Introduction

Early medical abortion using mifepristone with misoprostol is effective and highly acceptable to US women, with some preferring it over vacuum aspiration (1,2,3). Medical abortion is not a surgical procedure and can be offered by non-specialist clinicians (4), a fact that led some to believe that its availability would improve access to abortion services in the US. However, a recent analysis found that almost all medical abortion-only providers were located within 50 miles of a large-volume surgical abortion provider (5).

Telemedicine, the delivery of health care services at a distance using information and communication technology, has been used in many fields of medicine to improve access to services. In June 2008, Planned Parenthood of the Heartland in Iowa launched a program to provide medical abortion using telemedicine at clinic sites not staffed by a physician in order to improve access to early abortion and reduce physician travel to outlying clinics. This clinic network provided 74% of all abortions in Iowa in 2008 (6). Prior to introducing telemedicine, the network had seventeen clinic sites. Two clinics had an on-site physician and offered both medical and surgical abortion, two sites offered surgical and medical abortion when the physician traveled there, and two additional sites offered medical abortion when the physician traveled there. The remaining eleven clinics did not provide abortions. A recently published cohort study found that the telemedicine model provided by this clinic system was equally effective compared to a model involving an in-person visit with a physician; telemedicine was also found to be highly acceptable to women, with a low rate of adverse events (7). The objective of this study was to examine how the clinic's service delivery patterns changed after introducing telemedicine.

Methods

We used de-identified billing data from 17, 956 abortion encounters at Planned Parenthood of the Heartland clinics in Iowa between June 20, 2006 and June 30, 2010. By the end of this period, abortion care was being provided at fifteen clinic sites. The data set included date of service, clinic site where abortion was performed, client age, race and ethnicity, education level, home zip code and whether the client received financial assistance at the clinic to pay for her abortion. We analyzed these data to determine the effect of telemedine introduction (which occurred on June 25, 2008) on the following outcomes: the proportion of all abortions that were medical abortion (versus surgical abortion), the proportion of all abortions performed at ≤13 weeks (versus abortion >13 weeks), distance traveled to clinic (approximated using straight line calculations between client and clinic zip codes), and distance of client to the nearest clinic that offered surgical abortion to assess whether women came from more remote areas of the state following the introduction of telemedicine. Women whose reported home zip code was greater than 500 miles from the clinic were excluded from the distance analyses because the location data for these women was assumed to be permanent residence information, such as a parents' home address, rather than the woman's local address. After excluding these cases, the final data set for the geographical data analysis included 17,801 abortion encounters.

Chi-square analyses were conducted to compare pre- and post-telemedicine client characteristics. To evaluate the impact of telemedicine on our outcomes of interest, t-tests and linear regression were used for continuous distance variables and logistic regression was used for categorical variables (medication abortion provision, early abortion, and categorical distance variables). Additional pre- and post-telemedicine distance analyses were conducted among medication abortion clients only. The predictor variable in each model was telemedicine introduction (1=client attended a clinic post-telemedicine, 0=client attended a clinic pre-

telemedicine). Socio-demographic covariates to control for confounding were selected based on availability from the clinic billing dataset. All tests were performed using STATA 10.1 (StataCorps, College Station, TX).

We matched clients' residential zip codes to polygons in US Census shape files for Iowa and surrounding states. For each zip code, we calculated Z = (# of abortion clients before telemedicine - # after telemedicine). Using the centroids of zip code areas as approximate (X,Y)=(longitude, latitude) locations for clients produces a set { X,Y,Z } of locations and changes, with zip codes as the unit of observation. We then smoothed this {(X,Y,Z)} map using inverse-distance weighting (specifically, the krige() function in R's *gstat* package), in order to find spatial clusters of increased (blue) and decreased (red) case numbers after the introduction of telemedicine. We performed similar analyses for medical abortion and surgical abortion cases separately.

Results

There were 8,902 abortion encounters before and 9,054 abortion encounters after telemedicine was introduced, an increase of 1.7%. Demographic characteristics of the sample are shown in Table 1. There was no difference in the age of clients before and after telemedicine; however, there were slight differences by race ($p<0.001$) and education level ($p<0.001$).

