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RESEARCH ARTICLE

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# The effects of early pregnancy loss on health outcomes and health care utilization and costs

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## Abstract

**Objective:** To evaluate the effects of early pregnancy loss on subsequent health care use and costs.

**Data Sources:** Linked administrative health databases from Manitoba, Canada.

**Study Design:** This was a population-based cohort study. The exposure of interest was first recorded ectopic pregnancy or miscarriage (EPM). Outcomes included visits to all ambulatory care providers, family physicians (FPs), specialists, and hospitals, as well as the costs associated with these visits. We also assessed the impact of EPM on a global measure of health service utilization and the incidence and costs of psychotropic medications.

**Data Collection/Extraction Methods:** We identified women who experienced their first recorded loss (EPM) from 2003–2012 and created a propensity score model to match these women to women who experienced a live birth, with outcome measures available through 31 December 2014. We used a difference in differences approach with multivariable negative binomial models and generalized estimating equations (GEE) to assess the impact of EPM on the aforementioned health care utilization indicators.

**Principal Findings:** EPM was associated with a short-term increase in visits to, and costs associated with, certain ambulatory care providers. These findings were driven in large part by increased visits/costs to FPs (rate difference [RD]: $19.92 [95% CI: $16.33, $23.51]) and obstetrician-gynecologists (OB-GYNs) (RD $9.41 [95% CI: $8.42, $10.40]) in the year immediately following the loss, excluding care associated with the loss itself. We also detected an increase in hospital stays and costs and a decrease in the use of psychotropic medications relative to matched controls.

**Conclusion:** Pregnancy loss may lead to subsequent increases in certain types of health care utilization. While the absolute costs associated with post-EPM care are relatively small, the observed patterns of service utilization are informative for providers and policy makers seeking to support women following a loss.

KEYWORDS
early pregnancy loss, ectopic pregnancy, health care costs, health services, miscarriage, propensity score

**What is known on this topic**

- Pregnancy loss is a common event, occurring in up to a quarter of known pregnancies.
- The impacts on women who experience a loss are not systematically understood, particularly their resulting physical and mental health needs and their use of related health care services.

**What this study adds**

- We evaluated the effects of ectopic pregnancy or miscarriage (EPM) on subsequent health care use and costs.
- Our findings suggest an increase in utilization following an EPM (compared to women with a live birth) and a corresponding increase in costs, particularly for OB/GYN visits and hospitalizations.
- Understanding the impact of EPM on subsequent health care use will allow providers and health systems to improve the patient-centeredness and appropriateness of the care they provide.

## 1 | INTRODUCTION

Pregnancy loss is a common event, affecting up to a quarter of recognized pregnancies.[1] Most of these losses—including the majority of miscarriages (loss of a fetus before 20 weeks gestation) and virtually all ectopic pregnancies (implantation of a blastocyst outside of the uterus)—occur in the first trimester of pregnancy.[2–4] Although evidence suggests that many women who know they are experiencing an ectopic pregnancy or miscarriage (EPM) seek medical care,[5] the overall prevalence of EPM is impossible to precisely estimate in the general population as women may miscarry before realizing they are pregnant or miscarry at home, in which case these events are impossible to capture. Ectopic pregnancies, while comparatively rare, are easier to detect since resolution often requires medical intervention.[3,4]

Despite its prevalence, EPM is often a "silent" event due to a confluence of factors (e.g., stigma, shame). This culture may be shifting, with high-profile stories about miscarriage in recent popular media and initiatives among governments and workplaces to better support families who experience EPM.[6–10] Nevertheless, support remains largely informal and/or inadequate in many contexts. In addition to better support and bereavement care for patients at the time of EPM, a better understanding of the impacts on people and health care systems is needed. For women who know they are pregnant, the unintended loss of a pregnancy may have important implications. These women may respond to an EPM by increasing their utilization of health services above and beyond any loss-related care: for example, seeking psychological support to cope with the loss or pursuing treatment from specialists in the interest of conceiving again.[11]

While a small body of evidence[12–16] suggests that parental bereavement is associated with increased morbidity, there is currently no evidence on the impact of *fetal* death on women in terms of their subsequent health outcomes or service utilization. A recent scoping review[17] summarized a small selection of (largely qualitative) literature describing health care utilization patterns at the time of the loss, but to our knowledge, quantitative evidence on longer-term impacts is currently lacking. Future interventions to improve bereavement care could also be evaluated in part based on their impacts on these outcomes.

The relationship between EPM and health care utilization is difficult to quantify. Given the unfeasibility of detecting all EPMs, most analyses are essentially restricted to recognized and documented losses—in other words, losses for which women seek care. This is a selected group and may be disproportionately populated by women with repeated losses, women who are actively trying to conceive, and women with greater access to care (or a higher propensity toward seeking care), which may simultaneously increase the probability of EPM detection and shift patterns of subsequent health service utilization. It is also difficult to identify an appropriate comparison group for women who experience a loss. Although pregnancy loss often occurs due to "random" genetic abnormalities,[18] the overall distribution of clinical and social characteristics of women who experience an EPM tends to differ from that of women who experience a live birth.[1,3,19–21] Patterns of care may also shift over time: the highest concentration of visits (and therefore costs) may occur in the months immediately following the loss. For accounting for this, high-quality longitudinal data are required on health care utilization patterns both before and after the loss.

