

## ORIGINAL RESEARCH

# Impact of rurality on maternal and infant health indicators and outcomes in Maine

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## ABSTRACT

**Introduction:** Rural residents may face health challenges related to geographic barriers to care, physician shortages, poverty, lower educational attainment, and other demographic factors. In maternal and child health, these disparities may be evidenced by the health risks and behaviors of new mothers, the health of infants born to these mothers, and the care received by both mothers and infants.

**Methods:** To determine the impact of rurality on maternal and child health in Maine, USA, 11 years of data (2000–2010) for the state of Maine from the Pregnancy Risk Assessment Monitoring System (PRAMS) project were analyzed. PRAMS is a national public health surveillance system that uses questionnaires to survey women who had delivered live infants in the previous 2–4 months. Using a geographic information system, each questionnaire response was assigned a rurality tier (urban, suburban, large rural town, or isolated rural community) based on the rural–urban commuting area code of the town of residence of the mother. Results from the four rurality tiers were compared using the survey procedures in Statistical Analysis Software to adjust for the complex sampling strategy of the PRAMS dataset. Means (for continuous variables) and percentages (for categorical variables) were calculated for each rurality tier, along with 95% confidence intervals. Significant differences between rurality tiers were tested for using F-tests or  $\chi^2$  tests. If significant differences between rurality tiers existed ( $p < 0.05$ ), specific tiers were judged to be different from each other if their 95% confidence intervals did not overlap.

**Results:** A total of 12 600 mothers responded to the PRAMS questionnaire during the study period. Compared to mothers from more urban areas, rural mothers were younger (10.5% of mothers from isolated rural areas were teenagers compared to 6.2% of mothers from urban areas), less well educated, less likely to be married, and more likely to live in lower income households (39.6% of isolated rural mothers had household incomes  $\leq$ US\$20 000/year vs 28.8% of urban mothers). Rural mothers had higher pre-pregnancy body mass indexes (BMIs; average BMI 26.1 for isolated rural women vs 25.3 for urban women) and were more likely to smoke but less likely to drink alcohol (both before and during pregnancy). Compared to mothers from more urban areas, rural



mothers were not sure they were pregnant until a later gestational age but received prenatal care just as early and were just as likely to receive prenatal care as early as they wished. There were no differences among rurality tiers in Caesarean section rates, rates of premature births (<37 weeks gestation), or rates of underweight births (<2500 g). However infants born to rural mothers were less likely to be breastfed (52.9% of isolated rural vs 60.9% of urban infants breast fed for  $\geq 8$  weeks).

**Conclusions:** These results show that, while rural women face significant demographic and behavior challenges, their access to prenatal care, the care they receive while pregnant, and the outcomes of their pregnancies are similar to those of urban women. These results highlight areas where focused pre-pregnancy and prenatal education may improve maternal and child health in rural Maine.

**Key words:** health indicators, infant, maternal, prenatal care, USA.

## Introduction

People who live in rural communities face a range of challenges that may have an impact on their access to the healthcare system including longer travel distance and time to receive healthcare<sup>1</sup>, shortages of primary care providers<sup>2,3</sup>, hospitals undergoing financial stresses<sup>2</sup>, and greater risk of being uninsured<sup>4</sup>. These challenges are compounded by the strains resulting from higher poverty rates, lower rates of employment, and lower educational attainment for those who live in non-metropolitan (metro) areas compared to those who dwell in metro areas<sup>5</sup>. The geographic and demographic realities of rural life may also interact around health-related issues. Lower socioeconomic status is generally associated with poorer health, regardless of rurality of residence<sup>6</sup>, and greater distance to primary care has been associated with later diagnosis of serious health conditions in rural Maine, USA<sup>7</sup>. Even the types of employment available in rural areas (agriculture, mining, and fishing, for example) may come with health hazards<sup>2</sup>.

Considering these challenges, it is hardly surprising that rural residents are often thought to have poorer health compared to urban dwellers. In the area of chronic disease, unadjusted rates of type 2 diabetes, heart disease, hypertension, stroke, and cancer are all higher in rural compared to urban areas<sup>4</sup>. Some of these differences may be reduced or eliminated by adjusting for age, race, and income<sup>4</sup>. However, given the finding that life expectancy remains lower in rural compared

to urban areas<sup>8</sup>, it seems clear that some health disparities between rural and urban dwellers are far more than statistical artifacts. Rural dwellers also face challenges in the area of maternal and child health. Teenage birthrates<sup>9</sup>, neonatal mortality<sup>10</sup>, and adverse birth outcomes (eg low birth weight and prematurity)<sup>11</sup> have all been found to be higher in rural as compared to urban areas in some studies. However, as is the case for chronic disease, some of these disparities may reflect demographic differences in race and income<sup>4</sup>.

Because it has an impact on future generations, maternal and child health disparities along the rural–urban continuum are certainly a vital area of inquiry. The reasons for these differences are, to say the very least, multifactorial. Pre-pregnancy maternal demographics (age, race, marital status, and income), pre-pregnancy maternal behaviors (smoking, alcohol consumption, and body weight), and prenatal behaviors (smoking, alcohol consumption, weight gain, and seeking prenatal care) can all have an impact on the health of the pregnant women, the course of pregnancy (development of hypertension or gestational diabetes and the risk of Caesarean section birth), and the health of newborns. Postpartum maternal behaviors such as smoking and breastfeeding can also affect the newborn's health<sup>12</sup>. Further, many of these factors may differ in rural compared to urban communities, at least in some states<sup>4,13,14</sup>.