The proportion of all abortions that were medical abortion increased from 46% to 54% after telemedicine introduction (Table 1). Among all clients (n=17,956), women who came for services after the introduction of telemedicine had 1.52 greater odds of having a medical abortion ($p<0.001$); they also had 1.48 greater odds of having an early abortion at ≤13 weeks' gestation ($p<0.001$) compared to women who came before telemedicine, controlling for financial assistance, age, race/ethnicity, and education level. See Tables 2 and 3. Women who came for services after the introduction of telemedicine had a 3 mile decrease in average distance traveled to the clinic

($p<0.001$). They also had 0.88 lesser odds of traveling >50 miles to the clinic ($p=0.001$). Compared to women who were served before telemedicine introduction, after telemedicine was introduced, clients had 1.11 greater odds of residing >50 miles from a clinic that provided surgical abortion ($p=0.005$), controlling for socio-demographic factors. See Tables 4-6. Similar results were obtained when we analyzed women residing >25 miles from a surgical abortion clinic (data not shown).

Among medical abortion clients (n=8,860), women who came for services after the introduction of telemedicine had a 3 mile decrease in distance traveled to the clinic ($p=0.001$), and they had 0.87 lesser odds of traveling >50 miles to the clinic ($p=0.02$). After telemedicine was introduced, medical abortion clients had 1.16 greater odds of residing >50 miles from a clinic providing surgical abortion ($p=0.005$) compared to clients who came prior to telemedicine, controlling for socio-demographic factors. See Tables 7-9.

Figure 1 shows the smoothed mapping results for the changes in the number of abortion cases after telemedicine introduction according to client home zip code, while Figure 2 shows the same mapping results for surgical abortion cases and Figure 3 shows the mapping results for medical abortion cases. Clinics providing surgical abortion are noted as clinics A, B, C and D, and clinics that intermittently offered medical abortion before telemedicine was introduced when a doctor traveled to the clinic are shown as yellow squares (these latter sites also became telemedicine sites). Clinics that began offering medical abortion after telemedicine was introduced are shown as yellow triangles. The blue areas of the map show areas where increased numbers of women resided who received abortion services after telemedicine introduction; the darker the blue, the greater the increase in the number of cases. The red areas of the map show areas where there were reductions in the number of resident women who received abortion care after telemedicine introduction. Solid rings around clinics A, B, C and D indicate a distance of 25 miles from the clinic, and the dashed rings indicate a distance of 50 miles from the clinic.

As can be seen in Figure 1, there appeared to be a reduction in the number of abortion cases among women residing around Des Moines, while there appeared to be an increase in the number of women obtaining abortion in the eastern portion of the state. Figure 2, which maps the changes in surgical abortion, demonstrates that the numbers of surgical abortion cases decreased for women residing throughout the state, but especially for those living in the central and western portion of the state. Figure 3, which maps the changes in medical abortion, shows how the numbers of medical abortion cases increased for women residing throughout the state, but especially those in the western and eastern portions of the state. Most of the increase in the number of medical abortions after telemedicine introduction occurred among women living more than 50 miles from one of the surgical abortion clinics, especially in more remote parts of Iowa, as well as western Nebraska and northwest Illinois. In most cases, the increases occurred in areas surrounding telemedicine sites. There were scattered areas of decreased numbers of resident women obtaining medical abortion (shown in red), but no clear pattern emerged.

Conclusion

After the introduction of telemedicine, clients were significantly more likely to obtain medical abortion, and there was a move toward providing abortion earlier in pregnancy. Clients traveled somewhat shorter distances on average to obtain abortion, although these changes were small. Most importantly, it appears that introducing telemedicine in remote clinic sites improved access to abortion—and especially medical abortion—for women living more than 50 miles from a surgical abortion clinic. Taken together, these results suggest that telemedicine provision of medical abortion improves access to early abortion for rural women.