In this paper, we respond to the above challenges by using a rich administrative database and a difference-in-differences approach in a propensity score-matched sample (using women with a live birth as the comparison group) to evaluate the relationship between first recorded EPM and patterns of health care utilization.

## 2 | METHODS

### 2.1 | Data

Data for this study come from The Population Research Data Repository at the Manitoba Centre for Health Policy, University of Manitoba.[22] These data consist of several sources of linkable health data for Manitoba residents registered under the Manitoba Health Services

Insurance Plan, which covers virtually all Manitoba residents (except armed services personnel and federal inmates).[23] The Repository data include the provincial health insurance registry, fee-for-service physician billings, hospital discharge abstracts, emergency department visits, pharmaceutical dispensations, individual sociodemographics, and vital statistics, all linkable using an encrypted Personal Health Identification Number. About 80% of pregnant women in Manitoba receive their prenatal care from a family physician (FP) or an obstetrician-gynecologist (OB-GYN), and 70% deliver with an OB-GYN (home births account for less than <1% of all births).[24] The public insurer in Manitoba (and in other Canadian provinces) covers all services provided in-hospital or by a physician. This leaves many health care services to be covered by private insurers or paid out-of-pocket, including prescription drugs for most Canadians under age 65 and services from nonphysician providers like psychologists. Services not paid for by the public insurance plan are not captured in the administrative data.

Our objective was to identify women who experienced their first recorded loss (EPM) from 2003 to 2012. To exclude women with recorded losses prior to the beginning of our observation period, we extracted data from 1984–2014, capturing all losses (exposed) and live births (unexposed) through December 31, 2012 and outcome measures through December 31, 2014. We collected 4 years of data for every woman in our sample: the 2 years leading up to the index event (loss or live birth) (T−2, T−1), the year containing and immediately following the event (T+1), and the subsequent year (T+2).

## 2.2 | Exposure and outcome definitions

Our exposure of interest was first recorded EPM, as health care utilization patterns and the probability of reporting or seeking care for a loss (i.e., the probability of detection) likely change as the number of losses increases. The comparison group consisted of women who experienced a live birth, with additional restrictions summarized below. Our EPM identification strategy is described in detail elsewhere[19]; briefly, we used International Classification of Diseases (ICD) codes in the billing data and chief complaint codes in the emergency department (ED) data to identify women who experienced an EPM. Ectopic pregnancies were identified when women had at least one hospitalization or physician visit with a diagnosis of ectopic pregnancy (ICD-9633, ICD-10 O00). Miscarriages were identified when women had at least one hospitalization or physician visit with a diagnosis of noninduced abortion (ICD-9631, 632, 634, 637; ICD-10 O02, O03, O06), or at least one ED visit with a chief complaint of "pregnancy issues" with no recorded delivery in the following 40 weeks. The index date for all women in the sample was defined as the date of the visit associated with the codes/flags listed above related to miscarriage, ectopic pregnancy, or live birth.

To identify first recorded losses in our cohort (Table S1), we excluded women who had ever sought care for a miscarriage, ectopic pregnancy, stillbirth, or neonatal/infant death as of December 31, 2002 from both exposed and unexposed women, as well as women who sought care for a stillbirth or neonatal/infant death between January 1, 2003 and the date of their EPM (if exposed) or live birth (if unexposed). Women with stillbirths and neonatal/infant deaths occurring after the index event (EPM or live birth) remained in the sample for both exposed and unexposed women. Women in the EPM group who experienced another miscarriage within the 2 years following their first detected loss were excluded from the analysis. We also excluded women who had ever had a therapeutic abortion from 1984–2014, were uninsured by Manitoba Health for the two or more years leading up to the index event, and/or who had missing data on area-level socioeconomic status (Socio-Economic Factor Index [SEFI][25]). Women in both groups may have had previous live births.

We assessed the impacts of EPM on women's health service utilization, the associated costs, and indicators of mental and physical health. Outcomes included outpatient visits to FPs and specialists, hospital admissions, outpatient and inpatient costs, incident psychotropic medication dispensations, the prevalence of mood and anxiety disorders, and women's morbidity (using the resource utilization band [RUB], a composite indicator based on diagnoses and health care utilization).[26] We also assessed the impact on total health care costs. We excluded all pregnancy-related hospitalizations and prenatal visits across the entire observation period, as well as visits to OB-GYNs during the 2 weeks following the index event to eliminate any follow-up visits directly related to the birth or loss, and we expanded this window in sensitivity analyses. Each outcome was modeled independently (not conditional on the others).

