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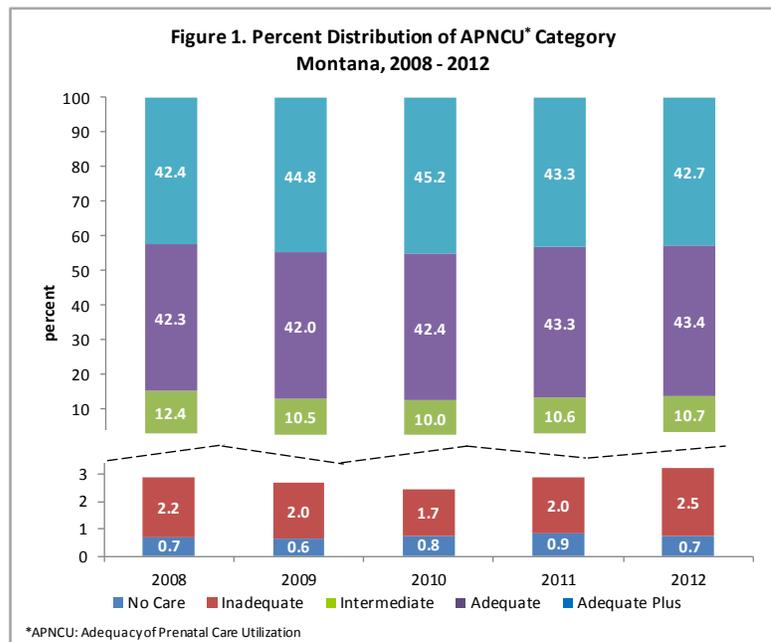
**Adequacy of Prenatal Care Utilization: Pregnancy Outcomes, Montana, 2008 – 2012.**

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**Introduction**

Prenatal care is associated with desirable birth outcomes and has largely been accepted to reduce low-weight and preterm births, improve overall birth outcomes and reduce rates of maternal morbidity and mortality.<sup>1,2</sup> While further research is necessary to determine the underlying factors associated with inadequate care and the degree of its effectiveness, prenatal care remains a central focus of maternal and child health programs.<sup>3,4</sup> Nevertheless, measuring the adequacy of prenatal care, its distribution within a population, and its relationship with birth outcome is a useful tool when beginning to examine factors related to maternal and infant health.

Prenatal care can be categorized on a scale from no or inadequate to adequate or adequate-plus by using the number of visits and time the visits were initiated.<sup>5</sup> Nationally from 1995 – 2002, an annual decrease in inadequate care offset a corresponding increase the percentage of women receiving adequate plus care.<sup>6</sup> In Montana during 2008 – 2012, 85% - 86% of pregnancies received adequate or adequate plus prenatal care while 2.9% - 3.2% received inadequate or adequate plus prenatal care. The fetal death ratio and infant death rate during this period of time did not change (averaging 4.4 and 6.1 deaths per 1,000 live-births, respectively).<sup>7</sup> This report presents data from an analysis of risk factors and birth outcomes by the Adequacy of Prenatal Care Utilization (APNCU) index for singleton live births that occurred in Montana from 2008 – 2012.



<sup>1</sup> Institute of Medicine. Preventing Low Birthweight. Washington DC: National Academy Press; 1985.

<sup>2</sup> World Health Organization. Antenatal Care and Maternal Health: How Effective is it? 1992.

<sup>3</sup> Fiscella F. Does Prenatal Care Improve Birth Outcomes? A Critical Review. *Obstetrics and Gynecology*. 1995; 85, 468-479.

<sup>4</sup> Feijen-de Jong E et al. Determinants of Late and/or Inadequate Use of Prenatal Care Healthcare in High-Income Countries: A Systematic Review. *European Journal of Public Health*; 2011, 22(6), 904-913.

<sup>5</sup> Kotelchuck M. An Evaluation of the Kessner Adequacy of Prenatal Care Index and a Proposed Adequacy of Prenatal Care Utilization Index. *American Journal of Public Health*; 1994, 84(9), 1414-1420.