The objective in this study was to define differences in pre-pregnancy, prenatal, and postpartum health-related variables along the rural–urban continuum in the state of Maine. To



accomplish this, data were analyzed for the state of Maine from the Pregnancy Risk Assessment Monitoring System (PRAMS) over the years 2000–2010<sup>15</sup>. PRAMS is a public health surveillance project conducted by the US Center for Disease Control and Prevention in conjunction with state health departments. The PRAMS dataset contains demographic, behavioral, and health information about new mothers as well as health information about their newborn babies. These data were mapped in a geographic information system (GIS) with each birth spatially referenced to the town of residence of the mother. The rurality of each town was defined by rural–urban commuting area (RUCA) codes<sup>16</sup>. Maine is an important location to perform this analysis because Maine’s communities are distributed broadly across the rural–urban continuum, rurality has already been shown to affect health in Maine<sup>17</sup>, and Maine is a state that is not successfully reducing its rates of important infant health indicators such as the rate of babies born with a low birth weight<sup>18</sup>. These results may be of interest to readers who are concerned about the impact of rurality on maternal and child health disparities in general, readers who are specifically concerned about these health issues in Maine, and readers who are interested in exploring maternal and child health indicators in their own area.

## Methods

### *PRAMS data extraction*

The PRAMS study population is all women who gave birth to a live infant in the previous 2–4 months, identified from birth certificates. The PRAMS study sample is a stratified representative sample of these women, with members of high-risk groups over-sampled. In Maine, women who gave birth to low birth weight infants are over-sampled. PRAMS methodology involves mailing questionnaires to women who have recently given birth, using telephonic follow-up to obtain information from non-responders, and linking questionnaire results to infant birth certificate data<sup>15</sup>. For this study, PRAMS data for Maine from 2000 to 2010 were

obtained from the Maine Center for Disease Control and Prevention<sup>18</sup>.

The following PRAMS variables were used in this study: maternal age; maternal marital status; maternal town of residence; whether or not the mother had a previous live birth; household income; maternal education and race; maternal height; maternal pre-pregnancy weight and weight gain during pregnancy; gestational age of the infant when the woman was sure she was pregnant and at the earliest prenatal visit; whether or not the mother received prenatal care as early as she wished and whether or not smoking, drinking, and breast feeding were discussed during prenatal visits; maternal tobacco and alcohol use before, during, and after pregnancy; presence of hypertension during pregnancy or gestational diabetes; method of birth (Caesarean section vs vaginal birth); infant gestational age at birth, weight at birth, length of stay in hospital, and admission to an intensive care unit; and breastfeeding.

These variables were analyzed as follows:

- Maternal age, pre-pregnancy body mass index (BMI) calculated from weight and height, weight gain during pregnancy, gestational age at which the women were sure they were pregnant, gestational age at which the women began receiving prenatal care, and infant birth weight were analyzed as continuous variables.
- BMI was used to place pre-pregnancy weights into the standard categories (underweight, normal weight, overweight, and obese) and these categories were used to determine if the amount of maternal weight gain during pregnancy was less than the recommended range, within the recommended range, or greater than the recommended range according to current Institute of Medicine guidelines<sup>19</sup>. Pregnancy weight gain was also analyzed categorically (<6.8 kg (15 lb), 6.8–20.4 kg (15–45 lb), >20.4 kg (45 lb)). Other categorical variables analyzed for this study included maternal age (<20 years, 20–35 years, >35 years),



length of the infant's hospital stay (1–2 days, 3–5 days,  $\geq 6$  days), infant birth weight (<2500 g, 2500–4000 g,  $\geq 4000$  g), and breastfeeding (never, <8 weeks,  $\geq 8$  weeks).

- Smoking and drinking were analyzed as dichotomous variables as were marital status; maternal educational attainment ( $\leq 12$  years vs  $> 12$  years); household income ( $\leq$ US\$20 000/year vs  $>$  US\$20 000/year); race (white vs all other races); whether or not the pregnant woman received prenatal care as early as she wished; and whether or not smoking, drinking, and breastfeeding were discussed during pregnancy.

## *Geographic information system construction*

GIS analysis was conducted using ArcMap v10.1 (ESRI; <http://www.esri.com/software/arcgis>). Base maps of Maine's counties, towns, and census blocks were obtained from the Maine Office of GIS data catalog<sup>20</sup>. Census blocks were merged to create a statewide map of census tracts. Primary and secondary RUCA codes were obtained for all Maine census tracts from the US Department of Agriculture Economic Research Service<sup>21</sup> and merged with the map of census tracts. Then each census tract was assigned to one of four rurality tiers (urban, suburban, large rural town, isolated rural) using the four-tier consolidation of the secondary RUCA codes<sup>22</sup>. There are 533 Maine towns and 358 Maine census tracts. In many instances in Maine census tracts and towns are defined by the same boundaries. In a very few of the largest cities there is more than one census tract in a city (although all of these census tracts fall into the same rurality tier), and in much of rural Maine a single census tract contains several towns. Rurality tiers were determined for each town by converting the census tract map to centroid points and determining which point was within the boundaries of or closest to each town. Finally, rurality tiers were assigned to each PRAMS questionnaire response based on the mother's town of residence.

## *Data analysis*

Results for study subjects from the four rurality tiers were compared using the survey procedures in Statistical Analysis

Software v9.3 (SAS Institute; <http://www.sas.com>) to adjust for the complex sampling strategy of the PRAMS dataset. Means (for continuous variables) and percentages (for categorical variables) were calculated for each rurality tier, along with 95% confidence intervals. Significant differences between rurality tiers were tested for using F-tests (for continuous variables) and  $\chi^2$  tests (for dichotomous and categorical variables). Significance was accepted at  $p < 0.05$ . If significant differences between rurality tiers existed, specific tiers were judged to be different from each other if their 95% confidence intervals did not overlap.

## *Ethics approval*

This protocol was approved by the University of Southern Maine Institutional Review Board (IRB protocol #101912-01) and vetted before the Maine Center for Disease Control and Prevention.

## Results

Between 2000 and 2010 there were 12 600 Maine women who answered PRAMS questionnaires. This is a response rate of  $> 70\%$  for each year and overall. After excluding 29 births for which the infant's birth weight was unknown and another 10 for which the town of residence of the mother was unknown there were a maximum of 12 561 respondents to any question. Of these births, 3575 were to women who resided in urban areas, 2649 to women who resided in suburban areas, 2432 to women who resided in large rural towns, and 3905 to women living in isolated rural areas.