Table 1. Background characteristics of clients, by introduction of telemedicine

	Telemedicine Introduction			
Characteristic	**Before**	**After**	**n**	***p*-value**
Total	8,902 (50%)	9,054 (50%)	17,956	
Age (y)				n.s.
9-20	2,225 (25%)	2,331 (26%)	4,556	
21-24	2,505 (28%)	2,475 (27%)	4,980	
25-29	2,085 (23%)	2,104 (23%)	4,189	
30-49	2,087 (23%)	2,144 (24%)	4,231	
Race				p<0.001
Non-Hispanic White	6,505 (73%)	6,583 (73%)	13,088	
Non-Hispanic Black	826 (9%)	922 (10%)	1,748	
Latina	729 (8%)	725 (8%)	1,454	
Asian/Pacific Islander	347 (4%)	323 (4%)	670	
More than one race	144 (2%)	178 (2%)	322	
Other Race*	63 (1%)	98 (1%)	161	
Unknown Race	288 (3%)	225 (2%)	513	
Highest education completed				p<0.001
<9	177 (2%)	166 (2%)	343	
9-12	4,541 (51%)	4,711 (52%)	9,252	
13+	3,298 (37%)	2,827 (31%)	6,125	
Unknown Ed. Level	886 (10%)	1,350 (15%)	2,236	
Financial assistance received	903 (10%)	4,506 (50%)	5,409	p<0.001
Service type				p<0.001
Medical abortion	4,095 (46%)	4,850 (54%)	8,945	
Surgical abortion ≤ 13 weeks	4,464 (50%)	3,886 (43%)	8,350	
Surgical abortion >13 weeks	343 (4%)	318 (4%)	661	

*Other Race includes: American Indian or AK Native, Other

Table 2. Odds of Medication Abortion after Telemedicine Was Introduced

	AOR	[95% CI]		*p*-value
Telemedicine	***1.52***	***1.42***	***1.62***	***<0.001***
Financial assistance received	0.82	0.76	0.88	<0.001
Age				
21-24 (*vs. 9-20*)	1.03	0.95	1.12	0.43
25-29	1.06	0.97	1.16	0.18
30-49	0.93	0.85	1.02	0.12
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	0.59	0.53	0.65	<0.001
Latina	0.72	0.64	0.81	<0.001
Asian/Pacific Islander	0.74	0.63	0.87	<0.001
>1 Race	0.82	0.66	1.03	0.09
Other Race	0.44	0.31	0.61	<0.001
Unknown Race	0.95	0.79	1.15	0.61
Highest level of education				
9-12 Grade (*vs. 13+)*	0.76	0.71	0.81	<0.001
<9 Grade	0.45	0.35	0.57	<0.001
Unknown Ed. Level	0.69	0.62	0.76	<0.001

Table 3. Odds of Early Abortion ≤13 Weeks after Telemedicine Was Introduced

	AOR	[95% CI]		*p*-value
Telemedicine	***1.48***	***1.24***	***1.77***	***<0.001***
Financial assistance received	0.57	0.48	0.69	<0.001
Age				
21-24 (*vs. 9-20*)	1.10	0.89	1.35	0.38
25-29	1.11	0.89	1.39	0.34
30-49	1.43	1.12	1.82	0.004
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	0.80	0.63	1.02	0.07
Latina	0.92	0.69	1.22	0.56
Asian/Pacific Islander	1.13	0.71	1.81	0.61
>1 Race	0.57	0.36	0.91	0.02
Other Race	0.28	0.17	0.45	<0.001
Unknown Race	0.96	0.60	1.53	0.87
Highest level of education				
9-12 Grade (*vs. 13+)*	0.69	0.56	0.84	<0.001
<9 Grade	0.76	0.42	1.38	0.37
Unknown Ed. Level	0.55	0.42	0.72	<0.001

