied and they usually involve home-based, clinical or hospital-based care. These studies have looked at different outcomes including patient satisfaction, breastfeeding rates, cost and hospital readmission for mothers and neonates.[19-21] The MONARCH integrative postpartum community-based clinic was established in January 2014 with the objective to provide support for mothers

during the first 4 weeks after discharge from the hospital. The original evaluation of MONARCH demonstrated high satisfaction among mothers and no difference in rates of readmission compared to those receiving standard of care.[15] Following success of the initial evaluation, there was institutional support for its continuation given the high degree of patient care, satisfaction and no evidence for increases in adverse outcomes.[15]

The present study was therefore established over a four-year period with sufficient duration of pre- and post-implementation periods and sample size to determine the impact of the MONARCH centre and institutional changes on postpartum LOS. The results were largely robust to sensitivity analyses conducted to address the presence of outliers (e.g., a single postpartum LOS of 950 hours due to an ICU admission). Although both analyses showed similar findings, it is likely that the MONARCH centre model may be favoured for typical or routine deliveries with fewer complications and these cases showed greater reductions in LOS. Rates of readmission were lower here than our previously published data (based on self-reports) and small changes across the study period did not seem to be associated with MONARCH. Results of the control analyses add support to our findings that changes in postpartum LOS were not due to changes in the population, characterized by gestational age at admission, which remained consistent at between 38 and 39 weeks throughout the study period and did not impact other procedures such as hysterectomies.

There are some limitations to our study. The study was conducted at a single clinical center, and therefore the findings may not be generalizable to other facilities with different patient populations, consultation models, or care settings. Similar trends have been seen in postpartum LOS following the implementation of the MONARCH centre in

a second centre at the General Campus of the Ottawa Hospital. Postpartum patient LOS is influenced by multiple others factors that are related to hospital operations, human resources and the general admitting unit and in some settings by maternity-stay legislation.[22] The process and decision on length of postpartum stay can often be complex requiring the coordinated effort of different groups including physicians, nurses, ancillary service staff, patients, their families, and in some settings, insurers. Secular trends in average postpartum LOS have been declining in many jurisdictions alongside reductions in LOS for all diagnoses and our observational study within this context therefore may be limited to determine a causal effect of a single program considering numerous possible confounding factors. We addressed this limitation through a robust analytical approach to separate changes in LOS during and following the implementation over and above what would have been expected assuming no intervention.

Concluding remarks

This study demonstrated a strong association between declines in postpartum LOS during and following the implementation of a community-based multidisciplinary postpartum clinic beyond what would have been observed due to secular changes in length of postpartum stay. This alternative model of postpartum care is safe and has high levels of patient satisfaction and with the potential for considerable cost savings for providers it should be considered for further implantation at the provincial and national levels.

REFERENCES

1. Barua B, Palacios M, Emes J. *The Sustainability of Health Care Spending in Canada 2017*: Fraser Institute;2017.
2. Canadian Institute for Health Information. *National Health Expenditure Trends, 1975 to 2017.* Ottawa, ON: CIHI;2017.

