Research Brief,

Short Paper

Vol. 5, No. 13

(2023, July 7)

The Illinois Institute for Rural Affairs (IIRA) works to improve the quality of life for rural residents by partnering with public and private agencies on local development and enhancement efforts.

Western Illinois University

Telemedicine and the Carbon Footprint of Healthcare: An Empirical Analysis of Metro versus Nonmetro Illinois

ISSN 2687-8844

Adee Athiyaman[1]

Abstract

The US healthcare sector is a significant contributor to greenhouse gas generation and thus climate change. This study explores the role of telemedicine in reducing environmental emissions; Illinois counties are the geographical unit of analysis. Results of data analysis indicate that Illinoisans had 14.9mil telemedicine visits in 2021 and these visits resulted in carbon savings of approximately 70mil to 91mil kilograms.

Introduction

The carbon footprint of the US healthcare sector is estimated at 546MMTCO2Eq[2]; around 8%-9% of the nation's greenhouse gas emissions (GHG). Healthwise, approximately 16% of all deaths are attributed to air pollution[3]. One way to reduce healthcare pollution is to reduce non-value-added care; for example, patient travel[4].

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[1] Professor, Illinois Institute for Rural Affairs, Western Illinois University.

[2] Total GHG emissions in the US in 2021 were 6,340 million metric tons; see, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions. The estimate of GHG for the healthcare sector, 546MMT, was deduced from an Environmental Input-Output Life-Cycle Assessment model; carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons were used in the assessment; see, Sherman, J. D., MacNeill, A. J., Biddinger, P. D., Ergun, O., Salas, R. N., & Eckelman, M. J. (2023). Sustainable and resilient health care in the face of a changing climate. *Annual Review of Public Health*, *44*, 255-277.

[3] Amounts to 9 million deaths, globally; see, Landrigan, P. J., Fuller, R., Acosta, N. J., Adeyi, O., Arnold, R., Baldé, A. B., ... & Zhong, M. (2018). The Lancet Commission on pollution and health. *The lancet*, *391*(10119), 462-512. For data on climate related mortality for Illinois, see Athiyaman, A. (2023). Climate and Mortality in Nonmetro Illinois: Retrospective Study, 1999-2021 and Projections of Mortality for 2030. *Research Brief*, 5(7), April 3. Available: http://www.iira.org/wp-content/uploads/2023/03/RB57-Climate-and-Mortality-in-Nonmetro-Illinois-Retrospective-Study-1999-2021-and-Projections-of-Mortality-for-2030.pdf.

[4] Patient travel or transportation has been a target for decarbonizing healthcare; see, Sampath B, Jensen M, Lenoci-Edwards J, Little K, Singh H, Sherman JD. (2022). *Reducing Healthcare Carbon Emissions: A Primer on Measures and Actions for Healthcare Organizations to Mitigate Climate Change*. (Prepared by nstitute for Healthcare Improvement under Contract No. 75Q80122P00007.) AHRQ Publication No. 22-M011. Rockville, MD: Agency for Healthcare Research and Quality.

This paper explores the environmental benefits of telemedicine. Specifically, using Illinois counties as the geographical units of analysis, the paper estimates travel-related carbon savings from telemedicine consultations.

Concepts and their Relations

The behavioral setting of interest is telemedicine, online consultation between a doctor and a patient. Within this setting, situations such as reasons for visit, for example, subsequent hospital care, are analyzed (Figure 1). The reason for discrete analysis stems from the fact that in some cases virtual consultations may only delay the need for face-to-face encounters, for example, preoperative visits[5]; in these situations, arguments for telemedicine induced carbon savings could be fallacious.

Figure 1 lists the situational characteristics of interest in this research within the familiar situational-organism-response paradigm[6]. In the figure, physical in the geography[7], and task includes the reason for telemedicine consultation[8].

The stimulus object would be telemedicine consultation. The concept of 'person' would include the stable and the general characteristics of the patient such as personality, sex, and race[9]. The response variable is not using car to visit a healthcare professional, reduction in GHG emissions.