## *Pre-pregnancy results*

There were significant differences along the rural–urban continuum for age, race, BMI, educational attainment, marital status, income, smoking risk, and drinking risk of women before pregnancy ( $p < 0.0001$  for each variable). There were also differences in the number of women who had a previous live birth ( $p = 0.01$ ; Tables 1, 2). The average ages of women from isolated rural areas (27.1 years) and



large rural towns (27.7 years) were significantly less than the average ages of women from urban (29.0 years) or suburban (28.7 years) areas (Table 1). These differences result from the continuous increase in the number of women aged <20 years giving birth as rurality increased (from 6.2% of urban women to 10.5% of women from isolated rural areas) with a decrease in the number of women aged >35 years giving birth (from 17.5% in urban areas to 9.9% in isolated rural areas; Fig1). Mean BMI increased from 25.3 in urban areas to 26.1 in isolated rural areas (Table 2).

Women from isolated rural areas were significantly less likely to be married and more likely to have a household income ≤US\$20 000/year than were women from any of the other rurality tiers. Among women from isolated rural areas, 57.8% were married (compared to 69.1% of women living in suburban areas) and 39.6% lived in households with income ≤US\$20 000/year (compared to 23.6% of women from suburban areas and 28.8% of women from urban areas; Table 1). Women from rural towns and isolated rural areas were both more likely to have no education past 12th grade and to smoke cigarettes prior to pregnancy compared to women from urban or suburban areas, and less likely to drink alcohol prior to pregnancy than were women from urban areas. Among women from isolated rural areas 35.4% smoked cigarettes prior to pregnancy (compared to 27.8% of suburban women) and 51.8% had no education past high school (compared to 37.7% of women from urban areas; Tables 1, 2). The likelihood of having had a previous live birth was highest for women from rural towns and lowest for women from urban areas despite the fact that rural women were younger and more likely to be aged <20 years (Table 1, Fig1). Racial diversity (although very low overall in Maine by national standards) was highest for urban women, intermediate for women from isolated rural areas and rural towns, and lowest for suburban women (Table 1).

## **Pregnancy results**

There were significant differences by rurality tier in smoking and drinking during pregnancy ( $p<0.0001$ ) as well as in the number of women who reported that these topics (but not

the topic of breastfeeding) were discussed during prenatal visits ( $p=0.004$  for discussion of smoking and  $p=0.03$  for discussion of drinking). There were significant differences in the prevalence of gestational diabetes ( $p=0.005$ ) but not hypertension during pregnancy (Tables 3, 4). Analysis by rurality tier also revealed significant differences in the amount of weight gained during pregnancy, both when measured as a continuous variable ( $p<0.001$ ) and when considered as a categorical variable ( $p=0.02$  or  $p=0.04$  depending on the categories used; Table 3, Figures 2, 3). There were significant differences by rurality tier in the gestational age at which women were sure they were pregnant ( $p<0.001$ ) but not in the gestational age at which they initiated prenatal care (Table 4).

As was the case before pregnancy, women from isolated rural areas had higher rates of smoking (22.3%) and lower rates of drinking (5.1%) during pregnancy than did women from urban (14.7% smoked and 9.0% drank alcohol) or suburban areas. Women from isolated rural areas were the most likely to receive discussion of smoking and drinking during pregnancy; however, the number of women who received prenatal discussion on these subjects was >75% for all rurality tiers (Table 4). Women from rural towns had the lowest rate of gestational diabetes (8.4% compared to 11.7% for urban women; Table 3) and a significantly lower average weight gain during pregnancy (13.1 kg (28.8 lb)) than did women from urban or suburban areas (13.7 kg (30.1 lb) for each; Table 3). The low average weight gain for women from rural towns is a result of the fact that they were the least likely to gain >20.4 kg (45 lb; Fig2). The number of women whose pregnancy weight gain was within the recommended range (42.5% overall) was similar for all rurality tiers (Fig3). Women from isolated rural areas were sure they were pregnant at a later gestational age (5.8 weeks) than were women from urban or suburban areas (5.3 weeks for both; Table 4). However, this did not affect the gestational age at which they obtained prenatal care (8.6 weeks for all rurality tiers) or their ability to receive prenatal care as early as they wanted it. More than 85% of women in this study reported receiving prenatal care as early as they wanted (Table 4).



**Table 1: Pre-pregnancy demographics by rurality tier<sup>†</sup>**

Rurality category	Previous live birth (95%CL) (%) (n=12 450)**	Married (95%CL) (%) (n=12 551)****	Education ≤12 years (95%CL) (%) (n=12 504)****	Income ≤US\$20k/year (95%CL) (%) (n=11 972)****	Non-white (95%CL) (%) (n=12 261)****	Age (95%CL) (years) (n=12 551)****
Urban	51.7 (49.8–53.7)	66.4 (64.5–68.3)	37.7 (35.7–39.6)	28.8 (26.9–30.6)	4.9 (4.0–5.8)	29.0 (28.8–29.3)
Suburban	54.4 (52.2–56.7)	69.1 (67.0–71.3)	40.1 (37.8–42.3)	23.6 (21.6–25.6)	1.4 (0.9–2.0)	28.7 (28.4–28.9)
Rural town	56.3 (54.0–58.6)	62.7 (60.3–65.0)	51.0 (48.7–53.4)	32.6 (30.3–34.9)	2.6 (1.8–3.4)	27.7 (27.4–27.9)
Isolated rural	55.2 (53.3–57.1)	57.8 (56.0–59.7)	51.8 (49.9–53.7)	39.6 (37.7–41.6)	2.8 (2.2–3.5)	27.1 (26.8–27.3)

\*\* $p=0.01$ , \*\*\*\* $p<0.0001$

<sup>†</sup> For demographic variables, mean (for age) or ‘% yes’ (for all other variables) is reported for each rurality category. The  $p$  values are determined by F-test for continuous variables and  $\chi^2$  test for categorical variables, and demonstrate if there are significant differences in the results for each variable by rurality category. Specific rurality categories differ significantly from each other if 95%CLs do not overlap.