## 2.3 | Propensity score matching

We used propensity score matching to achieve balance on relevant observable characteristics between women who experienced an EPM and those who experienced a live birth prior to conducting our main analyses. The propensity score model included a range of clinical and social factors (e.g., maternal age and region, parity, endometriosis, income assistance, etc.), and health care-related factors (e.g., visits with a FP or OB/GYN, inpatient length of stay, etc.) associated with EPM, measured at the time of an event or in the 1–2 years preceding the event. The full model contained 21 variables described in Table S2. Of note, because the use of certain antidepressants was contraindicated during pregnancy (and therefore if a woman was trying to conceive) throughout much of our observation period, we focused on the use of psychotropic medications (count, incidence, and costs) 2 years preceding the event. We also included past outcomes in the model in an effort to ensure that the outcome trends in the pre-exposure period were parallel in the two groups and that the unexposed group was a valid counterfactual.[27]

We estimated propensity scores via logistic regression and represented the predicted probability of EPM conditional on the model covariates. We assessed the distribution of propensity scores in exposed and unexposed women and restricted our sample to the area of common support. We trimmed our sample to exclude (1) the 1st

**TABLE 1** Sample characteristics at baseline (unmatched vs. matched)[a]

| | Unmatched | | | | Matched | | | |
|---|---|---|---|---|---|---|---|---|
| | Exposed ($n = 13,031$) | Unexposed ($n = 68,747$) | Std. diff. | P-value | Exposed ($n = 11,338$) | Unexposed ($n = 11,338$) | Std. diff. | P-value |
| Clinical and social indicators | | | | | | | | |
| Previous c-section[b] | 11.8% | 11.9% | −0.46 | 0.63 | 11.9% | 12.1% | −0.38 | 0.77 |
| Diabetes[c] | 4.2% | 3.4% | 3.75 | <0.01 | 3.7% | 3.9% | −1.16 | 0.38 |
| Endometriosis[c] | 1.0% | 1.0% | 4.38 | <0.01 | 1.0% | 1.0% | −1.65 | 0.22 |
| Hypertension[d] | 3.3% | 3.0% | 1.74 | 0.07 | 3.0% | 3.0% | 0.26 | 0.84 |
| Infertility drug use[e] | 3.7% | 2.3% | 8.16 | <0.01 | 2.3% | 2.5% | −1.39 | 0.29 |
| Substance abuse[e] | 3.0% | 2.6% | 2.48 | 0.01 | 2.8% | 3.0% | −1.74 | 0.19 |
| Suicide attempt[f] | 1.0% | 1.0% | 4.26 | <0.01 | 1.0% | 1.0% | 3.75 | <0.01 |
| Mean maternal age at event | 28.4 | 27.8 | 9.97 | <0.01 | 27.9 | 27.9 | 0.33 | 0.81 |
| Parity[b,g] | | | | | | | | |
| Nulliparous | 48.9% | 42.2% | 12.81 | <0.01 | 47.4% | 47.7% | 0.62 | 0.64 |
| Primiparous | 28.7% | 33.2% | −9.71 | <0.01 | 29.5% | 29.5% | −0.04 | 0.98 |
| Multiparous | 22.7% | 24.6% | 4.42 | <0.01 | 23.1% | 22.8% | 0.78 | 0.56 |
| Mother's SEFI (mean)[h] | 0.23 | 0.18 | 3.85 | <0.01 | 0.24 | 0.23 | 1.32 | 0.32 |
| Income assistance[i] | 8.9% | 9.9% | −3.68 | <0.01 | 8.5% | 8.5% | −0.03 | 0.98 |
| Baseline utilization and costs | | | | | | | | |
| Total healthcare cost (excl. psych. rx) | $399.90 | $228.80 | −11.26 | <0.01 | $281.80 | $287.30 | −0.57 | 0.43 |
| FP cost[d] | $142.60 | $93.56 | 40.12 | <0.01 | $124.60 | $124.60 | 0.03 | 0.98 |
| FP visits[d] | 4.28 | 2.88 | 37.48 | <0.01 | 3.75 | 3.78 | −0.79 | 0.55 |
| OB/GYN cost[d] | $16.46 | $10.69 | 14.64 | <0.01 | $10.57 | $10.39 | 0.61 | 0.65 |
| OB/GYN visits[d] | 0.36 | 0.21 | 16.23 | <0.01 | 0.22 | 0.21 | 0.48 | 0.72 |
| Specialist cost[d] | $55.96 | $40.33 | 8.95 | <0.01 | $43.42 | $44.08 | −0.41 | 0.76 |
| Specialist visits[d] | 0.90 | 0.61 | 14.74 | <0.01 | 0.66 | 0.68 | −1.00 | 0.45 |
| Hospitalization costs (adjusted)[d,j,k] | $184.90 | $84.27 | 7.34 | <0.01 | $103.20 | $108.20 | −0.55 | 0.68 |
| Hospitalization LOS (in days)[d,k] | 0.18 | 0.08 | 5.46 | <0.01 | 0.09 | 0.10 | −0.27 | 0.84 |
| Mood and anxiety disorders[e] | 16.4% | 12.1% | 12.33 | <0.01 | 14.3% | 14.6% | −1.03 | 0.44 |
| Number of psychotropic Rx[l] | 0.87 | 0.66 | 4.01 | <0.01 | 0.71 | 0.66 | 1.27 | 0.34 |
| Psychotropic Rx costs (adjusted)[j,l] | $33.66 | $25.53 | 4.78 | <0.01 | $28.00 | $27.25 | 0.51 | 0.70 |
| Any incident psychotropic Rx[l] | 5.7% | 5.0% | 3.43 | <0.01 | 5.5% | 5.4% | 0.43 | 0.75 |
| RUB[d] | 2.31 | 2.11 | 20.90 | <0.01 | 2.25 | 2.25 | −0.18 | 0.89 |

Abbreviations: Amb. phys, ambulatory physician; FP, family physician; LOS, length of stay; OB/GYN, obstetrician-gynecologist; RUB, resource utilization band; Rx, dispensation; SEFI, Socioeconomic Factor Index; Std. diff, standardized difference.