<sup>6</sup> Partridge S., Balayla J, Holcroft C, Abenheim H. Inadequate Prenatal Care Utilization and Risks of Infant Mortality and Poor Birth Outcome: A Retrospective Analysis of 28,729,765 U.S. Deliveries over 8 Years. *American Journal of Perinatology*. 2012; 29, 787-794.

<sup>7</sup> Montana Department of Public Health and Human Services. 2012 Montana Vital Statistics. <http://www.dphhs.mt.gov/statisticalinformation/vitalstats/2012MTVitalStatisticsReport.pdf>

## Methods

Data were obtained from the Montana Office of Vital Statistics; 2008 - 2012 birth, fetal death, and linked birth-infant death certificates for singleton live births to mothers residing in Montana (n=61,291) were used. Linked birth-infant death records were matched using a unique identifier for infants who were born and died in Montana and matched using several demographic variables for those infants born within the state but died elsewhere. We further excluded all non-singleton deliveries (n=1919) with gestations before 22 or after 44 weeks (n=229), those with any congenital anomaly noted on either the birth or fetal death certificates (n=1,034), and records with apparent miscoding of birth weight or gestational age (n=455). Records with the following missing or unknown maternal risk factors were also excluded: pre-pregnancy diabetes, gestational diabetes, pre-pregnancy diabetes, gestational hypertension and eclampsia, prior preterm birth, other poor birth outcome, infertility treatment, and history of a previous cesarean delivery (n=503). Lastly, we excluded records in which prenatal care utilization could not be calculated due to missing observations (n=2,582). A given pregnancy may have been excluded for more than one reason. This resulted in a five-year cohort of 54,569 deliveries.

The APNCU or **Table 1: Adequacy of Prenatal Care Utilization Index**<sup>5</sup>

Kotelchuck index was calculated using the obstetric estimation of gestation, number of prenatal care	Prenatal Care				
	No care / Inadequate	Inadequate	Intermediate	Adequate	Adequate-plus
Adequacy of received services	0%	< 0 - 50%	50 - 79%	80 - 109%	≥ 110%
Adequacy of initiation of prenatal care (month began)	No care	Care started ≥ 7 months	Care started by 5th or 6th month	Care started by 3rd or 4th month	Care started ≤ 3rd month
Summary of Adequacy of Prenatal Care Utilization Index	No care	After the 4th month or < 50%	By the 4th month and 50 to 79%	By the 4th month and 80 to 109%	By the 4th month and >109%

visits, and month of initial visit. A previous study conducted by this office determined no significant difference between the obstetric estimation and gestation calculated using the last menstrual period.<sup>8</sup> The APNCU is presented as ratio of completed prenatal care visits relative to the expected visits by gestational age according to the American Congress of Gynecologists and Obstetricians recommended guidelines for the frequency of prenatal care visits (Table 1).<sup>9</sup> A complete description of the APNC index and its assumptions are published elsewhere.<sup>5</sup>

Adverse birth outcomes were defined as preterm (delivery <37 weeks gestation), intrauterine growth restriction (IUGR), small for gestational age (SGA), and large for gestational age (LGA) as birth weight in the 3<sup>rd</sup>, 10<sup>th</sup>, and 90<sup>th</sup> percentiles, respectively, fetal death, neonatal death (< 28 days following delivery), and infant death. Maternal risk factors were obtained from the birth and fetal death certificates and included: pre-pregnancy diabetes, gestational diabetes, pre-pregnancy hypertension, gestational hypertension and eclampsia, prior preterm birth, other previous poor outcome, infertility treatment (infertility drugs and/or assisted reproductive technology), and previous cesarean section. Cut-offs for IUGR, SGA, LGA, and misclassification of birth weight and gestational age were derived using the population reference developed by Talge et al.<sup>10</sup>

The analysis consisted of performing descriptive statistics of the maternal characteristics, maternal risk factors, and birth outcomes by the APNCU categories: No care, Inadequate Care, Intermediate Care, Adequate Care, and

<sup>8</sup> Carpenedo D, Ballew C. Every Week Counts: Preterm Births among American Indian/Alaskan Native Montana Residents, 2008-2011. Montana Department of Public Health and Human Services; 2012.

