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MEMORANDUM

Date: October 1, 2019

To: Joint Labor, Health and Social Services Interim Committee
Joint Appropriations Interim Committee

From: Michael Ceballos, FOR
Wyoming Department of Health

Subject: Legislative Report: Section 338 Review of Sustained Hospital Viability

Ref: C-2019-464

Section 338 of House Enrolled Act 51 from the 2019 General Session requires the Department of Health to provide a report to the Joint Labor, Health, and Social Services interim committee and the Joint Appropriations Committee regarding access to hospital services in Wyoming.

Attached is a report that fulfills the Legislative mandate.

MAC/SJ/ff/jg

c: Governor Mark Gordon
Legislative Service Office (electronic copy)
State Department Depository (electronic copy)

SECTION 338 - REVIEW OF SUSTAINED HOSPITAL VIABILITY

Balancing access to services against cost in a rural and frontier State

Wyoming Department of Health
October 1st, 2019

LEGISLATIVE REQUIREMENTS

Section 338 (b) of House Enrolled Act 51 from the 2019 General Session requires the Department to study factors around Statewide hospital access and costs. The section reads:

> The department of health, with the assistance of qualified persons or contractors, shall study and report on all of the following:
>
> > (i) Identification of medical services provided through Wyoming public and private hospitals, if any, which are at risk of no longer being economically or medically viable in Wyoming or geographic regions of Wyoming;
> >
> > (ii) Identification of the health risks to Wyoming residents which may result from the lack of medical services identified under paragraph (i) of this subsection;
> >
> > (iii) Strategies and opportunities to maintain the highest quality and broadest range of medical services through existing public and private hospitals in Wyoming;
> >
> > (iv) Duplication and competition of medical services and efforts among public and private hospitals within a proximate geographic area based upon populations served;
> >
> > (v) The report shall include recommendations concerning:
> >
> > > (A) Efficient distribution of hospital medical services;
> > >
> > > (B) Whether development of specialized centers of excellence or regionally provided hospital services within Wyoming would improve the viability of Wyoming's public and private hospitals; and

(C) Sustaining and growing, efficient, cost-effective medical services within Wyoming's public and private hospitals.

These tasks imply two general research questions:

(1) How is access to specific hospital capabilities geographically distributed in Wyoming? [Items (i)(ii)(iv)]

(2) Exploring the tension between cost and access. How can an "efficient" distribution of hospital resources be balanced against "maintain[ing] the highest quality and broadest range of medical services" throughout the State? [Items (iii) and (v)]

The Department attempts to answer these questions by structuring the study along the Table of Contents shown on the next page.

In addition to studying these issues on a Statewide basis, the Department's workgroup requested that three specific areas be studied in the context of constructing new hospitals:

- Riverton;
- Pinedale; and
- Saratoga.

Accordingly, after discussion on all Wyoming hospitals and access to time-sensitive care, we include a section that attempts to estimate the impact of three new hospitals in these areas.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **4**

ECONOMIC AND MEDICAL VIABILITY 4
ACCESS TO CARE FOR TIME-SENSITIVE CONDITIONS 4
RECOMMENDATIONS 4

BACKGROUND **5**

1. OVERVIEW OF WYOMING HOSPITALS 5
3. HOSPITAL FINANCIAL HEALTH 12
4. WORKFORCE AND ACCESS TO MEDICAL PROVIDERS 19
5. AMBULANCE CAPABILITIES 24

STATEWIDE ACCESS TO TIME-SENSITIVE CARE **28**

1. OVERVIEW OF TIME-SENSITIVE CONDITIONS 28
2. CHILDBIRTH 31
3. TRAUMA 37
4. A NOTE ON STROKE AND HEART ATTACKS 41

NEW HOSPITAL PROJECTIONS **43**

1. PROJECTED IMPACTS 43
2. METHODOLOGY 44

RECOMMENDATIONS **50**

1. NAVIGATING THE TRADEOFF BETWEEN COST AND ACCESS 50
2. "TIME-SENSITIVE" VS. "SHOPPABLE" SERVICES 51
3. WHY CROSS-SUBSIDIES ARE A PROBLEM 51
4. LOSING ACCESS UNDER A "FULL" FREE MARKET 52
5. WHAT IF WE PAID FOR "TIME SENSITIVE" SERVICES SEPARATELY? 53
6. CONCLUSION AND NEXT STEPS 54

TECHNICAL APPENDIX **55**

1. EMS CHOICE MODEL 55
2. TOTAL FERTILITY RATE MODEL 56
3. TRAUMA RISK MODEL 60
4. STROKE RISK MODEL 61
5. OUT-OF-STATE ADMISSION MODEL 62
6. HOSPITAL ADMIT MODEL 63
7. MAJOR DIAGNOSTIC CATEGORY (MDC) MODEL 64
8. PUBLIC PAYER MODEL 66
9. HOSPITAL CHOICE MODEL 67

EXECUTIVE SUMMARY

Section 338 (b) of House Enrolled Act 51 from the 2019 General Session requires the Department to study the economic and medical viability of hospital services in Wyoming, as well as access to care for time-sensitive conditions.