[5] Stypulkowski, K., Uppaluri, S.., & Waisbren, S. (2015). Telemedicine for postoperative visits at the Minneapolis VA Medical Center. Results of a needs assessment study. *Minnesota medicine*, *98*(2), 34-36.

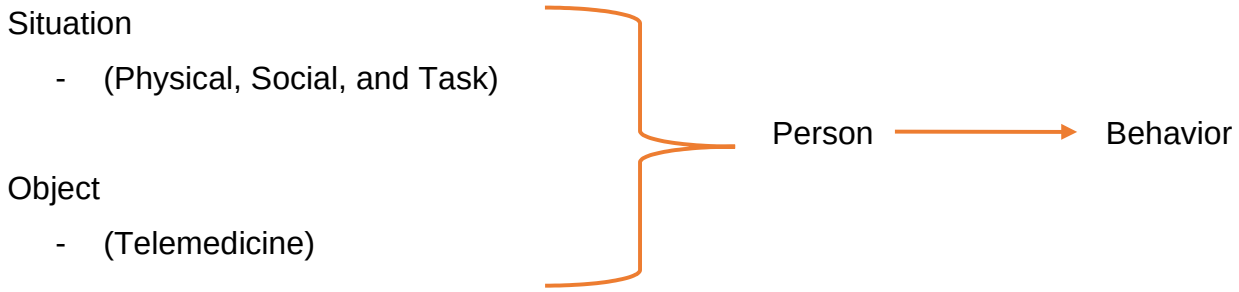
[6] For more on the S-O-R framework, see, Athiyaman, A. (2022). Telemedicine use in Illinois during the weeks leading to the spread of Covid-19, omicron variant: Insights from the Census Bureau's Household Pulse Survey. *Research Brief*, 4(1), January 12. Available: http://www.iira.org/wp-content/uploads/2022/01/RB4_1_household_pulse_survey_complete.pdf.

[7] For data on environmental correlates of telemedicine, see Athiyaman, A. (2021). Telemedicine in Illinois: Ecological Explanations. *Research Brief*, 3(4), February 21. Available: http://www.iira.org/wp-content/uploads/2021/02/telemedicine_ecological_explanation2.pdf.

[8] Adapted from, Belk, R. (1975). Situational variables in consumer behavior. *Journal of Consumer Research*, 2(December), 157-164.

[9] In my earlier research on the demographic correlates of telemedicine, only income was significant; see, Athiyaman, A. (2021). Consumer Awareness of Telemedicine During the Covid-19 Pandemic: Demographic Influences. *Research Brief*, 3(1), January 11. Available: http://www.iira.org/wp-content/uploads/2021/01/telemedicine_awareness_v3_1.pdf.

Figure 1: The S-O-R Paradigm



Methodology

Multiple data sources were utilized to gain insights into the issue, environmental benefits of telemedicine. State level, metro / nonmetro, telehealth utilization data were obtained from the data portal at CMS[10].

Table 1 lists the 'task' situations that are relevant for telemedicine consultations; the table shows all the CMS telemedicine codes that are commonly reported for Medicare patients.

Table 1: CMS Telemedicine / Telehealth Codes[11]

		Applicable to...	
Code	**Definition**	**New Patient**	**Established Patient**
99201 - 99215	Office visits	√	√
G0425 – G0427	Telehealth consultations, ER or initial inpatient.	√	√
G2010, G2250, G2252	Remote evaluation of multimedia files submitted by an established patient (e.g., store and forward).		√
G2012, G2251	Virtual check-in for an established patient.		√
99421 – 99423 G2061 – G2063	Online digital evaluation and management service.		√
99441 - 99443	Telephone evaluation and management		√

[10] https://data.cms.gov/summary-statistics-on-use-and-payments/.
[11] See, https://aasm.org/clinical-resources/coding-reimbursement/telemedicine-codes/. And https://tele-health.hhs.gov/providers/best-practice-guides/telehealth-for-behavioral-health/billing-for-telebehavioral-health. Appendix 1 is a comprehensive listing of all relevant telemedicine / telehealth services.