Table 4. Distance Traveled (continuous) after Telemedicine Was Introduced*

	β	[95% CI]		*p*-value
Telemedicine	***-3.23***	***-4.59***	***-1.88***	***<0.001***
Financial assistance received	1.20	-0.30	2.70	0.12
Age				
21-24 (*vs. 9-20*)	-0.09	-1.79	1.61	0.92
25-29	-2.53	-4.31	-0.74	0.006
30-49	-4.54	-6.35	-2.74	0.01
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	-13.97	16.06	11.88	<0.001
Latina	-8.60	10.91	-6.30	<0.001
Asian/Pacific Islander	-10.48	13.71	-7.24	<0.001
>1 Race	-9.62	14.19	-5.05	<0.001
Other Race	15.01	8.52	21.49	<0.001
Unknown Race	-2.52	-6.31	1.27	0.19
Highest level of education				
9-12 Grade (*vs. 13+)*	-4.42	-5.83	-3.02	<0.001
<9 Grade	-6.10	10.72	-1.48	0.01
Unknown Ed. Level	5.46	3.36	7.55	<0.001

*Includes clients who travelled less than 500 miles only (n=17,801)

Table 5. Odds of Distance Traveled >50 miles after Telemedicine Was Introduced*

Distance Traveled	AOR	[95% CI]		*p*-value
Telemedicine	***0.88***	***0.81***	***0.95***	***0.001***
Financial assistance received	1.07	0.98	1.16	0.14
Age				
21-24 (*vs. 9-20*)	1.04	0.95	1.15	0.39
25-29	0.93	0.84	1.04	0.19
30-49	0.86	0.77	0.95	0.00
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	0.45	0.39	0.52	<0.001
Latina	0.66	0.58	0.76	<0.001
API	0.50	0.40	0.62	<0.001
>1 Race	0.55	0.41	0.74	<0.001
Other Race	1.13	0.80	1.60	0.49
Unknown Race	0.85	0.69	1.05	0.12
Highest level of education				
9-12 Grade (*vs. 13+)*	0.83	0.76	0.90	<0.001
<9 Grade	0.79	0.59	1.06	0.12
Unknown Ed. Level	1.28	1.15	1.44	<0.001

*Includes clients who travelled less than 500 miles only (n=17,801)

Table 6. Odds of Distance to Nearest Clinic Providing Surgical Abortion >50 mi after Telemedicine Was Introduced*

Distance to Nearest Clinic	AOR	[95% CI]		*p*-value
Telemedicine	***1.11***	***1.03***	***1.20***	***0.005***
Financial assistance received	1.10	1.01	1.20	0.03
Age				
21-24 (*vs. 9-20*)	1.02	0.93	1.12	0.73
25-29	0.91	0.82	1.01	0.07
30-49	0.91	0.82	1.00	0.06
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	0.65	0.58	0.74	<0.001
Latina	0.56	0.48	0.64	<0.001
API	0.47	0.38	0.58	<0.001
>1 Race	0.51	0.38	0.69	<0.001
Other Race	1.04	0.73	1.46	0.85
Unknown Race	0.77	0.63	0.96	0.02
Highest level of education				
9-12 Grade (*vs. 13+)*	0.91	0.84	0.98	0.02
<9 Grade	1.11	0.85	1.45	0.45
Unknown Ed. Level	1.18	1.05	1.32	0.005

*Includes clients who travelled less than 500 miles only (n=17,801)

Table 7. Distance Traveled (continuous) after Telemedicine Was Introduced, among Medical Abortion Clients Only*

Distance Traveled	β	[95% CI]		*p*-value
Telemedicine	***-2.98***	***-4.68***	***-1.29***	***0.001***
Financial assistance received	-0.38	-2.27	1.52	0.70
Age				
21-24 (*vs. 9-20*)	0.57	-1.57	2.72	0.60
25-29	-2.18	-4.44	0.07	0.06
30-49	-3.08	-5.37	-0.79	0.008
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	13.49	16.44	10.53	<0.001
Latina	-6.82	-9.95	-3.70	<0.001
API	-6.79	11.07	-2.50	<0.001
>1 Race	-9.86	15.72	-4.00	0.001
Other Race	12.37	2.16	22.58	0.02
Unknown Race	3.52	-1.34	8.38	0.16
Highest level of education				
9-12 Grade (*vs. 13+)*	-3.05	-4.78	-1.32	0.001
<9 Grade	-3.40	10.58	3.78	0.35
Unknown Ed. Level	5.77	3.10	8.45	<0.001