Economic and medical viability

Most hospitals in Wyoming seem economically viable; few show any financial warning signs. Relative to their peers nationally, hospitals in Wyoming seem healthier, have stable liquidity and do not appear over-leveraged. They also seem to have higher costs, see a larger percentage of private-pay patients in their payer mix, have lower Medicare cost coverage; and provide a larger percent of uncompensated care.

In terms of 'medical viability', the availability of physicians is a major limiting factor. Yet while Wyoming ranks low nationally in terms of providers per capita, there is also significant variation across counties. Teton County, for example, has as many MDs per capita as New York or Massachusetts, while Big Horn County has actually regressed since the 1960s.

Access to care for time-sensitive conditions

In looking at two health risks — childbirth and trauma — two areas currently lacking a hospital stand out as having worse access than the rest of the State: Riverton and Pinedale. There is thus some justification on these grounds for new hospitals in both areas. We project patient volume for these new hospitals later in this report.

Recommendations

New hospitals may increase access, but they also add to cost. This study explores the inherent tension between (1) providing the "broadest range" and "highest quality" of medical services throughout the State while (2) also ensuring services are "cost effective" and "efficient."

Unfortunately, there will always be a tradeoff between access and cost. This resembles the "iron triangle" of contracting: "you can have things good, fast, or cheap — pick two."

If there is a role for the State in regulating this tradeoff in the hospital context, the Department sketches out a broad framework for isolating "time sensitive" services from "shoppable" services, and paying for the two types of service very differently.

BACKGROUND

This section begins by describing how rural hospitals can be categorized into meaningful groups. We then illustrate basic background statistics for Wyoming hospitals, to include measures of financial health. After this focus on hospitals, we look at variation across Wyoming in two important adjuncts to hospital care: Emergency Medical Services (EMS) agencies and availability of medical providers.

Key Takeaways	
Page 5-6	**Medicare Designations.** There are 11 Prospective Payment System (PPS) hospitals and 16 Critical Access Hospitals (CAH) in Wyoming. Other designations also impact financing and capability. Reimbursement formulas for Medicare differ for PPS and CAH hospitals.
Pages 8-11	**Basic statistics.** For-profit status, governance structures, and volume vary widely.
Pages 12-18	**Financial health.** Wyoming hospitals are generally healthy compared to national peers. Hospitals in the eastern part of the state seem weaker financially.
Pages 19-27	**Workforce.** When compared nationally, Wyoming does not appear to have a nursing shortage, but it does rank low in terms of physician availability. This differs widely across counties.

1. Overview of Wyoming hospitals

There are 33 hospitals in Wyoming. Only three (3) do not accept Medicare or Medicaid patients; two of these are VA hospitals, and one is a physician-owned facility. Of the 30 hospitals that accept all patients, two specialize in psychiatric care (the Wyoming State Hospital and Wyoming Behavioral Institute) and one, Elkhorn Valley, specializes in rehabilitative care. The remaining 27 general acute-care hospitals are the focus of the study.

Prospective Payment System (PPS) vs. Critical Access Hospitals (CAH)

Generally speaking, we split these 27 Wyoming hospitals into two major categories, based on how Medicare[1] reimburses for services to its members: there are 11 Prospective Payment System (PPS) hospitals and 16 Critical Access Hospitals (CAHs).[2]

Most hospital care in the United States — particularly for anything complex — takes place in a PPS hospital. Since 1983, Medicare has reimbursed these hospitals for

[1] Note that Medicare and Medicaid are different programs. Both are overseen by the US Department of Health and Human Services (HHS) through the Centers for Medicare and Medicaid Services (CMS).

[2] How Medicare pays for services might seem an odd choice here, given that plenty of other-insured people use hospital services, but Medicare generally leads all other payers in categorizing and paying for hospital services and its rules have significantly shaped the hospital landscape.

inpatient and outpatient services on a *prospective* basis. This means that the payment for any given admission is set in advance by a formula, regardless of the actual resources used to treat the individual, like the number of days they stayed in the hospital or intensity of care they received.

The basic version of the prospective formula has two major components:

- A hospital-specific **"base rate"** that incorporates a geographically-adjusted labor portion (e.g., the "area wage index") and non-labor portion.

- A **"relative weight"** for each particular admission, based on the diagnoses and procedures performed on the patient, grouped into code known as a "Medicare Severity Diagnosis Related Group," or MS-DRG.

  Each MS-DRG represents a standardized 'bundle' of hospital services that are expected to consume a similar amount of medical and surgical resources, and its assigned weight reflects its relative use of resources compared with the average case.

Details aside, the most important thing to note is that **PPS hospitals are fundamentally at risk for their overall cost structure** when it comes to Medicare payments. This is by design; the PPS system was implemented as an efficiency measure during a time when cost-based reimbursement had led to significant cost increases in the Medicare program.[3]

Most hospitals in Wyoming, however, fall into the Critical Access Hospital (CAH) category. This designation, developed in 1997 in response to waves of rural hospital closures in the 1980s and 90s, moves certain hospitals back to **cost-based reimbursement**. CAHs historically have been paid on an allowable-cost-plus-1% basis for the Medicare patients they see. Cuts to Medicare from the 2013 federal budget sequestration, however, reduced effective cost coverage to 99%.[4]

Obviously, not every hospital can receive CAH designation. As the name would suggest, these hospitals intended to be the only hospital for a widespread area. They also have to be small, with fewer than 25 beds. Table 1, on the next page, summarizes the eligibility and payment criteria for Critical Access Hospitals, as well as for other rural hospital classifications.