CL, confidence limit

**Table 2: Pre-pregnancy health behavioral variables by rurality tier<sup>†</sup>**

Rurality category	BMI (95%CL) (kg/m <sup>2</sup> ) (n=12 271)****	Smoked (95%CL) (%) (n=12 361)****	Drank alcohol (95%CL) (%) (n=12 301)****
Urban	25.3 (25.0–25.5)	28.5 (26.7–30.3)	66.0 (64.1–67.9)
Suburban	25.7 (25.4–25.9)	27.8 (25.7–29.8)	65.5 (63.3–67.6)
Rural town	26.0 (25.7–26.3)	33.8 (31.6–36.1)	61.1 (58.8–63.4)
Isolated rural	26.1 (25.8–26.3)	35.4 (33.6–37.3)	60.2 (58.3–62.1)

\*\*\*\* $p<0.0001$

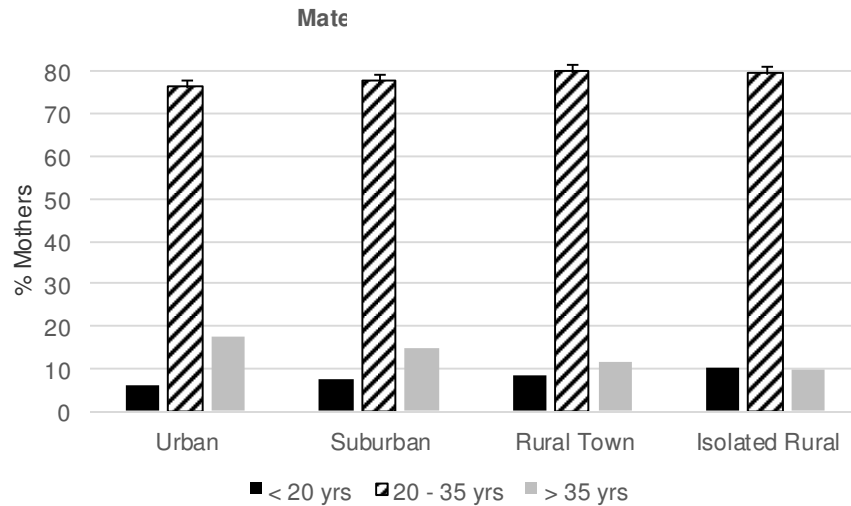
<sup>†</sup> For behavioral variables, mean (for BMI) or ‘% yes’ (for all other variables) is reported for each rurality category. ‘Smoked’ and ‘Drank alcohol’ indicate if the women giving birth reported smoking tobacco or drinking alcohol in the 3 months prior to pregnancy. The  $p$  values are determined by F-test for continuous variables and  $\chi^2$  test for categorical variables, and demonstrate if there are significant differences in the results for each variable by rurality category. Specific rurality categories differ significantly from each other if 95%CLs do not overlap.

BMI, body mass index. CL, confidence limit

## Postpartum results

There were significant differences by rurality tier in number of newborns admitted to an intensive care unit ( $p<0.0001$ ; Table 5) and the length of time that newborns spent hospitalized ( $p=0.03$ ; Fig4) but not in the number born by Caesarean section (overall, first time, or repeat; Fig5),

their birth weight (Fig6), or the number born prematurely (<37 weeks gestational age; Table 5). Length of breastfeeding differed significantly by rurality tier ( $p<0.0001$ ; Fig7) as did the number of women who smoked after giving birth ( $p<0.0001$ ; Table 5).



† Number of teenage mothers from isolated rural areas was significantly greater than number from either urban or suburban areas. Number of rural mothers aged >35 years was significantly less than number from either urban or suburban areas. Error bars show 95% confidence limits.

**Figure 1: Distribution of maternal ages as a categorical variable varied significantly by rurality tier, determined by  $\chi^2$  test ( $n=12\ 251$ ,  $p<0.0001$ ).†**

**Table 3: Pregnancy risk factor variables by rurality tier†**

Rurality category	Gestational weight gain (95%CL) (kg) ( $n=12\ 468$ )**	Smoked (95%CL) (%) ( $n=12\ 419$ )****	Drank alcohol (95%CL) (%) ( $n=12\ 378$ )****	Hypertension (95%CL) (%) ( $n=12\ 477$ )	Gestational diabetes (95%CL) (%) ( $n=12\ 531$ )**
Urban	13.7 (13.4–13.9)	14.7 (13.2–16.1)	9.0 (7.9–10.1)	24.6 (22.9–26.2)	11.7 (10.4–12.9)
Suburban	13.7 (13.3–13.9)	16.0 (14.2–17.7)	6.2 (5.1–7.3)	24.4 (22.4–26.3)	10.6 (9.3–12.0)
Rural town	13.1 (12.8–13.4)	18.9 (17.0–20.8)	6.3 (5.2–7.5)	24.2 (22.2–26.2)	8.4 (7.2–9.7)
Isolated rural	13.5 (13.2–13.7)	22.3 (20.6–23.9)	5.1 (4.3–6.0)	25.1 (23.4–26.7)	11.1 (10.0–12.3)

\*\* $p=0.01$  for gestational weight gain and 0.005 for gestational diabetes. \*\*\*\* $p<0.0001$

† For pregnancy risk factor variables, mean is reported for gestational weight gain and ‘% yes’ is reported for all other variables. ‘Smoked’ and ‘Drank alcohol’ indicate if the women reported smoking tobacco or drinking alcohol in the last 3 months of pregnancy. ‘Hypertension’ and ‘Gestational diabetes’ indicate the percentage of women who reported these complications during pregnancy. The  $p$  values are determined by F-test for continuous variables (weight gain) and  $\chi^2$  test for categorical variables and demonstrate if there are significant differences in the results for each variable by rurality category. Specific rurality categories differ significantly from each other if 95%CLs do not overlap. CL, confidence limit