<sup>9</sup> Guidelines for Perinatal Care. 7<sup>th</sup> ed. Elk Grove Village, IL and Washington, DC. American Academy of Pediatrics and the American College of Obstetricians and Gynecologists; 2012.

<sup>10</sup> Talge et al. United States Birth Weight Reference Corrected For Implausible Gestational Age Estimates. Pediatrics; 2014, 133(5), 844-853.

Adequate-Plus Care. Logistic regression was used to test for associations between the APNCU categories and birth outcomes--modeling each independent variable separately while controlling for both maternal characteristics and maternal risk factors.

## Results

### *Maternal Characteristics by APNCU category.*

The following maternal characteristics were associated with a higher proportion of no care, inadequate care, and intermediate care and decrease in adequate prenatal care: maternal age less than 20 years old, American Indian/Alaska Native (AI/AN) race, education less than or equal to a high school diploma, unmarried, prior live birth, smoking during pregnancy, and alcohol use in pregnancy. The frequency of adequate-plus care was similarly distributed among most groups but considerably lower for AI/AN race and maternal alcohol use during pregnancy (Table 2).

### *Maternal Risk Factors by APNCU category.*

The percentage of adequate-plus care responses was higher in all categories reporting a maternal risk factor whereas mothers without a reported risk factor received a higher proportion of nearly all other levels of care (Table 3).

### *Birth Outcomes by APNCU category.*

Mothers experiencing any type of poor birth outcome had a higher proportion of adequate-plus prenatal care than did mothers who did not experience poor birth outcomes. The association was stronger for preterm births, fetal, neonatal, and infant deaths. Outcomes that resulted in a fetal, neonatal and infant death had a 5 to 9 times higher proportion of no care than did mothers without a poor birth outcome (Table 4).

**Table 2. Maternal Characteristics by APNCU Category. Montana, 2008-2012.**

		No Care		Inadequate		Intermediate		Adequate		Adequate Plus	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<b>Age</b>											
	<19	50	1.0	154	3.0	650	12.8	1,995	39.4	2,219	43.8
	20-29	245	0.8	675	2.2	3,435	11.0	13,099	42.0	13,732	44.0
	30 +	108	0.6	306	1.7	1,821	9.9	8,203	44.8	7,876	43.0
<b>Race</b>											
	White	224	0.5	663	1.4	4,512	9.6	20,467	43.7	21,025	44.8
	AI/AN	176	2.6	442	6.6	1,289	19.2	2,437	36.4	2,354	35.1
	Other	3	0.3	30	3.1	105	10.7	394	40.2	448	45.7
<b>Maternal Education</b>											
	≤ High school	272	1.1	732	3.2	2,941	12.7	8,972	38.7	10,246	44.2
	> High school	122	0.4	386	1.2	2,900	9.4	14,167	45.7	13,444	43.3
<b>Marital Status</b>											
	Married	123	0.4	473	1.4	3,308	9.6	15,497	45.2	14,924	43.5
	Not Married	269	1.3	653	3.3	2,561	12.8	7,719	38.6	8,821	44.1
<b>Prior Live Birth</b>											
	Yes	301	0.9	801	2.5	3,743	11.5	13,807	42.3	14,007	42.9
	No	91	0.4	331	1.5	2,160	9.9	9,477	43.4	9,804	44.8
<b>Smoking During Pregnancy</b>											
	Yes	121	1.4	316	3.5	1,135	12.7	3,417	38.2	3,967	44.3
	No	235	0.5	774	1.7	4,704	10.4	19,755	43.7	19,756	43.7
<b>Alcohol During Pregnancy</b>											
	Yes	37	5.2	31	4.3	119	16.6	269	37.4	263	36.6
	No	298	0.6	1,043	2.0	5,626	10.6	22,701	42.9	23,301	44.0