*Includes clients who travelled less than 500 miles only (n=8,860)

Table 8. Odds of Distance Traveled >50 miles, among Medication Abortion Clients Only*

Distance Traveled	AOR	[95% CI]		*p*-value
Telemedicine	***0.87***	***0.78***	***0.98***	***0.02***
Financial assistance received	0.96	0.85	1.10	0.58
Age				
21-24 (*vs. 9-20*)	1.06	0.92	1.22	0.43
25-29	0.94	0.81	1.10	0.44
30-49	0.89	0.76	1.04	0.14
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	0.32	0.24	0.43	<0.001
Latina	0.73	0.59	0.91	0.006
API	0.63	0.46	0.86	<0.001
>1 Race	0.58	0.37	0.92	0.02
Other Race	1.35	0.73	2.49	0.34
Unknown Race	1.04	0.77	1.41	0.78
Highest level of education				
9-12 Grade (*vs. 13+)*	0.88	0.78	0.98	0.03
<9 Grade	0.79	0.46	1.35	0.38
Unknown Ed. Level	1.37	1.16	1.62	<0.001

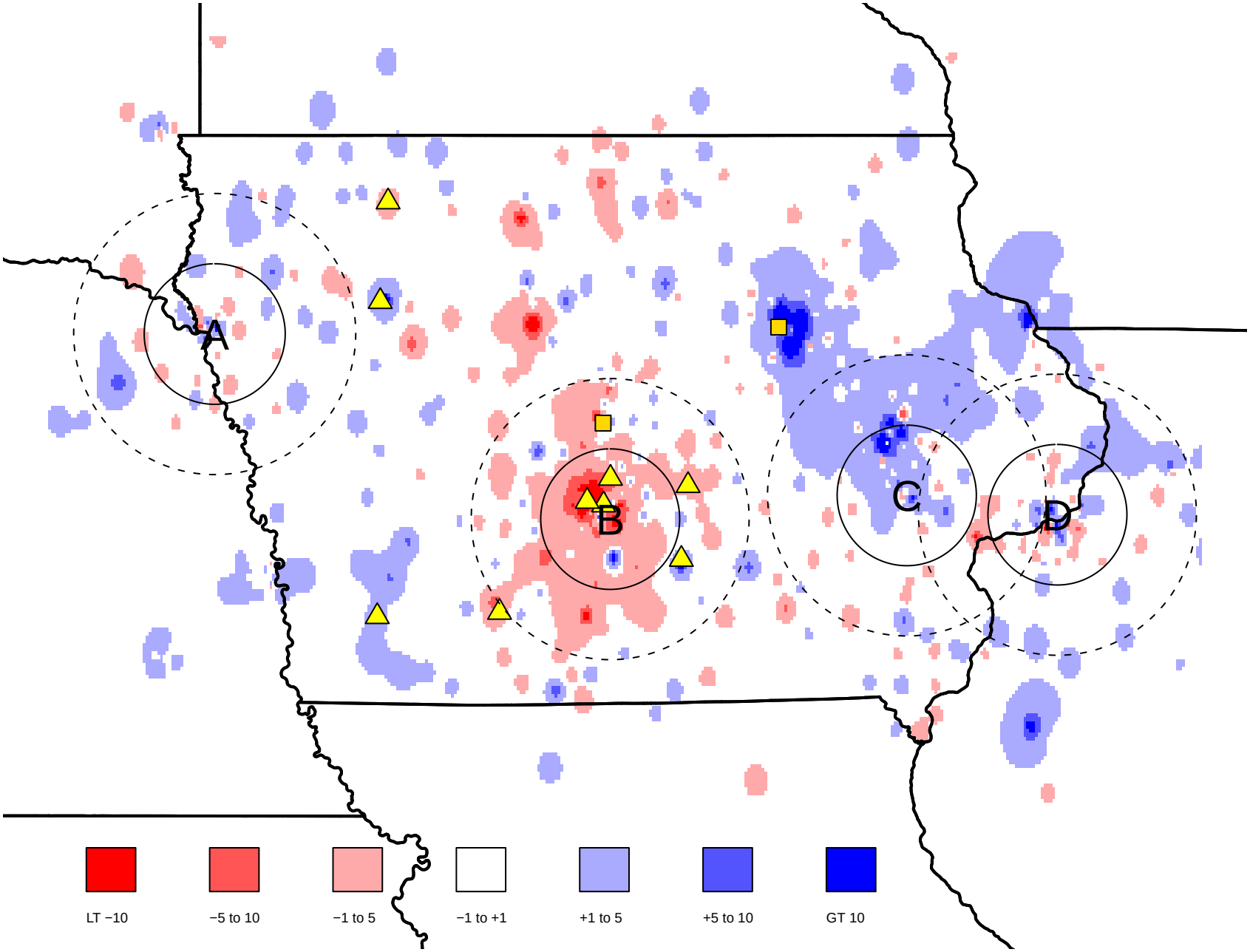
*Includes clients who travelled less than 500 miles only (n=8,860)