The online carbon footprint calculator provided by EDF was used to estimate GHG savings for telemedicine[12]; three types of 'travel distance' measures reported by Healthcare Cost and Utilization Project (HCUP) were used to estimate telemedicine-induced GHG savings at the metro / nonmetro level[13]:

- Baseline: patient location defined as the geocode of the geographic centroid of the patient's ZIP Code, hospital location defined as the AHA geocode, and straight-line distance measure.
- Scenario 1: patient location defined as the geocode of the population-weighted centroid of the patient's ZIP Code, hospital location defined as the Google Maps geocode, and straight-line distance measure.
- Scenario 2: patient location defined as the geocode of the population-weighted centroid of the patient's ZIP Code, hospital location defined as the Google Maps geocode, and Google Maps driving distance measure.

Data were analyzed using frequency counts and crosstabulations of variables. Appendix 2 shows the computations involved in estimating GHG savings for telemedicine at the county level.

Findings

During 2021, the number of telemedicine visits of Illinoisans totaled 14.94mil; of these, majority, 52%, were substitutes for face-to-face office visits, 25% were pre and post-hospitalization consults with physicians, and 9% of telemedicine visits were post-hospital care by nurse practitioners (Table 2).

[12] https://www.edf.org/travel-footprint-calculator.
[13] The distance measures are direct quotes from https://hcup-us.ahrq.gov/reports/methods/MS2021-02-Distance-to-Hospital.jsp#t5.

Table 2: Telemedicine Use by Task Situation

Situation	% of Visits
Office / outpatient consultations	52%
Pre / pot hospital care by physicians	25%
Subsequent hospital care by APRNs	9%
ER consults	4%
Other	10%
N (Total Visits)	14,946,791

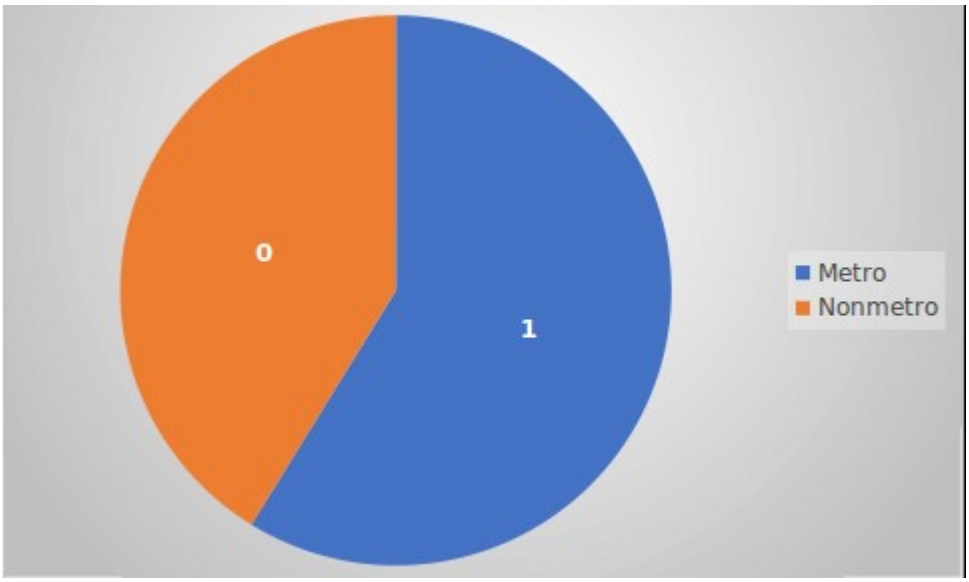
Source: See Footnote 8.

Figure 2 shows carbon savings from telemedicine consultations for metro and nonmetro Illinois; the computations were based on average driving distance to the nearby hospital[14]. In terms of GHG reductions, in 2021, telemedicine consultations benefited the state to a maximum 91mil kilograms.