3. Canadian Institute for Health Information. *Inpatient Hospitalizations, Surgeries, Newborns and Childbirth Indicators, 2015–2016.* Ottawa, ON: CIHI;2017.
4. Maisels MJ, Kring E. Length of stay, jaundice, and hospital readmission. *Pediatrics.* 1998;101:995-8.
5. Salas AA, Salazar J, Burgoa CV, De-Villegas CA, Quevedo V, Soliz A. Significant weight loss in breastfed term infants readmitted for hyperbilirubinemia. *BMC Pediatr.* 2009;9:82.
6. Mannan I, Rahman SM, Sania A, et al. Can early postpartum home visits by trained community health workers improve breastfeeding of newborns? *J Perinatol.* 2008;28:632-40.
7. Paul IM, Beiler JS, Schaefer EW, et al. A randomized trial of single home nursing visits vs office-based care after nursery/maternity discharge: the Nurses for Infants Through Teaching and Assessment After the Nursery (NITTANY) Study. *Arch Pediatr Adolesc Med.* 2012;166:263-70.
8. Bowers J, Cheyne H. Reducing the length of postnatal hospital stay: implications for cost and quality of care. *BMC Health Serv Res.* 2016;16:16.
9. Grupp-Phelan J, Taylor JA, Liu LL, Davis RL. Early newborn hospital discharge and readmission for mild and severe jaundice. *Arch Pediatr Adolesc Med.* 1999;153:1283-8.
10. Catz C, Hanson JW, Simpson L, Yaffe SJ. Summary of workshop: early discharge and neonatal hyperbilirubinemia. *Pediatrics.* 1995;96:743-5.
11. Britton JR, Britton HL, Beebe SA. Early discharge of the term newborn: a continued dilemma. *Pediatrics.* 1994;94:291-5.
12. De Carolis MP, Cocca C, Valente E, et al. Individualized follow up programme and early discharge in term neonates. *Ital J Pediatr.* 2014;40:70.
13. Escobar GJ, Braveman PA, Ackerson L, et al. A randomized comparison of home visits and hospital-based group follow-up visits after early postpartum discharge. *Pediatrics.* 2001;108:719-27.
14. Dodge KA, Goodman WB, Murphy RA, O'Donnell K, Sato J, Guptill S. Implementation and randomized controlled trial evaluation of universal postnatal nurse home visiting. *Am J Public Health.* 2014;104 Suppl 1:S136-43.
15. Laliberte C, Dunn S, Pound C, et al. A Randomized Controlled Trial of Innovative Postpartum Care Model for Mother-Baby Dyads. *PLoS One.* 2016;11:e0148520.
16. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther.* 2002;27:299-309.
17. Grimshaw J, Campbell M, Eccles M, Steen N. Experimental and quasi-experimental designs for evaluating guideline implementation strategies. *Fam Pract.* 2000;17 Suppl 1:S11-6.
18. *WHO Recommendations on Postnatal Care of the Mother and Newborn.* Geneva: WHO;2013.
19. Boulvain M, Perneger TV, Othenin-Girard V, Petrou S, Berner M, Irion O. Home-based versus hospital-based postnatal care: a randomised trial. *BJOG.* 2004;111:807-13.

20. Gagnon AJ, Edgar L, Kramer MS, Papageorgiou A, Waghorn K, Klein MC. A randomized trial of a program of early postpartum discharge with nurse visitation. *Am J Obstet Gynecol.* 1997;176:205-11.
21. Lieu TA, Braveman PA, Escobar GJ, Fischer AF, Jensvold NG, Capra AM. A randomized comparison of home and clinic follow-up visits after early postpartum hospital discharge. *Pediatrics.* 2000;105:1058-65.
22. Declercq E, Simmes D. The politics of "Drive-through deliveries": putting early postpartum discharge on the legislative agenda. *Milbank Q.* 1997;75:175-202.

TABLES

Table 1 Sample size, postpartum length of stay (LOS), maternal characteristics, and mode of delivery at the Ottawa Hospital between January 2012 and December 2016.

	C-Section	Vaginal	Total	p-value
Mothers	N=5,163	N=10,860	N=16,023	
Babies	N=5,509	N=11,006	N=16,515	
Postpartum LOS				
Mean (95% CI)	65.6 (64.8, 66.3)	36.6 (36.2, 37.0)	45.9 (45.5, 46.4)	<.001
Median (IQR)	66 (49-74)	34 (25-48)	44 (28-63)	<.001
% with Postpartum LOS > 48 Hours	3,923 (76.0%)	2,564 (23.6%)	6,487 (40.5%)	<.001
Gestational Age				
Mean (95% CI)	38.2 (38.1, 38.2)	38.9 (38.9, 38.9)	38.7 (38.6, 38.7)	<.001
Median (IQR)	39 (37-39)	39 (38-40)	39 (38-40)	<.001
Maternal Age at Admission				
Mean (95% CI)	32.74 (32.61, 32.88)	31.27 (31.17, 31.37)	31.75 (31.67, 31.82)	<.001
Median (IQR)	33 (29-36)	31 (28-35)	32 (28-35)	<.001
Parity				
Mean (95% CI)	1.4 (1.4, 1.5)	1.4 (1.4, 1.4)	1.4 (1.4, 1.4)	0.181
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	0.096
30-Day Unplanned Readmission Rate				
Mothers				
Cases eligible for readmission	5,130 (99.4%)	10,833 (99.8%)	15,963 (99.6%)	<.001
Cases (%) with readmission	102 (2.0%)	124 (1.1%)	226 (1.4%)	<.001
Babies				
Cases eligible for readmission	5,502 (99.9%)	10,982 (99.8%)	16,484 (99.8%)	0.203
Cases (%) with readmission	53 (1.0%)	199 (1.8%)	252 (1.5%)	<.001
Socioeconomic Quintile				
1	858 (16.6%)	1,960 (18.0%)	2,818 (17.6%)	<.001
2	858 (16.6%)	1,993 (18.4%)	2,851 (17.8%)	
3	1,091 (21.1%)	2,336 (21.5%)	3,427 (21.4%)	
4	1,109 (21.5%)	2,097 (19.3%)	3,206 (20.0%)	
5	1,231 (23.8%)	2,441 (22.5%)	3,672 (22.9%)	
Unknown	16 (0.3%)	33 (0.3%)	49 (0.3%)	
Language				
English	4,843 (93.8%)	10,177 (93.7%)	15,020 (93.7%)	0.002
French	233 (4.5%)	412 (3.8%)	645 (4.0%)	
Others	75 (1.5%)	229 (2.1%)	304 (1.9%)	
Unknown	12 (0.2%)	42 (0.4%)	54 (0.3%)	
Case Type*				
Atypical	414 (8.0%)	1,426 (13.1%)	1,840 (11.5%)	<.001
Typical	4,749 (92.0%)	9,434 (86.9%)	14,183 (88.5%)	