[a]Sample excludes exposed/unexposed women not covered for at least 2 years prior to event.

[b]Since 1984.

[c]In the 3 years before event.

[d]In the year before event.

[e]In the 2 years before event.

[f]In the 5 years before event.

[g]0 = nulliparous, 1 = primiparous, 2 = multiparous.

[h]At time of event.

[i]For at least 1 month in the year before event.

[j]In 2010 dollars.

[k]Excludes pregnancy/delivery-related hospitalizations.

[l]Over a 1-year period starting 2 years before the event date.

and 2nd percentiles of the exposed group (PS = 0–0.070), and (2) the 98th and 99th percentiles of the unexposed (PS = 0.379–1). We used 1:1 nearest neighbor matching with replacement (of the woman, not the birth) to generate our final sample, as this approach tends to reduce bias and (given our sample size) we did not need an additional gain in precision,[28,29] This strategy matched women who experienced their first EPM from 2003–2012 to women who experienced a live birth within 90 days surrounding the loss. We calculated descriptive statistics before and after restriction to ensure that relevant maternal attributes were balanced in the final sample.

### 2.4 | Models

We fit negative binomial models with indicator variables for time and exposure status and a time*exposure interaction term to generate our effect estimates. This difference-in-differences approach allowed us to account for temporal trends in the outcome(s) of interest and time-fixed differences between women who ultimately experienced an EPM and women who experienced a live birth, effectively isolating the impact of EPM on service use and costs. Our estimation strategy allowed us to produce contrasts at several points along the observation period (T−2, T−1, T+1, T+2). For time points before the event date, we were essentially generating comparisons between women who would eventually experience a loss and women who would instead experience a live birth. If the matching process was successful, we would expect to see minimal differences between groups prior to the event.

Given the matched and longitudinal structure of our data, there were two possible sources of correlation: correlation within women over time and correlation induced by matching. To account for both, we used generalized estimating equations (GEE) with an exchangeable correlation structure. Finally, we used postestimation commands to estimate contrasts on the absolute scale (rate differences [RDs] and appropriate standard errors).

We conducted several sensitivity analyses to assess the robustness and validity of our findings. Specifically, we (1) omitted all visits and costs to both OB-GYNs and FPs for 2 weeks after the index event, (2) omitted all visits and costs to OB-GYNs only for 28 days after the index event, and (3) restricted to miscarriages only (no ectopic pregnancies). Approval for this study was obtained from the Human Health Research Ethics Board at the University of Manitoba, the Manitoba Health Information Privacy Committee, and the McGill University Faculty of Medicine Research Ethics Board. All analyses were conducted in SAS 9.4 (SAS Institute, Cary NC).

## 3 | RESULTS

### 3.1 | Propensity score matching results

The unmatched sample contained 13,031 women in the EPM group and 68,747 women in the unexposed group. As expected, there were several noteworthy differences in pre-event characteristics between groups (e.g. mothers' age at the time of event, rates of mood and anxiety disorders); these differences are summarized in Table 1 (Table S3 and Figure S1 present additional details). In Figure 1, we illustrate the propensity score distribution by group, with the untrimmed area of common support in gray. Exposed and unexposed groups in our final matched sample were well-balanced on all relevant clinical, social, and health care use variables (Table 1). At baseline, women in our sample had on average 3.8 FP and 0.7 specialist visits per year, with one-third of the specialist visits to OB/GYNs. Three percent of women were admitted to hospital in the past year (for nonpregnancy-related reasons), and total health care costs averaged $315 (2010 Canadian dollars). One in seven women (14.5%) experienced a mood or anxiety disorder in the 2 years leading up to the index date, and 5.5% had an incident psychotropic dispensation.

### 3.2 | Effect estimates

Table 2 summarizes our model estimates representing the impact of EPM on provider visits. Estimates are expressed as RDs (95% CI), interpretable as the average (between-group) difference in visits per person year, with base rates provided for context. Pre-event RDs (T−2 and T−1) were negligible, illustrating the pre-event balance between our comparison groups. In the post-EPM/birth period (T+1, T+2), EPM was associated with a greater number of visits to FPs (RD: 0.59 [0.48, 0.70]) and certain types of specialists—particularly OB-GYNs (RD: 0.22 [0.20, 0.24]), per person-year. These estimates reflect less than one additional visit per person-year among women who experienced an EPM but represent meaningful increases of 16% for FPs and 100% for OB/GYNs, given base rates of 3.8 and 0.2, respectively. While we observed a sustained increase in OB-GYN visits over the post-event period, the association between EPM and FP visits changed direction in the second year after the loss (RD: −0.14 [−0.24, −0.04]), suggesting that women who experienced an EPM