**Table 3. Maternal Risk Factors by APNCU Category. Montana, 2008-2012.**

		No Care		Inadequate		Intermediate		Adequate		Adequate Plus	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Pre-pregnancy Diabetes											
	Yes	3	0.9	2	0.6	26	8.0	58	17.8	237	72.7
	No	400	0.7	1,133	2.1	5,880	10.8	23,240	42.8	23,590	43.5
Gestational Diabetes											
	Yes	3	0.7	17	1.1	116	7.3	541	34.1	909	57.3
	No	400	0.8	1,118	2.1	5,790	10.9	22,757	43.0	22,918	43.3
Pre-pregnancy Hypertension											
	Yes	4	1.2	2	0.6	17	4.9	99	28.6	224	64.7
	No	399	0.7	1,133	2.1	5,889	10.9	23,199	42.8	23,603	43.5
Gestational Hypertension and Eclampsia											
	Yes	17	0.7	29	1.2	155	6.6	689	29.2	1,471	62.3
	No	386	0.7	1,106	2.1	5,751	11.0	22,609	43.3	22,356	42.8
Prior Preterm Birth											
	Yes	17	1.6	31	2.9	92	8.6	320	29.9	609	57.0
	No	386	0.7	1,104	2.1	5,814	10.9	22,978	43.0	23,218	43.4
Other Poor Outcome											
	Yes	6	0.9	22	3.4	62	9.5	217	33.2	347	53.1
	No	397	0.7	1,113	2.1	5,844	10.8	23,081	42.8	23,480	43.6
Infertility Treatment											
	Yes	0	0.0	2	0.6	18	5.4	131	39.3	182	54.7
	No	403	0.7	1,133	2.1	5,888	10.9	23,167	42.7	23,645	43.6
Previous Cesarean											
	Yes	49	0.8	139	2.3	658	10.7	2,496	40.5	2,823	45.8
	No	354	0.7	996	2.1	5,248	10.8	20,802	43.0	21,004	43.4

**Table 4. Birth Outcomes by APNCU Category. Montana, 2008-2012.**

		No Care		Inadequate		Intermediate		Adequate		Adequate Plus	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Preterm Birth											
	Yes	99	2.5	67	1.7	253	6.4	612	15.5	2,925	73.9
	No	304	0.6	1,068	2.1	5,653	11.2	22,686	44.8	20,902	41.3
IUGR											
	Yes	16	1.2	39	2.9	127	9.5	545	40.6	616	45.9
	No	387	0.7	1,096	2.1	5,779	10.9	22,753	42.8	23,211	43.6
SGA											
	Yes	53	1.1	123	2.5	498	10.2	2,018	41.3	2,198	45.0
	No	350	0.7	1,012	2.0	5,408	10.9	21,280	42.8	21,629	43.5
LGA											
	Yes	44	0.9	102	2.0	534	10.6	2,104	41.9	2,237	44.6
	No	359	0.7	1,033	2.1	5,372	10.8	21,194	42.8	21,590	43.6
Fetal Death											
	Yes	5	3.2	5	3.2	7	4.5	36	23.2	102	65.8
	No	398	0.7	1,130	2.1	5,899	10.8	23,262	42.8	23,725	43.6
Neonatal Death											
	Yes	5	6.1	2	2.4	3	3.7	22	26.8	50	60.9
	No	398	0.7	1,133	2.1	5,903	10.8	23,276	42.7	23,777	43.6
Infant Death											
	Yes	11	6.1	3	1.7	6	3.3	56	31.1	101	57.8
	No	392	0.7	1,132	2.1	5,900	10.9	23,242	42.7	23,723	43.6