LOS, length of stay

* Typical deliveries were defined as cases where the mother is admitted to the hospital through the birthing unit, then after delivery, is transferred to the mother/baby unit, from

which she is routinely discharge as an obstetrics patient. This excludes women who are admitted to other units during the hospitalization (e.g. ICU, PACU, admitted to the hospital through the Emergency Department, etc.) and those transferred back and forth from the birthing unit and the mother/baby unit while waiting for the start of the delivery.

Table 2 Parameter estimates for interrupted time series regression models of postpartum length of stay for vaginal and cesarean deliveries at the Ottawa hospital, January 2012-December 2016

	Vaginal deliveries				**Cesarean deliveries**			
	All Cases		**Typical Cases**		**All Cases**		**Typical Cases**	
	Estimate	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**
Intercept (β_0)	41.6205	<0.0001	43.9919	<0.0001	70.9738	<0.0001	70.9463	<0.0001
Time (β_1)	-0.1088	0.0476	-0.0057	0.9077	0.0357	0.7301	-0.0132	0.8107
Implementation (β_2)	-3.6481	0.1741	-5.7028	0.0251	-7.1894	0.1664	-9.4768	0.0013
Time After (β_3)	-0.0730	0.4860	-0.1750	0.0772	-0.3450	0.0941	-0.2613	0.1940

Table 3 Parameter estimates for interrupted time series regression models of control analyses of gestational age at delivery for vaginal and cesarean deliveries at the Ottawa hospital, January 2012-December 2016

	All Cases		**Typical Cases Only**	
	Parameter Estimate	**Approx. Pr > |t|**	**Parameter Estimate**	**Approx. Pr > |t|**
Vaginal Deliveries				
Intercept	38.8272	<0.0001	38.8447	<0.0001
Time	0.0050	0.2397	0.0033	0.4668
Implementation	-0.3962	0.0644	-0.3256	0.1489
Time After	0.0083	0.3175	0.0103	0.2456
Cesarean Deliveries				
Intercept	38.2783	<0.0001	38.4544	<0.0001
Time	-0.0068	0.3752	-0.0073	0.2814
Implementation	0.3831	0.3722	0.3307	0.2535
Time After	-0.0075	0.6129	-0.0036	0.7839

Table 4 Parameter estimates for interrupted time series regression models of control analyses of post-hysterectomy length of stay by type of admission at the Ottawa hospital, January 2012-December 2016

	Model 1: Inpatient - Admitted		**Model 2: Inpatient – Same Day Admission**		**Model 3: Outpatient – Day Surgery**	
	Parameter Estimate	**Approx. Pr > |t|**	**Parameter Estimate**	**Approx. Pr > |t|**	**Parameter Estimate**	**Approx. Pr > |t|**
Intercept	59.3501	<.0001	18.6234	<.0001	3.1228	<.0001
Time	-0.6980	0.0223	0.0203	0.4607	0.0080	0.4642
Implementation	-1.0488	0.9428	1.5970	0.2446	0.5941	0.2770
Time After	0.7489	0.1984	-0.0760	0.1617	-0.0335	0.1228