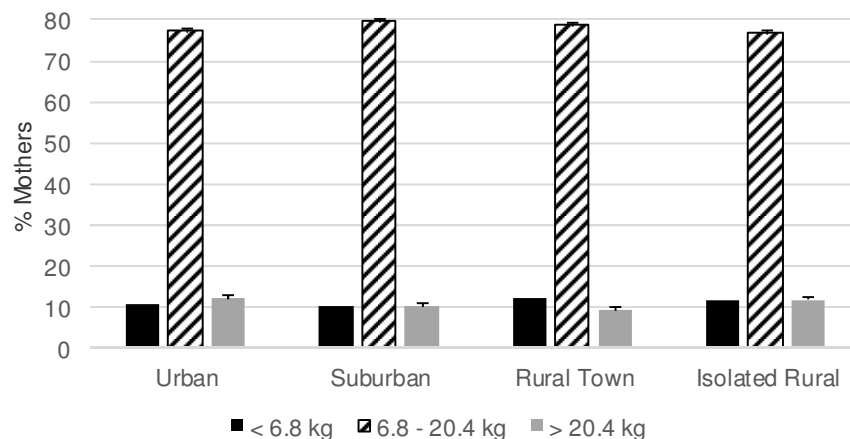


**Table 4: Pregnancy care variables by rurality tier<sup>†</sup>**

Rurality category	Sure pregnant (95%CL) (weeks pregnant) (n=12 066)****	First prenatal visit (95%CL) (weeks pregnant) (n=12 315)	Care early as wanted (95%CL) (%) (n=12 454)	Discussion of breastfeeding (95%CL) (%) (n=12 373)	Discussion of smoking (95%CL) (%) (n=12 353)**	Discussion of drinking (95%CL) (%) (n=12 355)*
Urban	5.3 (5.2–5.4)	8.6 (8.4–8.7)	85.7 (84.3–87.1)	89.7 (88.5–90.8)	76.2 (74.6–77.9)	77.1 (75.5–78.7)
Suburban	5.3 (5.1–5.5)	8.6 (8.4–8.8)	88.0 (86.5–89.5)	89.7 (88.4–91.1)	76.4 (74.5–78.3)	78.0 (76.1–79.8)
Rural town	5.6 (5.4–5.7)	8.6 (8.4–8.7)	86.0 (84.3–87.6)	90.5 (89.2–91.9)	78.7 (76.8–80.6)	76.1 (74.1–78.1)
Isolated rural	5.8 (5.6–5.9)	8.6 (8.4–8.7)	86.4 (85.1–87.7)	91.5 (90.4–92.5)	79.8 (78.3–81.3)	79.6 (78.1–81.1)

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*\*  $p < 0.0001$

<sup>†</sup> For pregnancy care and risk factor variables, ‘% yes’ is reported for each rurality category. The ‘Discussion’ variables indicate that the pregnant women reported at least one prenatal discussion with a health provider on the risk factor. The  $p$  values are determined by  $\chi^2$  test and demonstrate if there are significant differences in the results for each variable by rurality category. Specific rurality categories differ significantly from each other if 95%CLs do not overlap. CL, confidence limit



<sup>†</sup> Women from rural towns were significantly less likely to gain >20.4 kg (45 lb) than were women from urban areas. Error bars show 95% confidence limits.

**Figure 2: Distribution of maternal gestational weight gain as a categorical variable varied significantly by rurality tier, determined by  $\chi^2$  test (n=12 192,  $p=0.02$ ).<sup>†</sup>**

During the study period, 10.9% of newborns with mothers from urban areas and 10.7% of newborns with mothers from suburban areas were admitted to intensive care units while only 8.4% of those born to mothers from isolated rural areas and 6.9% of those born to mothers from rural towns were (Table 5). There were also differences by rurality tier in the

length of time newborns spent in the hospital. During the study period 8.5% of newborns of urban mothers and 8.8% of newborns of suburban mothers were hospitalized  $\geq 6$  days, compared to newborns to women from rural towns (8.0% hospitalized  $\geq 6$  days) and isolated rural areas (7.7% hospitalized  $\geq 6$  days; Fig4). Interestingly, these differences





did not seem to reflect any of the pregnancy outcomes measured in this study. The number of births by Caesarean section across all rurality tiers was 28.2% (17.5% first-time Caesarean sections and 10.7% repeat operations with no differences by rurality tier; Fig5), 8.1% of newborns were born prematurely (with no differences by rurality tier; Table 5), and the number of newborns weighing <2500 g was 5.7% (again with no differences by rurality tier; Fig6). The number of women from isolated rural areas who did not breastfeed their infants at all was 24.7%, significantly higher than the number of urban women who did not breastfeed (19.3%). The number of women from isolated rural areas who breastfed for  $\geq 8$  weeks was 52.9%, significantly lower than the number of urban women who breastfed for this length of time (60.9%; Fig7).

## Discussion

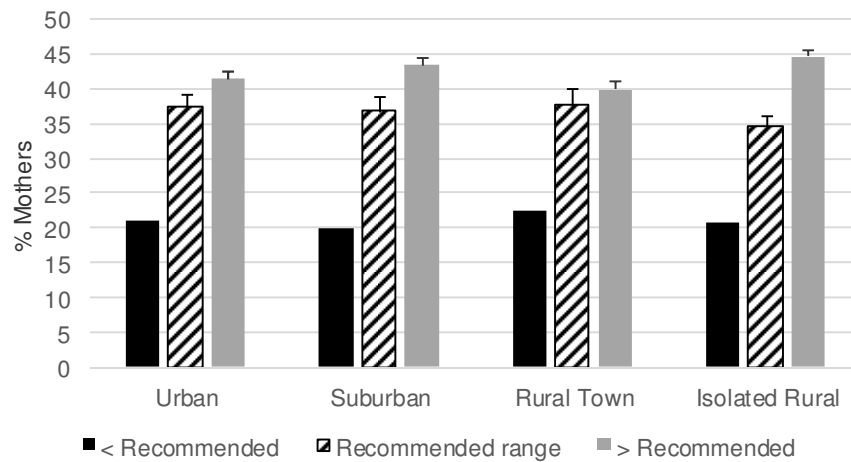
### Demographics

Differences in pre-pregnancy demographics along the rural–urban continuum similar to the results reported here have been reported in several other studies. A nationwide comparison of births in urban versus rural hospitals found that women who gave birth in rural hospitals were more likely to be younger, more likely to receive Medicaid (social health care for low income earners), and less racially diverse compared to those who gave birth in urban hospitals<sup>23</sup>. Similarly, in Oregon, rural women who gave birth were, on average, younger, less well educated, and less racially diverse than were urban women<sup>13</sup>. It should be noted that the results reported here for Maine and those from the Oregon study were spatially referenced by the rurality of the mother's residence, not by the rurality of the hospital where she gave birth as in the national study, and some women from rural areas with high-risk pregnancies may be sent to urban hospitals to give birth. However, all three studies show that rural women are younger, both the work reported here and the national study show that rural women had greater financial challenges (if receiving Medicaid is a marker for financial challenges), and both the Oregon study and the Maine results reported here show that rural women who gave birth were less well educated than their urban counterparts (Table 1, Fig1)<sup>13,23</sup>.