**Table 5. Odds Ratio of Maternal Risk Factors by APNCU Category. Montana, 2008-2012.**

	APNCU Category				
	No Care	Inadequate	Intermediate	Adequate	Adequate Plus
	OR (95% CI)	OR (95% CI)	OR (95% CI)	Reference	OR (95% CI)
Pre-pregnancy Diabetes	2.20 (0.66 - 7.31)	0.58 (0.14 - 2.37)	<b>1.67 (1.05 - 2.65)</b>	1	<b>4.07 (3.05 - 5.42)</b>
Gestational Diabetes	<b>0.26 (0.08 - 0.81)</b>	<b>0.60 (0.37 - 0.98)</b>	0.84 (0.69 - 1.04)	1	<b>1.71 (1.53 - 1.91)</b>
Pre-pregnancy Hypertension	1.69 (0.59 - 4.82)	0.37 (0.09 - 1.50)	0.67 (0.40 - 1.12)	1	<b>2.27 (1.79 - 2.88)</b>
Gestational Hypertension and Eclampsia	1.63 (0.99 - 2.69)	0.95 (0.65 - 1.39)	0.92 (0.77 - 1.10)	1	<b>2.18 (1.99 - 2.39)</b>
Prior Preterm Birth	1.31 (0.69 - 2.48)	<b>1.64 (1.11 - 2.43)</b>	1.09 (0.86 - 1.38)	1	<b>1.93 (1.68 - 2.21)</b>
Other Poor Outcome	0.81 (0.33- 1.99)	<b>1.82 (1.16 - 2.87)</b>	1.10 (0.83 - 1.46)	1	<b>1.60 (1.35 - 1.90)</b>
Infertility Treatment	§	0.59 (0.14 - 2.39)	0.69 (0.42 - 1.13)	1	<b>1.48 (1.18 - 1.86)</b>
Previous Cesarean	<b>0.65 (0.46 - 0.92)</b>	0.91 (0.76 - 1.11)	0.97 (0.88 - 1.07)	1	<b>1.15 (1.08 - 1.22)</b>

Each outcome modeled separately. Adjusted for maternal characteristics . Bold type indicates statistically significant p <0.05

**Table 6. Odds Ratio of Birth Outcomes by APNCU Category. Montana, 2008-2012.**

	APNCU Category				
	No Care	Inadequate	Intermediate	Adequate	Adequate Plus
	OR (95% CI)	OR (95% CI)	OR (95% CI)	Reference	OR (95% CI)
Preterm Birth	<b>10.10 (7.83 - 13.03)</b>	<b>2.04 (1.56 - 2.65)</b>	<b>1.60 (1.38 - 1.86)</b>	1	<b>4.83 (4.41 - 5.28)</b>
IUGR	1.56 (0.92 - 2.63)	<b>1.42 (1.01 - 1.99)</b>	0.92 (0.75 - 1.11)	1	1.05 (0.94 - 1.18)
SGA	<b>1.43 (1.06 - 1.94)</b>	1.21 (0.99 - 1.47)	0.96 (0.87 - 1.06)	1	1.04 (0.97 - 1.10)
LGA	1.19 (0.86 - 1.65)	0.97 (0.79 - 1.20)	0.98 (0.89 - 1.09)	1	1.02 (0.96 - 1.09)
Fetal Death	<b>7.66 (2.89 - 20.32)</b>	<b>2.66 (1.03 - 6.88)</b>	0.75 (0.33 - 1.68)	1	<b>2.60 (1.77 - 3.81)</b>
Neonatal Death <sup>§</sup>	<b>8.49 (2.88 - 25.04)</b>	1.34 (0.31- 5.84)	0.49 (0.15 - 1.64)	1	<b>2.06 (1.24 - 3.41)</b>
Infant Death	<b>8.83 (4.34 - 17.98)</b>	0.89 (0.28 - 2.89)	<b>0.40 (0.17 - 0.92)</b>	1	<b>1.73 (1.25 - 2.40)</b>

Each outcome modeled separately. Adjusted for maternal characteristics and maternal risk factors reported during last pregnancy. Bold type indicates statistically significant p <0.05.

§ Model failed to converge on this outcome measure. Interpret with caution.

### *Logistic Regression for Maternal Risk Factor by APNCU category.*

Women with any maternal risk factor were significantly more likely than not to receive adequate-plus care. Women with a pre-pregnancy history of diabetes were significantly more likely to have intermediate care. Women with gestational diabetes were more likely to have no care or inadequate care while women who had had a prior preterm birth or other prior poor outcome were more likely to have inadequate care. Women with a history of a previous cesarean were less likely to have no care (Table 5).

### *Logistic Regression for Birth Outcome by APNCU category.*

Women giving birth prematurely were significantly more likely than women who did not to have a poor birth outcome and receive no care, inadequate or intermediate care, but also to have adequate-plus care. With respect to infant growth, IUGR and SGA were significantly associated with inadequate care and no care, respectively, while women with a LGA outcome were equal across all categories. Women who had a fetal death were more likely than women who gave live-birth to have a poor outcome and receive no care, inadequate care, and adequate-plus care while women with an infant death were more likely to have no care and adequate-plus care but less likely to have a poor birth outcome and receive intermediate care. The model for neonatal deaths failed to converge and the odd estimates should be interpreted cautiously (Table 6).