Table 5 Effect of the MONARCH postpartum centre model on postpartum length of stay, absolute and relative effects with 95% confidence intervals (CI) at 1.5 years following clinic implementation

	All Cases	**Typical Cases Only**
Vaginal Deliveries		
Prediction		
Without MONARCH Centre	35.0	43.6
With MONARCH Centre	28.6	31.5
Difference		
Absolute (95% CI)	-6.3 (-11.8, -0.9)	-12.2 (-17.2, -7.2)
Relative (95% CI)	-0.182 (-0.311, -0.052)	-0.279 (-0.366, -0.192)
Cesarean Deliveries		
Prediction		
Without MONARCH Centre	73.2	70.1
With MONARCH Centre	53.2	51.0
Difference		
Absolute (95% CI)	-20.0 (-30.4, -9.5)	19.1 (-24.7, -13.6)
Relative (95% CI)	-0.273 (-0.382, -0.164)	-0.273 (-0.333, -0.212)

FIGURES

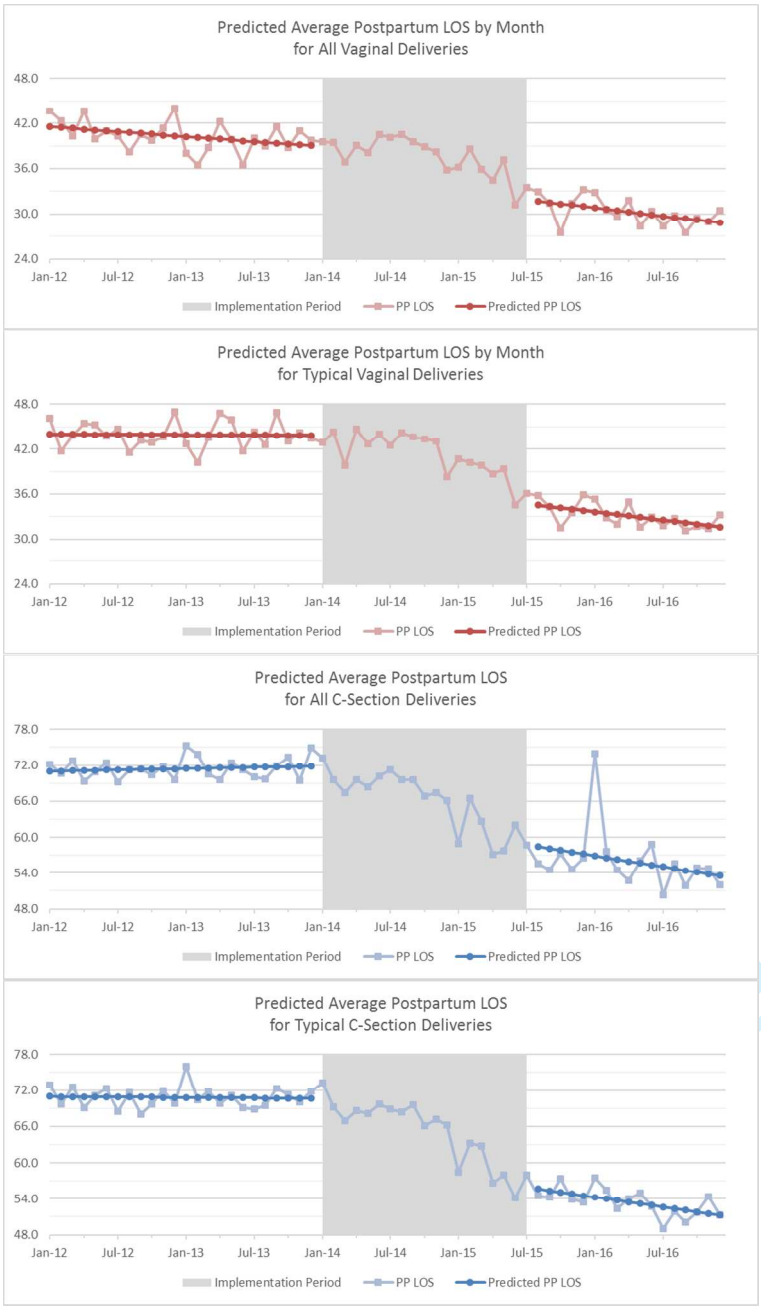

Figure 1 Effects of implementation of the MONARCH postpartum centre model on postpartum length of stay from January 2012 to December 2016 at the Ottawa Hospital.