Table 3 provides county-wise carbon savings data for the metro and the nonmetro. Nonmetro counties that had the least number of telemedicine visits and thus carbon emission reductions include Brown, Pope, and Scott; La Salle County had the best outcome. In the metro, Cook County had the best carbon savings from telemedicine and Calhoun County had the least savings. Appendix 3 contains carbon savings categorized by use situation.

[14] See Appendix 2; Figure 2 is based on distance measure, scenario 2.

Figure 2: Carbon Emissions Savings from Telemedicine: Metro *versus* Nonmetro



Note: Total carbon emission savings = 91,156,259 Kilograms

Table 3: Telemedicine's Role in Carbon Emission Reductions, Illinois Counties

Metro County	Rank, 1 = Best	Metro County	Rank, 1 = Best
Cook	1	DeKalb	21
DuPage	2	Henry	22
Lake	3	Macoupin	23
Will	4	Jackson	24
Kane	5	Boone	25
Winnebago	6	Grundy	26
Madison	7	Woodford	27
McHenry	8	Clinton	28
St. Clair	9	Monroe	29
Sangamon	10	Jersey	30
Peoria	11	Mercer	31
Rock Island	12	Piatt	32
Champaign	13	Bond	33
Tazewell	14	DeWitt	34
McLean	15	Marshall	35
Macon	16	Menard	36
Kankakee	17	Ford	37
Vermilion	18	Alexander	38
Williamson	19	Stark	39
Kendall	20	Calhoun	40

Table 3: Telemedicine's Role in Carbon Emission Reductions, Illinois Counties (Continued)

Nonmetro County	Rank, 1 = Best	Nonmetro County	Rank, 1 = Best	Nonmetro County	Rank, 1 = Best
LaSalle	1	Logan	22	Washington	43
Adams	2	Saline	23	Johnson	44
Whiteside	3	McDonough	24	Lawrence	45
Knox	4	Shelby	25	Wabash	46
Stephenson	5	Fayette	26	Moultrie	47
Ogle	6	Perry	27	Greene	48
Coles	7	Hancock	28	Cass	49
Franklin	8	Edgar	29	Cumberland	50
Marion	9	Carroll	30	Jasper	51
Jefferson	10	Union	31	Hamilton	52
Bureau	11	Wayne	32	Schuyler	53
Livingston	12	Crawford	33	Henderson	54
Christian	13	Douglas	34	Edwards	55
Fulton	14	Richland	35	Putnam	56
Lee	15	Warren	36	Pulaski	57
Morgan	16	Clark	37	Gallatin	58
Jo Daviess	17	Pike	38	Hardin	59
Effingham	18	Massac	39	Scott	60
Iroquois	19	Mason	40	Pope	61
Montgomery	20	White	41	Brown	62
Randolph	21	Clay	42		

Summary and Conclusion

This paper provides estimates of carbon savings from telemedicine for Illinois; the premise is that face-to-face consultations with healthcare providers require patient travel to healthcare facilities by car. The argument is that reduction of automobile travel is the primary factor for decreased carbon emissions.

Data on telemedicine use were obtained from the CMS; 2021 data were mined. Results of data analysis indicate that Illinoisans had 14.9mil telemedicine visits in 2021. This translates to carbon savings of approximately 70mil to 91mil kilograms. The nonmetro saved 30mil to 37.6mil kilograms of carbon and the metro witnessed reductions in carbon emissions to a tune of 39mil to 54mil kilograms.

In an earlier research, I showed that the climate crisis will worsen in the years to come, with increases in heat-related mortality[15]. This research shows how telemedicine reduces GHGs and minimize adverse impacts of climate change on Illinois communities.

[15] See Footnote 3.