These findings have wide-ranging implications. Very young women who give birth (teenage pregnancies) are at risk for complications during pregnancy (hypertension, anemia, and premature labor) while women aged >35 years giving birth are at risk for complications of labor (prolonged labor, excess bleeding during labor, and increased rates of Caesarean section birth), particularly if they are giving birth for the first time<sup>24</sup>. Thus in Maine, where rural women giving birth are more likely to be aged <20 years and less likely to be aged >35 years compared to women from urban areas (Fig1), rural women giving birth may be at greater risk for some complications but at lower risk for others.

The financial challenges associated with rural residence may also present health challenges. This study reports that 39.6% of women from isolated rural areas of Maine had household incomes  $\leq$ US\$20 000/year, representing 102% of the federal poverty limit for a family of three in 2013. Low income/poverty correlate with higher rates of both pre-pregnancy risks<sup>25</sup> and pregnancy complications<sup>26</sup>. The lower level of educational attainment for rural women may also interact with lower income to produce even greater health challenges. Higher educational attainment is associated with better general health<sup>27</sup> and some of this difference may result from the higher incomes associated with more education<sup>28</sup>.

Maine, however, does seem to have some unique characteristics. In Maine the number of women giving birth who were married decreased as their residences became more rural (Table 1), whereas in Oregon women from rural towns were least likely to be married and women from isolated rural areas were most likely to be married<sup>13</sup>. In the case of racial diversity, the Oregon study found that the number of women giving birth who were white increased along the continuum for urban to rural<sup>13</sup> while in Maine there was a U-shaped relationship between rurality and racial diversity with the number of non-white women giving birth highest in urban and isolated rural areas (Table 1). These results suggest that rural areas in different parts of the country are not necessarily homogeneous and highlights the importance of performing analysis of the impact of rurality on health indicators in multiple locations.



† However, none of the differences between specific rurality tiers reached statistical significance. Error bars show 95% confidence limits.

**Figure 3: Distribution of maternal gestational weight gain relative to Institute of Medicine recommendations varied significantly by rurality tier, determined by  $\chi^2$  test ( $n=12\ 192$ ,  $p=0.04$ ).†**

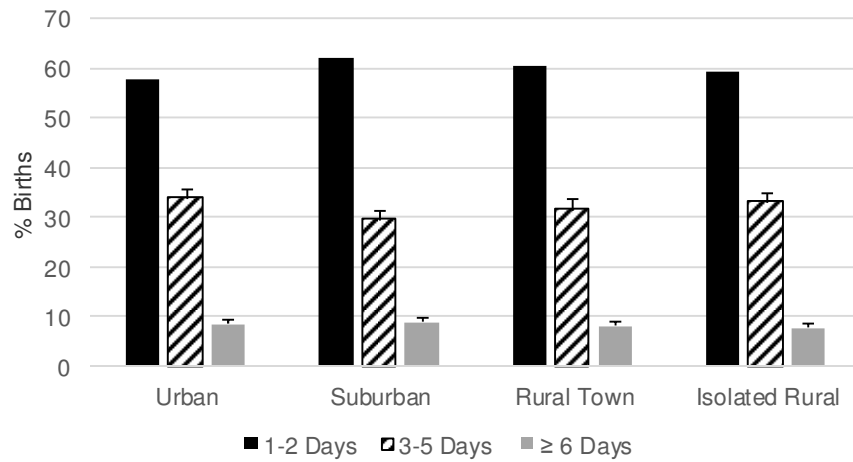
**Table 5: Postpartum outcome and risk factor variables by rurality tier†**

Rurality category	Infant in intensive care unit (95%CL) (%)**** ( $n=12\ 470$ )	Infant lives with mother (95%CL) (%) ( $n=12\ 125$ )	Current smoker (95%CL) (%)**** ( $n=12\ 430$ )	Gestational age <37 weeks (95%CL) (%) ( $n=12\ 546$ )
Urban	10.9 (9.8–12.0)	99.4 (99.1–99.7)	20.3 (18.7–21.9)	7.9 (7.1–8.8)
Suburban	10.7 (9.5–12.0)	99.7 (99.4–99.9)	20.0 (18.1–21.8)	8.7 (7.7–9.7)
Rural town	6.9 (5.9–8.0)	99.4 (99.0–99.7)	24.7 (22.7–26.8)	7.6 (6.6–8.6)
Isolated rural	8.4 (7.5–9.3)	99.7 (99.5–99.9)	27.6 (25.9–29.3)	8.1 (7.3–8.9)

\*\*\*\* $p < 0.0001$

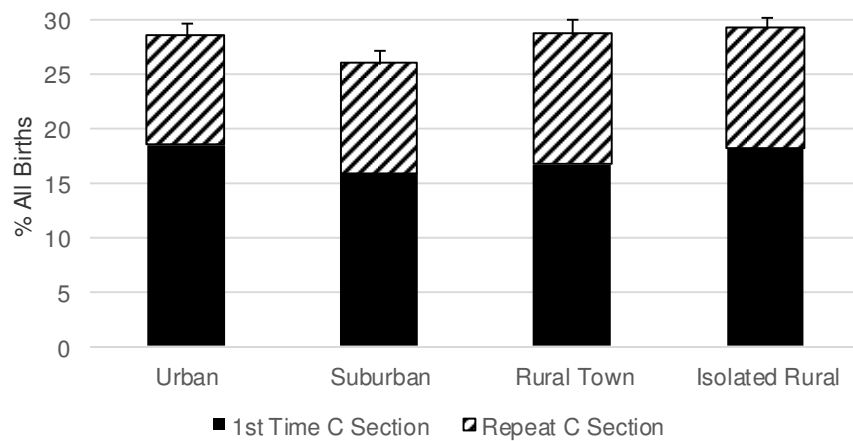
† For postpartum outcome and risk factor variables, ‘% yes’ is reported for each rurality category. The  $p$  values are determined by  $\chi^2$  test and demonstrate if there are significant differences in the results for each variable by rurality category. Specific rurality categories differ significantly from each other if 95%CLs do not overlap.