LOS, length of stay; PP, postpartum
Top 2 panels vaginal births, bottom 2 for cesarean. Typical deliveries defined as admissions to hospital through the birthing unit and direct transfer to mother/baby unit prior to discharge and excludes women who are admitted to other units during the hospitalization and multiple transfers prior to delivery.

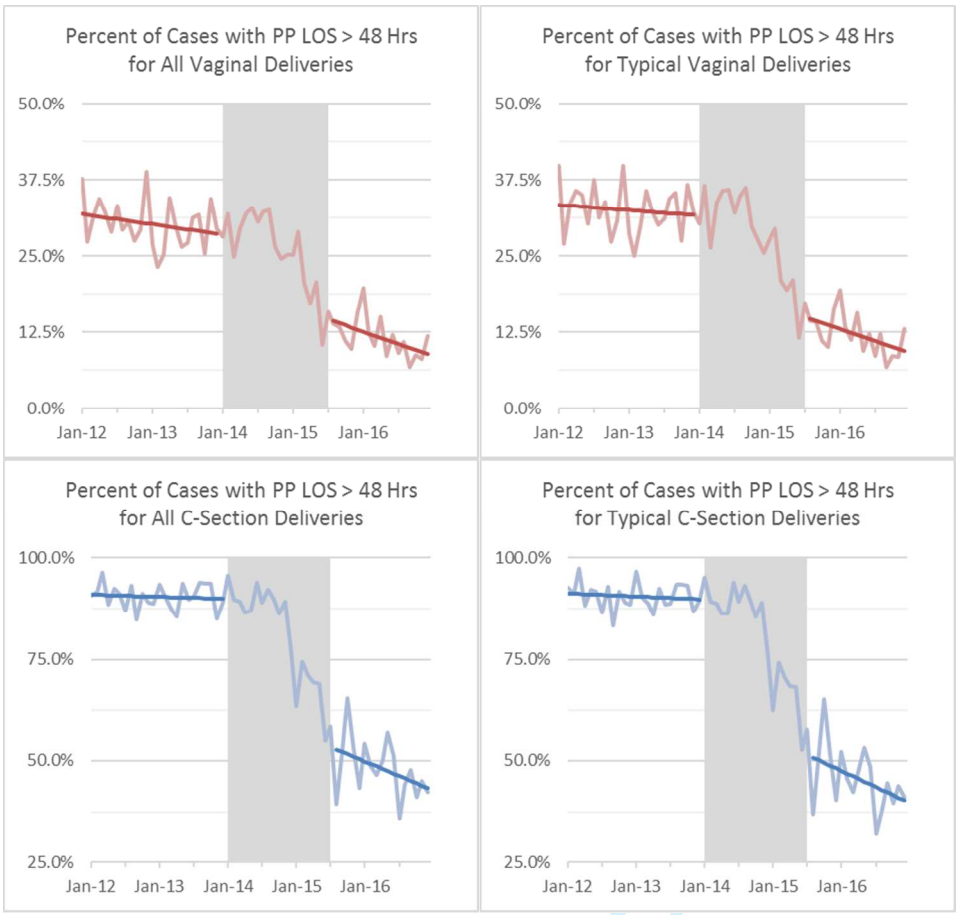

Figure 2 Effects of implementation of the MONARCH postpartum centre model on percent of postpartum lengths of stay exceeding 48 hours for vaginal and cesarean deliveries from January 2012 to December 2016 at the Ottawa Hospital.