Appendix 1: CMS Telemedicine Codes

Telehealth CPT codes	Service / Definition
96105, 96125	Aphasia and cognitive assessment
96127	Behavioral screening
90791, 90792	Diagnostic evaluation
90832, 90833, 90834, 90836, 90837, 90838	Psychotherapy
90845	Psychoanalysis
90853	Group psychotherapy
90846, 90847	Family psychotherapy
96116, 96121, 96130, 96131, 96132, 96133, 96136, 96137, 96138, 96139	Psychological and neurobehavioral testing or status exam
90839, 90840, 90785	Crisis intervention and interactive complexity
92524	Speech-language behavioral analysis
96130, 96131	Psychological evaluation
96132, 96133	Neuropsychological evaluation
96156, 96160, 96161	Health behavior assessment
96158, 96159	Health behavior intervention, individual
96164, 96165	Health behavior intervention, group
96167, 96168	Health behavior intervention, family with patient
96112, 96113	Developmental screening and testing
97151, 97152, 0362T	Adaptive behavior assessment
97153, 97154, 97155, 97156, 97157, 97158, 0373T	Adaptive behavior treatment

Appendix 2: Methodology, Estimates of Carbon Savings

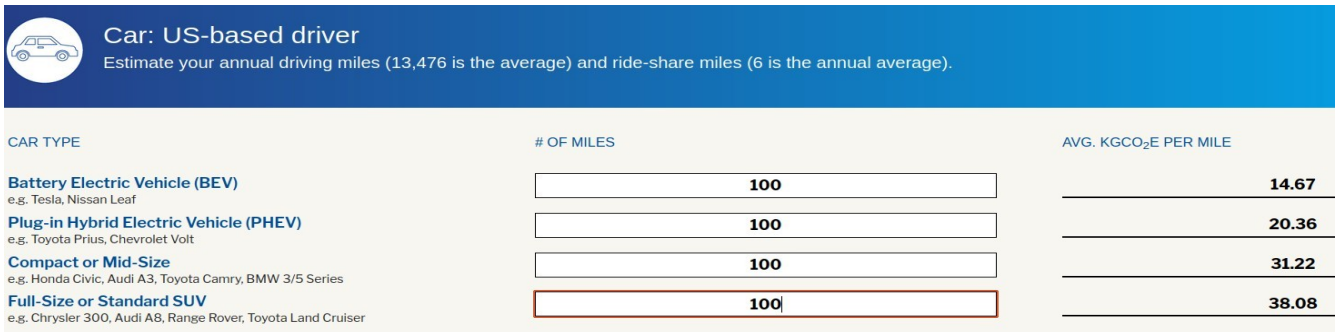
Telemedicine visits in Illinois totaled 14.9mil in 2021; these were allocated to counties using Medicare population data from the ACS 2021, five-year estimates (Table No. S2704). Specifically, population data were used as weights to estimate the number of telemedicine visits in the counties[16].

The 'visits' were then compounded with three distance measures: baseline, scenario 1, and scenario 2 (see the methods section of the paper for definitions). Median distance between hospital and patient locations, reported in the *HCUP Methods Series, Methods for Calculating Patient Travel Distance to Hospital in HCUP Data*, Report #2021-02, were used as inputs in the travel-footprint calculator (https://www.edf.org/travel-footprint-calculator) to obtain carbon savings from telemedicine.

For example, Adams County had 2,015 telemedicine office visits. These visits were weighted by the median values of the three 'distance' measures for both micropolitan and noncore geographic areas (see table below). Since the estimates were for one-way travel, they were adjusted to reflect roundtrip miles.

	Travel Distance (Median)		
Geography	**Baseline**	**Scenario1**	**Scenario2**
Micropolitan	14.2	13.78	16.89
Noncore	26.21	26.05	32.13
Avg., Rural	20.205	19.915	24.51

Finally, using data on CO_2 emissions from the edf calculator, see below, estimates of carbon savings were derived for the county, by telemedicine use category (Appendix 3).



[16] Mathematical formulations can be obtained from, Athiyaman A. (2021). Value of Telemedicine. *Research Brief*. 3(3), February 3. Available: http://www.iira.org/wp-content/uploads/2021/02/Telemedicine_ResBrief3_Feb3_2021.pdf.