CL, confidence limit



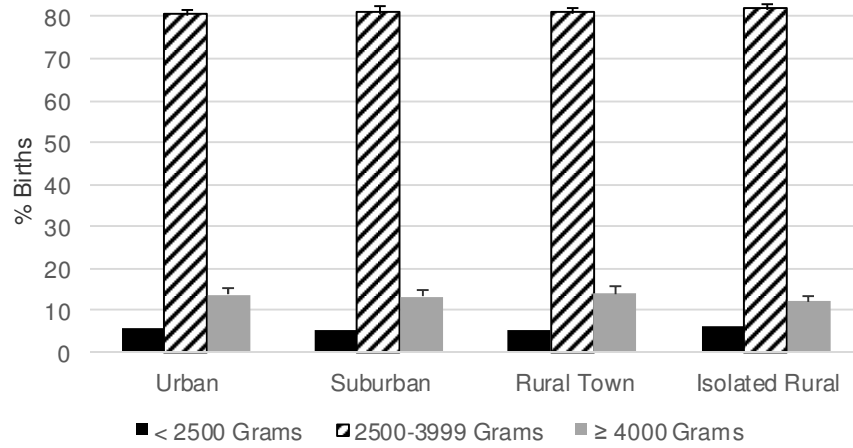
† Babies born to women from suburban areas were significantly more likely to spend 1–2 days in the hospital and significantly less likely to spend 3–5 days in the hospital than were babies born to women from urban areas. Error bars show 95% confidence limits.

**Figure 4: Distribution of hospital length of stay for newborns differs significantly by rurality category, determined by  $\chi^2$  test ( $n=12\ 341$  and  $p=0.03$ ).<sup>†</sup>**



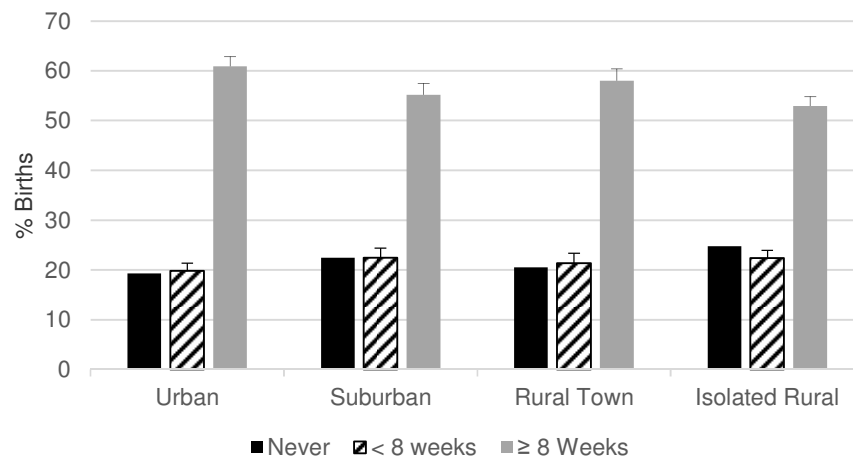
† Error bars show 95% confidence limits.

**Figure 5: Distribution of first-time and repeat Caesarean (C) section birth rates did not differ significantly by rurality tier, determined by  $\chi^2$  test ( $n=12\ 551$ ,  $p=0.07$  for first-time C sections,  $p=0.18$  for repeat C sections, and  $p=0.10$  for all C sections).<sup>†</sup>**



† Error bars show 95% confidence limits.

**Figure 6: Infant birth weight as a categorical variable did not vary significantly by rurality tier, determined by  $\chi^2$  test ( $n=12\ 550$ ,  $p=0.21$ ).†**



† Women from isolated rural communities were significantly less likely to breastfeed their infants for  $\geq 8$  weeks than were women from any other rurality tier and significantly more likely not to breastfeed at all than were urban or suburban women. Error bars show 95% confidence limits.

**Figure 7: Breastfeeding behavior differed significantly by rurality tier, determined by  $\chi^2$  test ( $n=12\ 028$ ,  $p<0.0001$ ).†**



## *Health-related behaviors*

Rurality can also affect health-related behaviors around pregnancy. A South Carolina study divided women into two categories (urban and rural) and found that rural women were more likely to be overweight or obese prior to pregnancy compared to urban women<sup>14</sup>. This result is in general agreement with the increasing BMI by rurality tier reported here for Maine (Table 2). Higher pre-pregnancy BMI is important because even small increases in maternal BMI above 25 are associated with increased risk of infant death. In a large meta-analysis, the risk of death for infants born to mothers with a pre-pregnancy BMI of 27.5 was 8% higher than the risk for infants born to mothers with a BMI of 25<sup>29</sup>.

The reason for the differences in pregnancy BMI by rurality tier reported here and elsewhere requires further study, and does not seem to be related to differences in perceptions about the barriers to exercise<sup>30</sup>. The South Carolina study found that rural women were slightly more likely to have inadequate gestational weight gain (GWG) and slightly less likely to have excessive GWG compared to urban women. The results reported here show a similar result, but only for women from rural towns and not for women from isolated rural areas (Figs 2, 3), demonstrating that the use of four rather than two rurality tiers can reveal subtle differences even among rural women.