Table 9. Odds of Distance to Nearest Clinic Providing Surgical Abortion >50 mi after Telemedicine Was Introduced, among Medication Abortion Clients Only*

Distance to Nearest Clinic	AOR	[95% CI]		*p*-value
Telemedicine	***1.16***	***1.05***	***1.28***	***0.005***
Financial assistance received	1.14	1.01	1.27	0.03
Age				
21-24 (*vs. 9-20*)	0.97	0.86	1.11	0.69
25-29	0.89	0.77	1.02	0.09
30-49	0.94	0.82	1.08	0.35
Race/ethnicity				
Non-Hispanic Black (*vs. Non-Hispanic White*)	1.03	0.87	1.23	0.71
Latina	0.54	0.44	0.67	<0.001
API	0.57	0.43	0.77	<0.001
>1 Race	0.65	0.44	0.95	0.03
Other Race	1.16	0.64	2.09	0.62
Unknown Race	0.89	0.66	1.20	0.45
Highest level of education				
9-12 Grade (*vs. 13+)*	1.01	0.91	1.12	0.86
<9 Grade	2.16	1.44	3.25	<0.001
Unknown Ed. Level	1.04	0.89	1.23	0.61

*Includes clients who travelled less than 500 miles only (n=8,860)

Figure 1 **Changes in Total # of Abortion Cases**



LT-less than GT-greater than

Figure 2 **Changes in # of Surgical Abortion Cases by Client Zipcode**

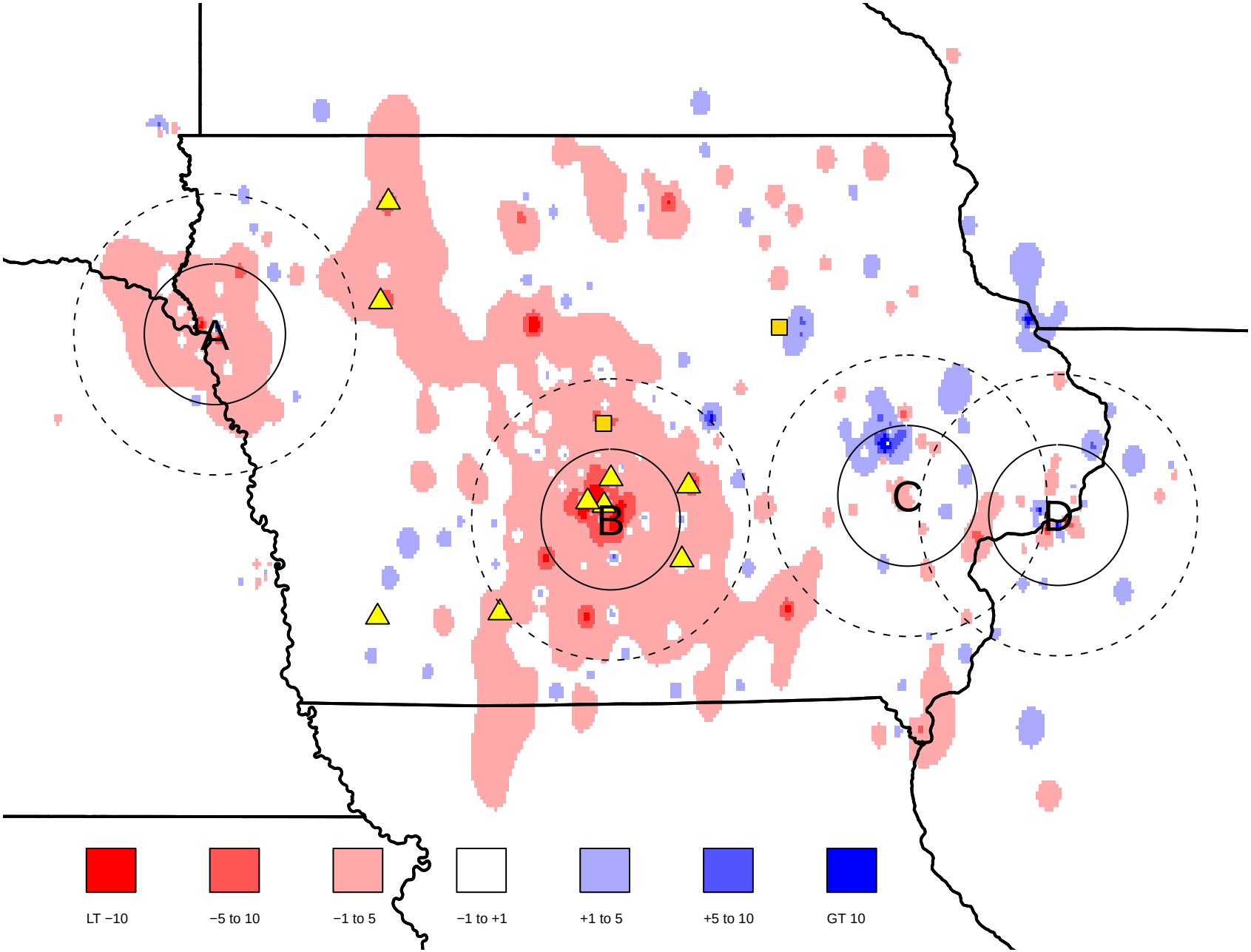
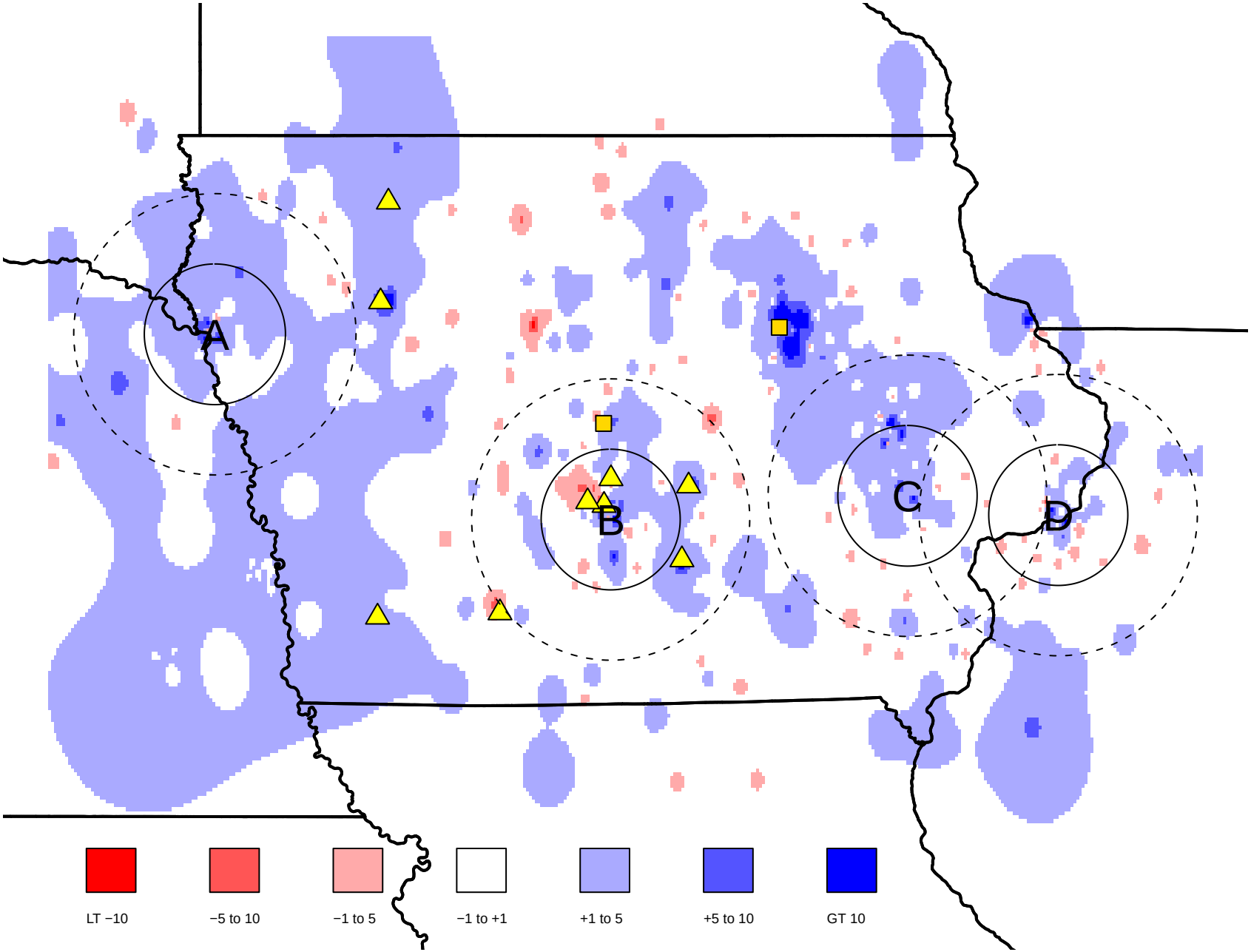