## **Discussion and Recommendations**

Women who had inadequate or no prenatal care were more likely to experience a variety of poor birth outcomes in comparison to those who had adequate care. This was particularly notable for preterm birth, fetal death, neonatal death, and infant death. Women who had intermediate prenatal care were more likely to experience preterm births than women who had adequate care. Women who had adequate-plus care were also more likely to experience a variety of poor outcomes relative to women who had adequate care, especially preterm births, LGA infants, fetal death, neonatal death, and infant death. This counter-intuitive finding is likely due to clinicians' recognition of maternal risk and special effort to intensify prenatal care to mitigate the risk. Our findings regarding the association between maternal risk factors and prenatal care utilization seems to support this observation and is consistent with the literature with respect to intensive utilization and more generally an improvement in birth outcome from no care and inadequate care through adequate care (Figure 2).<sup>5,11,12</sup>

This study reports on the frequency of prenatal care as reported in the birth or fetal death certificate and cannot address the quality of care or other health-seeking behavior of the mother. Birth and fetal death certificates do not contain a complete medical history and some discordance between the certificate and its corresponding clinical record has been previously reported.<sup>13</sup> Much study remains to address prenatal care in respect to its utilization, health-related behaviors, outcomes, and cost-effectiveness.<sup>14</sup> While the frequency of poor birth outcomes in women with inadequate prenatal care is small, the benefits of even a modest improvement in utilization would potentially be substantial by reducing health care costs, improving the quality of life for both the mother and infant, and reducing the number of fetal losses and infant deaths.

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<sup>11</sup> Kotelchuck M. The Adequacy of Prenatal Care Utilization Index: Its US Distribution and Association with Low Birthweight. *American Journal of Public Health*; 1994, 84(9), 1486-1489.

<sup>12</sup> Alexander G, Cornely D. Prenatal Care Utilization: Its Measurement and Relationship to Pregnancy Outcome. *American Journal of Preventive Medicine*; 1987, 3, 243-253.

<sup>13</sup> Clark K, Fu C-M, Burnett C. Accuracy of Birth Certificate Data Regarding the Amount, Timing, and Adequacy of Prenatal Care Using Prenatal Clinic Medical Records as Referents. *American Journal of Epidemiology*; 1997, 145, 68-71.

<sup>14</sup> Alexander G, Kotelchuck M. Assessing the Role and Effectiveness of Prenatal Care: History, Challenges, and Directions for Future Research. *Public Health Reports*; 2001, 116, 306-316.

“Although many different factors contribute to the problem of inadequate access to prenatal care, an underlying cause is the nation’s patchwork, non-systematic approach to making prenatal services available.”

*Institute of Medicine, 1985*

In the 29 years following the Institute of Medicine’s landmark report, only modest improvements to the delivery of prenatal care have been achieved. Births of low birth weight infants have generally increased, between one-third to one-half of pregnancies are unintended, and issues involving access to health care remain mixed.<sup>15,16,17,18</sup> By beginning to view prenatal care as an intervention that begins before pregnancy and ends with at least one post-partum visit can we begin to address the complex role of prenatal care plays in preventing poor birth outcomes.

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<sup>15</sup> Martin J, Hamilton B, Ventura S, et al. Births: Final data for 2010. National vital statistics reports; 2012,61(1).

<sup>16</sup> Centers for Disease Control and Prevention. Core State Preconception Health Indicators—Pregnancy Risk Assessment Monitoring System and Behavioral Risk Factor Surveillance System, 2009. Morbidity and Mortality Weekly Report; 2014, 63(SS-3), 1-62.

<sup>17</sup> Braveman et. al. Access to Prenatal Care Following Major Medicaid Eligibility Expansions. Journal of the American Medical Association; 269(10), 1285-1289.

<sup>18</sup> Roman et al. A Statewide Medicaid Enhanced Prenatal Care Program: Impact on Birth Outcomes. JAMA Pediatrics; 2014, 168(3), 220-227.