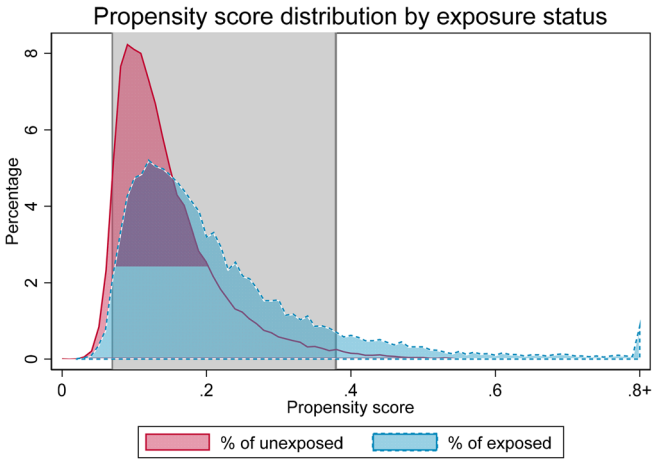


**FIGURE 1** Propensity score distribution by exposure status [Color figure can be viewed at wileyonlinelibrary.com]

**TABLE 2** Impact of EPM on health services utilization and health indicators[a]

| | Base count[b] | Rate differences | | | |
|---|---|---|---|---|---|
| | | T−2 | T−1 | T+1 | T+2 |
| Visits[c] | | | | | |
| FP | 3.75 | −0.001 (−0.10, 0.10) | −0.01 (−0.08, 0.07) | 0.59 (0.48, 0.70) | −0.14 (−0.24, −0.04) |
| Specialist | 0.66 | 0.01 (−0.04, 0.05) | −0.01 (−0.06, 0.03) | 0.36 (0.32, 0.41) | 0.18 (0.13, 0.23) |
| By type | | | | | |
| OB/GYN | 0.22 | −0.004 (−0.02, 0.02) | 0.004 (−0.01, 0.02) | 0.22 (0.20, 0.24) | 0.19 (0.17, 0.21) |
| Internal med | 0.08 | −0.0002 (−0.01, 0.01) | −0.04 (−0.06, −0.03) | 0.03 (0.02, 0.05) | 0.01 (−0.002, 0.03) |
| Psychiatry | 0.08 | 0.01 (−0.02, 0.04) | 0.0002 (−0.03, 0.03) | 0.01 (−0.01, 0.04) | 0.001 (−0.03, 0.03) |
| Anesthesia | 0.02 | −0.002 (−0.01, 0.002) | 0.004 (0.001, 0.01) | 0.10 (0.09, 0.11) | 0.01 (0.002, 0.01) |
| IM: Genetics | 0.004 | 0.001 (−0.001, 0.002) | −0.01 (−0.01, −0.008) | 0.005 (0.003, 0.01) | 0.002 (0.0002, 0.004) |
| Gyne/onc | 0.001 | −0.0003 (−0.002, 0.001) | −0.0003 (−0.001, 0.001) | 0.01 (0.003, 0.01) | 0.001 (−0.001, 0.003) |
| Hospitalizations[d] | | | | | |
| Admissions | 0.03 | −0.01 (−0.01, 0.0004) | −0.001 (−0.01, 0.004) | 0.01 (0.007, 0.02) | 0.008 (0.002, 0.015) |
| Length of stay (days) | 0.13 | −0.01 (−0.04, 0.02) | −0.003 (−0.03, 0.02) | 0.08 (0.03, 0.13) | 0.16 (0.09, 0.22) |
| Mood and anxiety disorders[e] | 0.11 | −0.01 (−0.02, −0.001) | 0.002 (−0.01, 0.01) | 0.01 (−0.001, 0.01) | −0.01 (−0.02, −0.003) |
| Psychotropic Rx | | | | | |
| Incident (any new) | 0.06 | 0.01 (0.001, 0.01) | 0.02 (0.01, 0.02) | 0.01 (0.007, 0.02) | 0.01 (0.004, 0.014) |
| Count | 0.71 | 0.04 (−0.04, 0.13) | 0.16 (0.07, 0.24) | −0.15 (−0.28, −0.03) | −0.14 (−0.31, 0.02) |
| Resource utilization band[f] | | | | | |
| | 2.25 | −0.01 (−0.04, 0.02) | −0.001 (−0.02, 0.02) | 0.25 (0.22, 0.27) | 0.08 (0.05, 0.11) |

Abbreviations: EPM, ectopic pregnancy and miscarriage; FP, family physician; Gyne/onc, gynecologic oncology; IM, internal medicine; OB/GYN, obstetrician-gynecologist.

[a]All models are adjusted for correlation and exclude prenatal visits and OBGYN visits 2 weeks following the event. RDs reflect average differences in the number of visits per person-year, by group/timepoint.

[b]Average count/rate per person-year among exposed women at T−1 (unexposed women are nearly identical given the matching strategy) for all indicators except psychotropic medications, which are based on T−2.

[c]All estimated via NLEstimate (postestimation of model w/log link).

[d]Excludes pregnancy/delivery-related hospitalizations across the observation period.

[e]The base count of mood and anxiety disorders differs slightly from Table 1 as our regression results here are based on a one-year definition.

[f]Mean differences in resource utilization band, excluding any event/birth-related services: non-users (RUB = 0), healthy users (RUB = 1), low morbidity (RUB = 2), moderate morbidity (RUB = 3), high morbidity (RUB = 4), very high morbidity (RUB = 5).

had slightly fewer visits to their FPs than their unexposed counterparts by this point. This may be due to substitution between provider types, given the sustained increase in visits to OB-GYNs. We also detected a sustained increase in hospital admissions and length of stay in women who experienced an EPM. These hospitalization estimates exclude pregnancy-related hospitalizations across the observation period but should be interpreted with caution (see Discussion section).