Appendix 3: County-wise Estimates of Carbon Savings

Scenario 2

	County	Office / outpatient consultations	Subsequent hospital care by physicians	Subsequent hospital care by APRNs	ER consults	Other	Total
Urban	Alexander	23,535	11,099	3,941	1,886	4,589	45,050
	Bond	53,173	25,076	8,903	4,262	10,367	101,781
	Boone	139,167	65,631	23,302	11,154	27,134	266,388
	Calhoun	18,166	8,567	3,042	1,456	3,542	34,774
	Champaign	429,034	202,333	71,836	34,386	83,651	821,241
	Clinton	103,365	48,747	17,307	8,284	20,154	197,857
	Cook	12,514,553	5,901,886	2,095,395	1,003,001	2,440,033	23,954,868
	DeKalb	210,615	99,327	35,265	16,880	41,065	403,152
	DeWitt	49,786	23,479	8,336	3,990	9,707	95,299
	DuPage	2,243,761	1,058,162	375,688	179,830	437,479	4,294,919
	Ford	39,532	18,644	6,619	3,168	7,708	75,671
	Grundy	121,656	57,373	20,370	9,750	23,720	232,869
	Henry	166,666	78,600	27,906	13,358	32,496	319,026
	Jackson	143,287	67,574	23,992	11,484	27,938	274,275
	Jersey	69,669	32,856	11,665	5,584	13,584	133,358
	Kane	1,141,756	538,454	191,172	91,508	222,615	2,185,504
	Kankakee	308,658	145,564	51,681	24,738	60,181	590,821
	Kendall	218,403	102,999	36,569	17,504	42,583	418,059
	Lake	1,624,634	766,180	272,023	130,209	316,764	3,109,811
	Macon	343,977	162,220	57,594	27,569	67,067	658,427
	Macoupin	161,594	76,208	27,057	12,951	31,507	309,317
	Madison	805,723	379,980	134,908	64,576	157,096	1,542,284
	Marshall	44,854	21,153	7,510	3,595	8,745	85,858
	McHenry	741,266	349,583	124,115	59,410	144,529	1,418,903
	McLean	381,308	179,826	63,845	30,561	74,346	729,886
	Menard	40,547	19,122	6,789	3,250	7,906	77,613
	Mercer	54,577	25,739	9,138	4,374	10,641	104,470
	Monroe	97,933	46,186	16,398	7,849	19,095	187,460
	Peoria	520,553	245,494	87,160	41,721	101,495	996,423
	Piatt	53,750	25,349	9,000	4,308	10,480	102,887
	Rock Island	457,767	215,884	76,647	36,689	89,253	876,239
	Sangamon	594,546	280,389	99,549	47,651	115,922	1,138,056
	St. Clair	721,930	340,463	120,877	57,860	140,759	1,381,889
	Stark	19,883	9,377	3,329	1,594	3,877	38,060
	Tazewell	409,994	193,354	68,648	32,860	79,939	784,794
	Vermilion	243,203	114,695	40,721	19,492	47,419	465,529
	Will	1,476,119	696,140	247,156	118,306	287,807	2,825,528
	Williamson	218,965	103,264	36,663	17,549	42,693	419,135
	Winnebago	877,453	413,808	146,918	70,325	171,082	1,679,585
	Woodford	107,859	50,867	18,060	8,645	21,030	206,460