Figure 3

Changes in # of Medical Abortion Cases by Client Zipcode



References

[1] Spitz IM, Bardin CW, Benton L, Robbins A. Early pregnancy termination with mifepristone and misoprostol in the United States. N Engl J Med 1998;338(18):1241-7.

[2] Winikoff B, Ellertson C, Elul B, Sivin I. Acceptability and feasibility of early pregnancy termination by mifepristone-misoprostol. Results of a large multicenter trial in the United States. Mifepristone Clinical Trials Group. Arch Fam Med 1998;7(4):360-6.

[3] Fjerstad M, Trussell J, Sivin I, Lichtenberg ES, Cullins V. Rates of serious infection after changes in regimens for medical abortion. N Engl J Med 2009;361(2):145-51.

[4] Yarnall J, Swica Y, Winikoff B. Non-physician clinicians can safely provide first trimester medical abortion. Reprod Health Matters 2009;17(33):61-9.

[5] Finer LB, Wei J. Effect of mifepristone on abortion access in the United States. Obstet Gynecol 2009;114(3):623-30.

[6] Iowa Department of Public Health, Bureau of Vital Statistics. 2009 Vital Statistics of Iowa. Des Moines, IA: Iowa Department of Public Health; 2010.

[7] Grossman D, Grindlay K, Buchacker T, Lane K, Blanchard K. Effectiveness and Acceptability of Medical Abortion Provided Through Telemedicine. Obstetrics and Gynecology 2011;118(2 Pt 1):296-303.