Women in the EPM group had higher RUBs in the year after (and to a lesser extent, in the second year after) the loss, which aligns with the detected increases in health service utilization. We observed no change in the rate of incident psychotropic dispensations among women who experienced an EPM relative to the unexposed group. However the number of psychotropic dispensations decreased by 21% for the 2 years after the event, relative to women in the unexposed group (RD: −0.15 [−0.28, −0.03]). We also detected an increase of about 9% in rates of mood and anxiety disorders in the year after the event among women who experienced an EPM, relative to the unexposed group, which did not persist into year two.

Table 3 summarizes the association between EPM and health care costs. Women in the EPM group incurred 53% higher total health care costs in the year following the loss (RD: $165.49 [$47.50, $283.48]) compared to women who experienced a live birth, excluding costs related to the loss and birth themselves. Similar to our findings for visits, this effect was driven in large part by FP and specialist costs (particularly OB-GYN), with an average person-year increase of approximately $19.92 (16%) for FPs ($16.33, $23.51) and $9.41 (89%) for OB-GYNs ($8.42, $10.40). Costs associated with other specialty providers (e.g., internal medicine and anesthesia) were slightly higher as well, but these estimates were comparably modest. Hospitalization costs were 71%–76% higher for the EPM group in the 2 years following the loss, likely driven at least in part by the increase in length of

**TABLE 3** Impact of EPM on health care costs[a]

| | | Rate differences | | | |
|---|---|---|---|---|---|
| | Base cost[b] | T−2 | T−1 | T+1 | T+2 |
| Total health care costs | 314.77 | −5.99 (−39.19, 27.20) | 33.61 (−20.65, 87.88) | 165.49 (47.50, 283.48) | 39.51 (−52.76, 131.78) |
| Provider-specific costs[c,d,e] | | | | | |
| FP | 124.63 | −0.09 (−3.38, 3.20) | 0.77 (−1.59, 3.13) | 19.92 (16.33, 23.51) | −5.89 (−9.52, −2.26) |
| Specialist | 43.42 | 1.45 (−2.72, 5.63) | −0.31 (−4.46, 3.85) | 15.89 (11.86, 19.92) | 7.34 (2.33, 12.36) |
| By type | | | | | |
| OB/GYN | 10.57 | 0.32 (−0.53, 1.17) | 0.23 (−0.57, 1.03) | 9.41 (8.42, 10.40) | 8.01 (7.02, 8.99) |
| Internal med | 5.86 | 0.22 (−0.53, 0.98) | −1.71 (−2.72, −0.70) | 2.36 (1.42, 3.31) | 0.79 (−0.24, 1.82) |
| Psychiatry | 8.94 | 0.96 (−2.63, 4.55) | −0.13 (−3.67, 3.41) | 1.58 (−1.68, 4.84) | 0.68 (−3.62, 4.97) |
| Anesthesia | 0.36 | −0.06 (−0.15, 0.02) | 0.01 (−0.10, 0.12) | 1.83 (1.65, 2.01) | 0.18 (0.06, 0.31) |
| IM: Genetics | 0.50 | 0.13 (−0.06, 0.31) | −1.50 (−1.85, −1.14) | 0.78 (0.51, 1.04) | 0.29 (0.02, 0.56) |
| Hospitalizations[f] | 119.69 | −8.28 (−37.78, 21.22) | −4.21 (−27.95, 19.53) | 84.61 (29.26, 139.96) | 90.53 (−3.45, 184.50) |
| Psychotropic Rx | 28.00 | 0.64 (−3.24, 4.53) | 5.05 (1.40, 8.69) | −6.41 (−10.26, −2.55) | −6.02 (−10.43, −1.60) |

Abbreviations: EPM, ectopic pregnancy and miscarriage; FP, family physician; Gyne/onc, gynecologic oncology; IM, internal medicine; OB/GYN, obstetrician-gynecologist.

[a]Expressed in 2010 dollars. All models are adjusted for correlation and exclude prenatal visits and OBGYN visits 2 weeks following the event. RDs reflect average differences in costs per person-year, by group/timepoint.

[b]Average cost per exposed woman at T−1 (costs for unexposed women are nearly identical given the matching strategy) for all indicators except psychotropic medications, which are based on T−2.

[c]All estimated via NLEstimate (postestimation of model w/log link).

[d]Rates reflect costs per person-year.

[e]Gynecological oncology is omitted here as estimates were undefined.

[f]Excludes pregnancy/delivery-related hospitalizations across the observation period.