	County	Office / outpatient consultations	Subsequent hospital care by physicians	Subsequent hospital care by APRNs	ER consults	Other	Total
Rural	Adams	897,986	423,492	150,356	71,971	175,085	1,718,889
	Brown	57,307	27,026	9,595	4,593	11,174	109,696
	Bureau	479,540	226,152	80,293	38,434	93,499	917,917
	Carroll	256,117	120,785	42,883	20,527	49,936	490,248
	Cass	150,842	71,138	25,257	12,090	29,411	288,737
	Christian	462,625	218,175	77,460	37,078	90,201	885,540
	Clark	213,010	100,456	35,666	17,072	41,532	407,735
	Clay	191,930	90,514	32,136	15,383	37,422	367,384
	Coles	569,919	268,775	95,425	45,677	111,120	1,090,917
	Crawford	235,289	110,963	39,396	18,858	45,876	450,381
	Cumberland	142,638	67,268	23,883	11,432	27,811	273,031
	Douglas	226,390	106,766	37,906	18,144	44,141	433,347
	Edgar	259,209	122,243	43,401	20,775	50,539	496,168
	Edwards	90,505	42,683	15,154	7,254	17,646	173,242
	Effingham	407,969	192,399	68,309	32,697	79,544	780,918
	Fayette	291,145	137,304	48,748	23,334	56,766	557,298
	Franklin	552,437	260,530	92,498	44,276	107,712	1,057,453
	Fulton	453,663	213,948	75,960	36,360	88,453	868,385
	Gallatin	83,310	39,289	13,949	6,677	16,244	159,470
	Greene	163,970	77,329	27,455	13,142	31,970	313,865
	Hamilton	121,747	57,416	20,385	9,758	23,738	233,043
	Hancock	280,605	132,334	46,984	22,490	54,711	537,123
	Hardin	74,096	34,944	12,406	5,939	14,447	141,831
	Henderson	110,197	51,969	18,451	8,832	21,486	210,935
	Iroquois	393,453	185,553	65,878	31,534	76,714	753,131
	Jasper	122,567	57,803	20,522	9,823	23,898	234,614
	Jefferson	484,463	228,474	81,117	38,828	94,458	927,340
	Jo Daviess	418,635	197,429	70,095	33,552	81,624	801,335
	Johnson	186,249	87,836	31,185	14,927	36,314	356,511
	Knox	689,962	325,387	115,525	55,298	134,526	1,320,698
	LaSalle	1,339,405	631,666	224,265	107,349	261,151	2,563,836
	Lawrence	177,666	83,788	29,748	14,239	34,641	340,081
	Lee	449,119	211,805	75,199	35,995	87,567	859,686
	Livingston	463,383	218,532	77,587	37,139	90,348	886,989
	Logan	351,797	165,908	58,904	28,195	68,592	673,397
	Marion	510,403	240,707	85,460	40,907	99,516	976,993
	Mason	202,722	95,604	33,943	16,248	39,526	388,043
	Massac	202,785	95,634	33,954	16,253	39,538	388,164
	McDonough	320,556	151,175	53,673	25,692	62,501	613,596
	Montgomery	385,248	181,684	64,505	30,876	75,114	737,426
	Morgan	444,575	209,662	74,438	35,631	86,681	850,988
	Moultrie	164,223	77,448	27,497	13,162	32,019	314,348

	County	Office / outpatient consultations	Subsequent hospital care by physicians	Subsequent hospital care by APRNs	ER consults	Other	Total
Rural	Ogle	655,628	309,195	109,776	52,546	127,831	1,254,978
	Perry	284,265	134,060	47,596	22,783	55,425	544,130
	Pike	212,568	100,247	35,592	17,037	41,446	406,889
	Pope	64,881	30,598	10,863	5,200	12,650	124,193
	Pulaski	86,214	40,659	14,435	6,910	16,810	165,027
	Putnam	87,602	41,313	14,668	7,021	17,080	167,685
	Randolph	380,262	179,332	63,670	30,477	74,142	727,882
	Richland	219,069	103,313	36,680	17,558	42,713	419,333
	Saline	344,476	162,456	57,678	27,609	67,164	659,383
	Schuyler	113,605	53,576	19,022	9,105	22,150	217,459
	Scott	68,163	32,146	11,413	5,463	13,290	130,475
	Shelby	311,531	146,918	52,162	24,968	60,741	596,320
	Stephenson	683,903	322,530	114,510	54,813	133,344	1,309,101
	Union	249,931	117,868	41,848	20,031	48,731	478,409
	Wabash	169,903	80,126	28,448	13,617	33,127	325,221
	Warren	213,325	100,605	35,718	17,097	41,593	408,339
	Washington	191,551	90,336	32,073	15,352	37,348	366,659
	Wayne	248,543	117,213	41,615	19,920	48,460	475,751
	White	200,198	94,414	33,520	16,045	39,034	383,210
	Whiteside	763,553	360,093	127,847	61,196	148,874	1,461,563