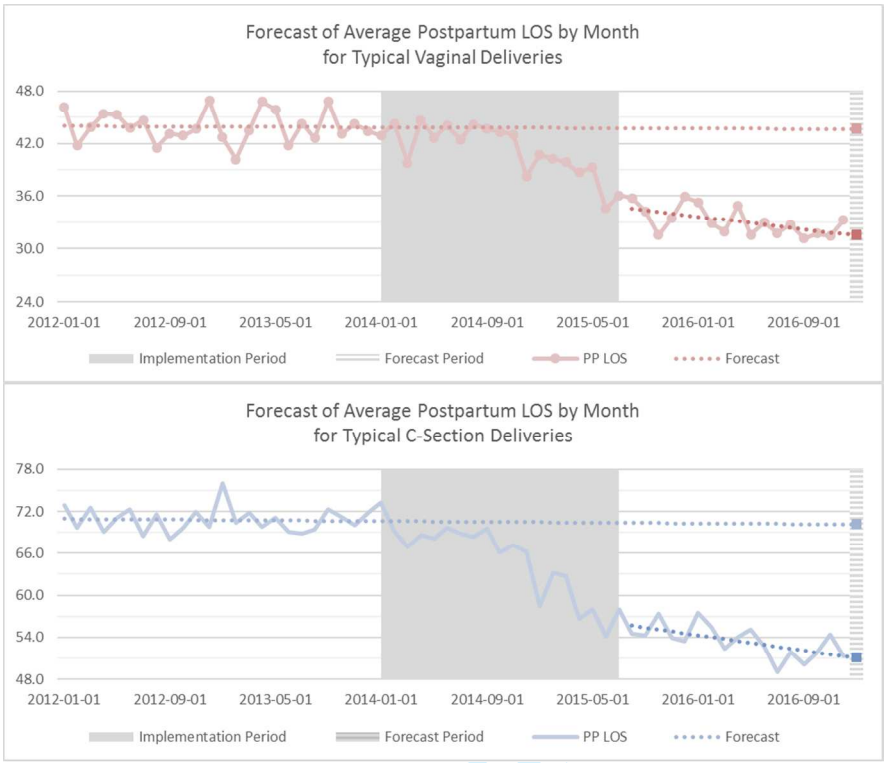

Figure 3 Analyses evaluating the effect of the implementation of the MONARCH postpartum centre on postpartum length of stay from January 2012 to December 2016 at the Ottawa Hospital.

Top panel for vaginal births, bottom for cesarean. Typical deliveries only, see Table 1. Points represent mean postpartum length of stay in monthly intervals, light dashed lines indicate projected trend assuming no intervention and darker lines are fitted linear regression line in the post-implementation period.

SUPPLEMENTAL APPENDIX

Effect of an innovative care model, The MONARCH Centre, on decreasing postpartum length of stay: an interrupted time series study

Table A Sample size, postpartum length of stay (LOS), maternal characteristics, and readmission rates among all vaginal deliveries at the Ottawa Hospital between January 2012 and December 2016 stratified by study period**.**

	All Vaginal Deliveries			
VARIABLE	**Jan 2012 - Dec 2013**	**Jan 2014 - Jul 2015**	**Aug 2015 - Dec 2016**	**TOTAL**
Mothers	N=4,487	N=3,306	N=3,067	N=10,860
Babies	N=4,543	N=3,354	N=3,109	N=11,006
Postpartum LOS				
Mean (95% CI)	40.2 (39.6, 40.9)	37.6 (36.8, 38.4)	30.2 (29.5, 30.9)	36.6 (36.2, 37.0)
Median (IQR)	40 (27-52)	35 (25-49)	27 (23-36)	34 (25-48)
% with Postpartum LOS > 48 Hours	1,356 (30.2%)	854 (25.8%)	354 (11.5%)	2,564 (23.6%)
Gestational Age				
Mean (95% CI)	38.9 (38.8, 38.9)	38.9 (38.8, 39.0)	38.9 (38.9, 39.0)	38.9 (38.9, 38.9)
Median (IQR)	39 (38-40)	39 (38-40)	39 (38-40)	39 (38-40)
Maternal Age at Admission				
Mean (95% CI)	31.1 (30.9, 31.2)	31.4 (31.2, 31.6)	31.4 (31.2, 31.6)	31.3 (31.2, 31.4)
Median (IQR)	31 (28-35)	32 (28-35)	32 (28-35)	31 (28-35)
Parity				
Mean (95% CI)	1.4 (1.3, 1.4)	1.4 (1.3, 1.4)	1.4 (1.4, 1.5)	1.4 (1.4, 1.4)
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)
30-Day Unplanned Readmission Rate				
Mothers				
Cases eligible for readmission	4,478 (99.8%)	3,300 (99.8%)	3,055 (99.6%)	10,833 (99.8%)
Cases (%) with readmission	43 (1.0%)	48 (1.5%)	33 (1.1%)	124 (1.1%)
Babies				
Cases eligible for readmission	4,537 (99.9%)	3,351 (99.9%)	3,094 (99.5%)	10,982 (99.8%)
Cases (%) with readmission	62 (1.4%)	70 (2.1%)	67 (2.2%)	199 (1.8%)