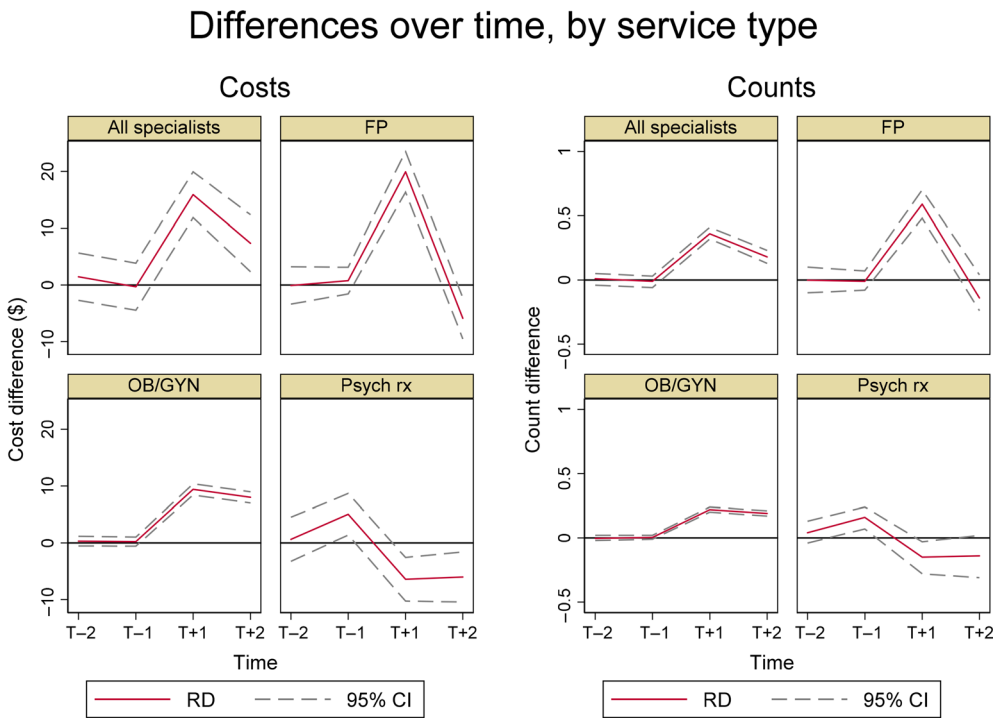


**FIGURE 2** Differences in ambulatory costs and visits over time. Positive values on the y-axis indicate higher values in the ectopic pregnancy/miscarriage (EPM) group (vs. unexposed). FP, family physician; OB/GYN, obstetrician-gynecologist; Psych rx, psychotropic medications [Color figure can be viewed at wileyonlinelibrary.com]

stay. In line with the utilization results, we observed a persistent decrease in costs related to psychotropic dispensations of about 23%.

We illustrate a selection of these differences in costs and visits over time (EPM – unexposed) in Figure 2. Plotting the estimated differences at each time point, we see the success of our propensity score matching strategy, as the differences in the two groups in the 2 years preceding the event are essentially zero. We can also clearly see the sustained increase in specialist visits and costs, driven

primarily by OB/GYNs, and the increase in FP visits and costs in the first year only. The persistent decreases in utilization and costs of psychotropic medications are also evident.

We present our sensitivity analyses in Table S4. We ran these robustness checks focusing specifically on FP, specialist, and OB-GYN visits (outcomes for which our effect estimates were noteworthy in the original analysis). We first excluded all visits to an OB-GYN in the 28 days following the index event to further reduce the likelihood that services directly related to the birth or loss were included with our outcome measures. Our findings were relatively robust to this change: most estimates at T+1 (the year of the event) were slightly attenuated but substantively similar to our original results. We then excluded all visits to FPs in the 2 weeks following the index event (in addition to our original strategy of excluding OB-GYN visits within this window). The estimate for FP visits was substantially reduced to an RD of .06 (−0.04, 0.16), which suggests that much of the original estimate was driven by FP visits close to the event date, and therefore, potentially related to the event itself. When we restricted our sample to miscarriages only (and their matched unexposed counterparts), estimates were similar to our original RDs: this was unsurprising as ectopic pregnancies accounted for only 13.3% of our original sample.

## 4 | DISCUSSION

EPM may impact women and their families in multiple ways, including influencing women's patterns of health care utilization in the years following the loss. In our sample, women who sought care for an EPM had increased visits to, and costs associated with, FPs and OB-GYNs, and (to a lesser degree) other specialists relative to the unexposed group. This increase was more sustained among OB-GYNs. Women with an EPM experienced increased hospital length of stay and hospital costs in the 2 years following the event. They also experienced an increase in rates of mood and anxiety disorders and a sustained decrease in costs associated with psychotropic medications. Given our analytical strategy and the pre-event balance between our exposed and unexposed groups, it is feasible that the observed differences in visits and costs are attributable to EPM. While the cost increases are relatively small in absolute dollars, they reflect large percentage increases, particularly for hospital admissions and OB/GYN visits. These findings regarding patterns of service utilization are informative for providers and policy makers seeking to support women following a loss, in Canada and in other contexts where health care is widely accessible. They are also relevant for insurers considering value-based funding or bundled payment for maternity care, which must account for the costs and outcomes of pregnancy, delivery, and neonatal care.[30,31]

From a provider's perspective, our findings on outpatient visits are likely intuitive: assuming the pregnancy was desired, women who experienced an EPM may be eager to conceive again, which could partially explain the uptick in FP and OB-GYN visits. Some women may require fertility treatments to conceive again, which would lead to a more sustained increase in visits to OB-GYNs (particularly reproductive endocrinologists). It is important to reiterate that pregnancy/delivery-related hospitalizations and prenatal care visits were excluded from the outcome measures across the entire observation period, so the observed increases in costs and visits are not attributable to differential rates of postevent pregnancy. Failure to exclude these visits would inflate the effect estimates, as women in the EPM group would be more likely to become pregnant shortly after the index date than women who had a live birth. For example, 47% of the women in the EPM group had a prenatal care visit in the 2 years following their loss (compared to 25% of unexposed women), and 11% had a live birth within our observation period (compared to 7% of unexposed women).