Smoking before and during pregnancy is a risk to both the pregnant woman and the fetus<sup>12</sup>. The higher rates of smoking before, during, and after pregnancy among rural women reported here (Tables 2, 3, 5) are also in agreement with previous results from Oregon<sup>13</sup> and from older women in British Columbia, Canada<sup>31</sup> for smoking during pregnancy. The reason for these differences is unknown. However, poverty and lower educational attainment are associated with increased smoking risk among pregnant women in South Carolina<sup>32</sup>. Thus, the lower household incomes and educational attainment reported in this study for rural women (Table 1) may help explain the high smoking rates

among rural women before, during, and after pregnancy in Maine. Regardless of the reason that so many pregnant rural women smoke, the higher number of rural women who report discussion of the dangers of smoking during pregnancy (Table 4) seems appropriate. However, it is also clear that more needs to be done to reduce tobacco-exposed pregnancies in Maine and elsewhere. Interestingly, a national study found lower rates of smoking during pregnancy in rural as compared to urban women<sup>33</sup>. However, rurality was defined as a dichotomous variable at the county level – a much different approach than the one taken in the study reported here.

The finding of this study that fewer Maine women from isolated rural areas consumed alcohol before and during pregnancy compared to the number of urban women who did so is also at odds with the higher rates of alcohol consumption found for older rural women in British Columbia, Canada<sup>31</sup> and the higher rates of alcohol-related hospital admission for pregnant rural women in Australia<sup>34</sup>. This may reflect either site-specific variability in behaviors, the younger age of rural women in Maine, or differences in experimental approaches.

## *Access to care and pregnancy outcomes*

Lack of access to health care is commonly cited as one of the most important challenges to rural health, if not the most important challenge<sup>4</sup>. There is little question that rural life produces barriers to obtaining health care. Rural dwellers travel further to obtain their health care and visit specialists less often<sup>1</sup>. There is also evidence that, in Maine, those who live further from hospitals receive somewhat different care when they do arrive in emergency rooms with acute complaints<sup>17</sup>. However, it remains an open question whether or not these barriers are sufficient to produce differences in maternal and child health outcomes.

In Alabama in the USA, a study that defined rurality in three categories by RUCA codes (urban, large town, and small town) found different temporal trends for women from small towns for 1990–2010 in the rates of pre-term and low-birth-



weight births, until by the end of the study period risks for both of these outcomes were highest among women from small towns<sup>11</sup>. However, for women over the age of 35 years in British Columbia, women from rural area had a lower risk of small-for-gestational-age birth but a higher risk of perinatal mortality compared to urban women<sup>32</sup>. In Oregon, at least, any differences in pregnancy outcomes could not be easily explained by inability to obtain prenatal care. Rural women in that state were just as likely as urban women to receive prenatal care in the first trimester and just as likely to have received it as early as they wanted<sup>13</sup>. Other studies have failed to find that rurality constitutes a measurable barrier to positive maternal and child health outcomes. A four-state study failed to find that increased travel time to a clinic predicted increased risk of teenage pregnancy or unintended pregnancy<sup>35</sup>. Caesarean section rates have also been found to be lower in rural compared to urban hospitals<sup>23</sup>, and lower for older rural compared to older urban women in British Columbia<sup>31</sup>.

The results reported here also contain little evidence that rurality is negatively affecting either access to care or the type of care given during pregnancy and childbirth in Maine. In results similar to those obtained in Oregon<sup>13</sup> rural women in Maine started prenatal care as early as urban women and were just as likely to receive prenatal care as early as they wished, even though they were not sure they were pregnant until a slightly later gestational age (Table 4). The high rate of discussions of smoking, drinking, and breastfeeding during prenatal visits reported by rural women (Table 4) suggests that they received quality prenatal care, as do the comparable rates of hypertension during pregnancy and lower rate of gestational diabetes for women living in rural towns (Table 3). The results reported here also found no differences by rurality tier in other outcomes that could suggest lack of access to high quality care including gestational age at birth, low birth weight (Fig6, Table 5), or Caesarean section rates (Fig5). However, this should not be taken as evidence that maternal health indicators that do differ by rurality tier (eg pre-pregnancy BMI, gestational weight gain, and smoking) have no impact on newborn health. A multi-variable analysis of factors predicting poor infant health

would be needed to address this point. On the other hand, it does suggest that the differences found in this study in the care rural neonates received in the hospital (less likely to be admitted to an intensive care unit and less likely to spend 6 or more days in the hospital; Fig4, Table 5) may reflect the availability of services and medical practice norms in different areas rather than actual newborn health differences across rurality tiers.

## *Limitations*

The output of the PRAMS project is a national dataset with an extremely well respected sampling methodology, and the advantages of working with such a dataset are obvious. However, these data do come with some limitations. First, the data collected by questionnaire are self-reported. As such they may have systematic biases, particularly in biometrics (height and weight) and behaviors (smoking and drinking). However, there is no reason to believe that these biases have different impacts by rurality tier and direct confirmation of the reported data would be nearly impossible. Second, in some limited instances (eg birth weight) data from 100% of hospital births could be available from birth certificates. However, the robust nature of the PRAMS sampling method makes it very likely that this sample is representative of all Maine births and the advantages of having all study variables obtained from the same sample outweigh this limitation. Third, because the PRAMS dataset only contains information collected from women who had live births it cannot be used to assess such important health indicators as still-birth rate and perinatal mortality rate.

## Conclusions

This study contains a report of changes in pre-pregnancy, pregnancy, and postpartum variables that may affect maternal and child health along the rural–urban continuum in Maine. This includes a range of demographic and behavioral factors that may negatively affect the health of rural dwellers and their newborns, most notably a high number of teenage pregnancies, high pre-pregnancy BMI, low educational attainment and household income, high smoking rates, and



low rates of breastfeeding. However, rural women seem to have access to prenatal care similar to that of urban women, as measured by the age at which they receive their initial prenatal visit. The care rural women receive also seems similar to that given to urban women as measured variables ranging from risk factor discussions during prenatal visits to Caesarean section rates. Rates of premature and low-birth-weight births are similar for urban and rural women in Maine as well. These results highlight areas where focused pre-pregnancy and prenatal education may improve maternal and child health in rural Maine.

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