Table B Sample size, postpartum length of stay (LOS), maternal characteristics, and readmission rates among all cesarean deliveries at the Ottawa Hospital between January 2012 and December 2016 stratified by study period**.**

	All Cesarean Deliveries			
VARIABLE	**Jan 2012 - Dec 2013**	**Jan 2014 - Jul 2015**	**Aug 2015 - Dec 2016**	**TOTAL**
Mothers	N=2,131	N=1,651	N=1,381	N=5,163
Babies	N=2,276	N=1,748	N=1,485	N=5,509
Postpartum LOS				
Mean (95% CI)	71.4 (70.6, 72.3)	66.2 (65.0, 67.5)	55.8 (54.0, 57.6)	65.58 (64.85, 66.32)
Median (IQR)	70 (63-77)	67 (51-74)	48 (43-63)	66 (49-74)
% with Postpartum LOS > 48 Hours	1,927 (90.4%)	1,336 (80.9%)	660 (47.8%)	3,923 (76.0%)
Gestational Age				
Mean (95% CI)	38.2 (38.1, 38.3)	38.3 (38.2, 38.4)	38.1 (37.9, 38.2)	38.2 (38.1, 38.2)
Median (IQR)	39 (37-39)	39 (38-39)	39 (37-39)	39 (37-39)
Maternal Age at Admission				
Mean (95% CI)	32.7 (32.5, 33.0)	32.6 (32.4, 32.9)	32.9 (32.6, 33.2)	32.7 (32.6, 32.9)
Median (IQR)	33 (29-36)	33 (29-36)	33 (30-36)	33 (29-36)
Parity				
Mean (95% CI)	1.4 (1.3, 1.5)	1.4 (1.3, 1.5)	1.5 (1.4, 1.6)	1.4 (1.4, 1.5)
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)
30-Day Unplanned Readmission Rate				
Mothers				
Cases eligible for readmission	2,122 (99.6%)	1,641 (99.4%)	1,367 (99.0%)	5,130 (99.4%)
Cases (%) with readmission	41 (1.9%)	28 (1.7%)	33 (2.4%)	102 (2.0%)
Babies				
Cases eligible for readmission	2,274 (99.9%)	1,747 (99.9%)	1,481 (99.7%)	5,502 (99.9%)
Cases (%) with readmission	13 (0.6%)	18 (1.0%)	22 (1.5%)	53 (1.0%)

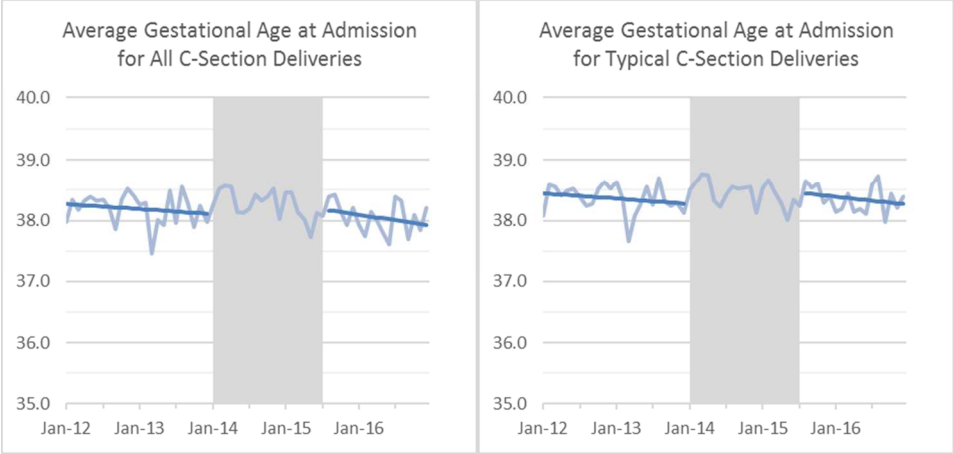

Figure A Control analysis of effects of implementation of MONARCH postpartum centre model on gestational age at admission.