We also detected a higher probability of hospitalization, a longer average hospital stay, and greater hospital costs in the EPM group. There was considerable overlap between groups in the leading diagnoses associated with hospital admission (Table S5), particularly at T+2, but there were also noteworthy differences. Gallbladder issues topped the list for both groups at both time points, but ovarian, fallopian, and uterine disorders were leading causes of admission for the EPM group only, and only in T+1, which suggests that some of the losses in this group may have highlighted underlying health issues (e.g., uterine fibroids). However, with a relatively small number of hospitalizations in this cohort, the most frequent diagnoses are sensitive to small fluctuations in patient counts, and so these results remain suggestive.

While we initially viewed the decrease in post-EPM psychotropic medications as counterintuitive, these findings have several possible explanations. One possibility is that more women in the EPM group are actively trying to conceive in the year following the index event, during which time the use of most psychotropic medications is contraindicated. The difference in psychotropic medications may also reflect systemic issues in access to care, particularly if depression and other mood/anxiety disorders are perceived by providers (and perhaps patients) as a "normal" consequence of EPM. The fact that women with an EPM experienced increased rates of mood and anxiety disorders in the year after the event suggests that their mental health needs are at least equal to those of women who had a live birth. These findings merit additional exploration in future research and attention to mental health treatment and support options in clinical practice.

This work offers new information on the impact of EPM on subsequent health service utilization, but we are cognizant of several limitations. Despite our rich administrative dataset, unmeasured confounding remains a possibility: for example, we did not have access to information on smoking or other relevant lifestyle factors. Furthermore, as noted, a number of early losses inevitably go undetected/unreported. Our sample, therefore, consists of women who both experienced an EPM and sought medical attention. We further restricted to women experiencing a first EPM, as they are likely more similar to the live birth group than women with recurrent losses. However, it remains possible that some women in our EPM group experienced a previous (unrecorded) loss. All of these factors likely impact the generalizability of our findings. Importantly, health

outcomes and health services use are likely quite different for the smaller number of women who experience multiple EPMs.

Our findings were generally robust to model specification, but our attempt to exclude all services directly associated with the loss or birth (e.g., miscarriage follow-up care) may have been imperfect. Our sensitivity analyses suggested that the observed difference in FP visits/costs may have been attributable to activity close to the event date, which raises concerns that these visits were linked to the loss itself. By contrast, our specialist and OB-GYN estimates were quite stable. Differences between groups may have been amplified in the year following the loss due to potential underuse of services among postnatal women (e.g., if new mothers delay nonurgent care); this is speculative, but we would expect this phenomenon to subside by T+2. It is also possible that the relatively modest observed effects are due to large changes for a small number of women and no-to-small changes for the majority, rather than a modest increase across the entire population. Table S6 summarizes the distributions of pairwise differences in specialist visits between matched women at each time point. While the distributions before the event are fairly symmetrically distributed around zero, in T+1 and T+2 we see evidence that the differences in means are driven by differences at the tails of the distributions. Future analyses could further investigate effect heterogeneity and identify the characteristics of subpopulations that experience the largest impacts in order to optimize service provision and payment models.

The hospitalization variables (admissions, costs, length of stay) posed a number of analytical challenges. There were relatively few hospitalizations in this large cohort, but SAS cannot currently accommodate zero-inflated GEE, so our modeling strategy did not account for zero inflation. While this may not have a meaningful impact on our estimates, we acknowledge that our models are not an optimal fit for the hospital data. These data also contained outliers, which were differentially distributed between groups. While outliers are commonplace in hospitalization data and the standard approach is to treat them as "real,"[32] this modeling decision may have inflated our estimates.

Finally, we opted to use propensity score matching (rather than weighting) in this analysis. While weighting has emerged as the preferred approach for many researchers,[33] it does carry the risk of positivity violations, and it is arguably less intuitive than relying on clearly overlapping distributions of individuals. Nevertheless, we acknowledge that this approach has the capacity to introduce bias. There are several aspects of our design that would protect against this, including matching with (vs. without) replacement and our large sample sizes postmatch. We also illustrate prematch and postmatch imbalances (via standardized differences) in Table 1 and Figure S1 to demonstrate the improvement in covariate balance in the postmatch sample.

Pregnancy loss is a common event. A better understanding of its impact on women and subsequent health service utilization is important to optimize support for patients and health services use. Our findings suggest an increase in utilization following early pregnancy loss (compared to women with a live birth) and a corresponding increase in costs, particularly for OB/GYN visits and hospitalizations. While modest on the individual scale, given the prevalence of EPM, these costs are not negligible. Understanding the impact of EPM on subsequent health needs and health care use will allow providers and health systems to improve the patient-centeredness and appropriateness of the care they provide.

To directly support women and families experiencing EPM, it is important to recognize the loss and the grief which may accompany it.[34–36] Primary bereavement care, defined as "health care professionals capturing and creating opportunities to be with and support individuals/families in their experiences of grief and mourning,"[37] may be an effective intervention in this regard.[38–40] Future research supporting the implementation of evidence-informed primary bereavement care guidelines and evaluating the impacts on health services utilization, costs, and health outcomes would provide valuable information to improve care for families experiencing EPM.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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