Post-Hysterectomy Length of Stay

Preliminary analyses showed that hysterectomy patients admitted as inpatients, same-day admissions (including overnight stays) and day surgeries had markedly different post-surgery length of stay (Figure B). Control analyses of the post-hysterectomy cohort was stratified by these three groups.

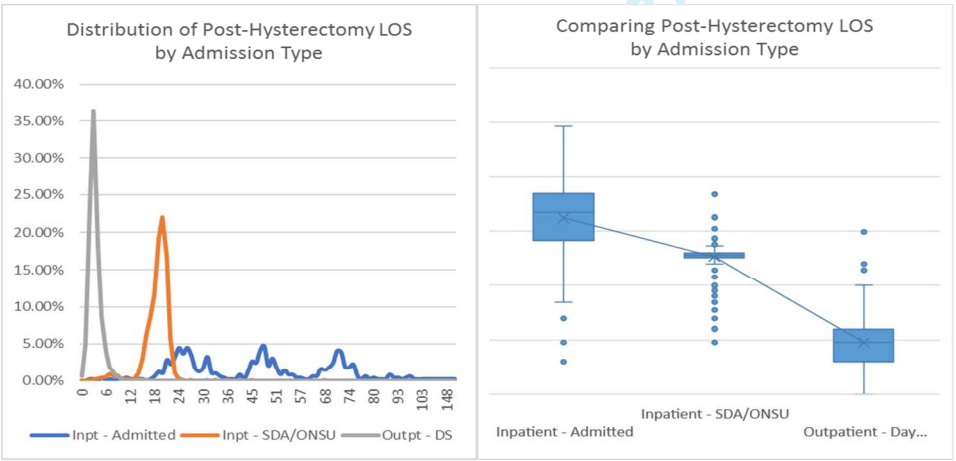

Figure B Distribution of post-hysterectomy LOS by inpatients, same-day admissions, and day surgeries.

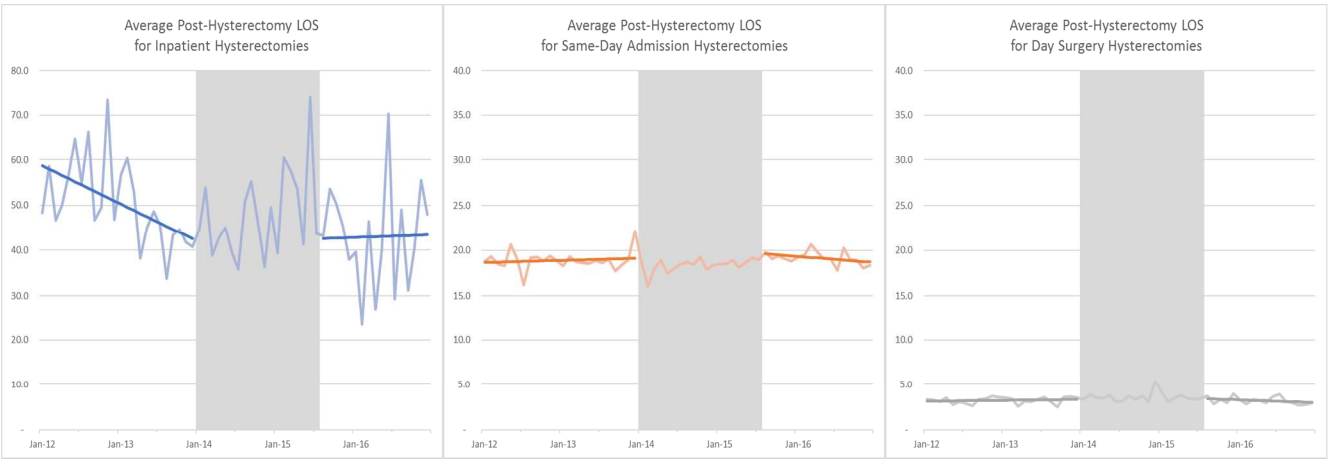

Figure C Control analysis of effects of implementation of MONARCH postpartum centre model on post-hysterectomy LOS, according to type of admission.