Of the other (non-CAH) special classifications listed, the most significant in recent years has been the loss (in 2011) and recovery (2018) of Sole Community Hospital

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[3] The real costs per Medicare beneficiary roughly doubled between 1974 and 1983. https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/HealthCareFinancingReview/Downloads/CMS1191951dl.pdf

[4] This brief provides an update on the continuing effects of sequestration: https://hfmawesternsymposium.org/2020/wp-content/uploads/2018/01/Tuesday-100-Reimbursement-King-and-Rivera.pdf

status for Wyoming Medical Center (WMC) after it bought out a competing hospital in Casper.[5]

Currently, all PPS hospitals except Summit Medical Center (Casper) are also Sole Community Hospitals. For WMC, the impact on Medicare revenue from regaining SCH status has been significant (an additional ~$8 million per year).

Table 1: Overview of Medicare Rural Hospital Classifications

Classification	Requirements[6]	Medicare Payment[7]
Critical Access Hospital (CAH)	▪ 35 miles from nearest hospital ▪ No more than 25 beds ▪ Provides 24/7 emergency services ▪ Less than 96 hour average length of stay (excluding swing beds)	▪ 101% (99% today) of the allowable costs for most services ▪ Cost-based reimbursement for exclusive regional ambulance service
Sole Community Hospital (SCH)	▪ Outside 35 miles from other "like" hospitals, <u>or</u> ▪ In a rural area, 25 - 35 miles from other like hospitals <u>and</u>: o <= 25% of inpatients in service area are admitted to other hospitals within 35 miles, <u>or</u> o <= 50 beds and would meet the 25% criteria if it offered specialized care available at other hospitals. ▪ In a rural area, 15 - 25 miles from other like hospitals, but other hospitals are inaccessible for at least 30 days in each 2 of every 3 years, <u>or,</u> ▪ In a rural area and travel time to the nearest like hospital is over 45 minutes.	▪ PPS, but paid based on the highest rate among three historical rate sources ▪ Disproportionate share adjustment (DSA) (capped at 12%) provides additional funding for costs based on percent of low-income patients ▪ Volume decline adjustment provides additional funding for fixed costs when caseload declines
Medicare-Dependent Hospital (MDH)	▪ Rural location ▪ <100 beds ▪ High number of Medicare patients ▪ Does not meet SCH eligibility	▪ PPS *plus* a historic cost-per-discharge adjustment ▪ DSA (no cap) ▪ Volume decline adjustment

[5] Wyoming Tribune Eagle article on WMC regaining SCH status, and projected impacts: https://trib.com/news/local/casper/wyoming-medical-center-regains-sole-community-provider-status-will-reap/article_67d144c7-712a-569b-90c0-4704a71ef26a.html

[6] CAH: 42 CFR § 485.601-647; SCH: 42 C.F.R. § 412.92; MDH: 42 C.F.R. § 412.108; RRC: 42 C.F.R. § 412.96

[7] https://www.shepscenter.unc.edu/rural/pubs/report/FR98.pdf

Hospital districts and county memorial hospitals

In addition to enhanced Medicare reimbursements, some hospitals in the State receive county-level support through State statutes designating them as hospital districts (15 hospitals in Wyoming) or county memorial hospitals (6 hospitals).

- County hospitals can benefit from part of the total 12 mills that counties may impose on their residents under W.S. § 39-13-104(b). Typically, the portion allocated to the hospital is less than 1 mill.

- Hospital districts can benefit from up to 6 mills from the assessed value of the district, per W.S. § 35-2-414(b), (c) and (d).

Teaching status

Another important Medicare-related distinction is whether or not the hospital provides and receives compensation for Graduate Medical Education (GME). While they receive revenue, teaching hospitals also incur additional expenses in educating residents and interns. These costs can be direct (stipends) or indirect (additional tests, slower procedures done for educational purposes, etc.).

Typically, teaching hospitals are larger (usually over 200 beds) and tend to care for more complex patients. In Wyoming, both Wyoming Medical Center and Cheyenne Regional Medical Center are listed as teaching hospitals.

Medicaid payment methodology

Unlike Medicare, Wyoming Medicaid pays **all** hospitals a prospective rate. Before 2018, this was through an idiosyncratic system that assigns "Levels of Care" to procedure bundles, revenue and diagnosis codes.

In 2019, Wyoming Medicaid moved to the All-Payer Refined (APR) DRG methodology, which includes bundles that are more appropriate for the Medicaid demographic (pediatrics, maternity).

Since Medicaid pays hospitals on roughly the same basis and since Medicaid is usually a lower percent of hospital revenues, we do not use Medicaid payments to categorize hospitals for the purposes of this study.

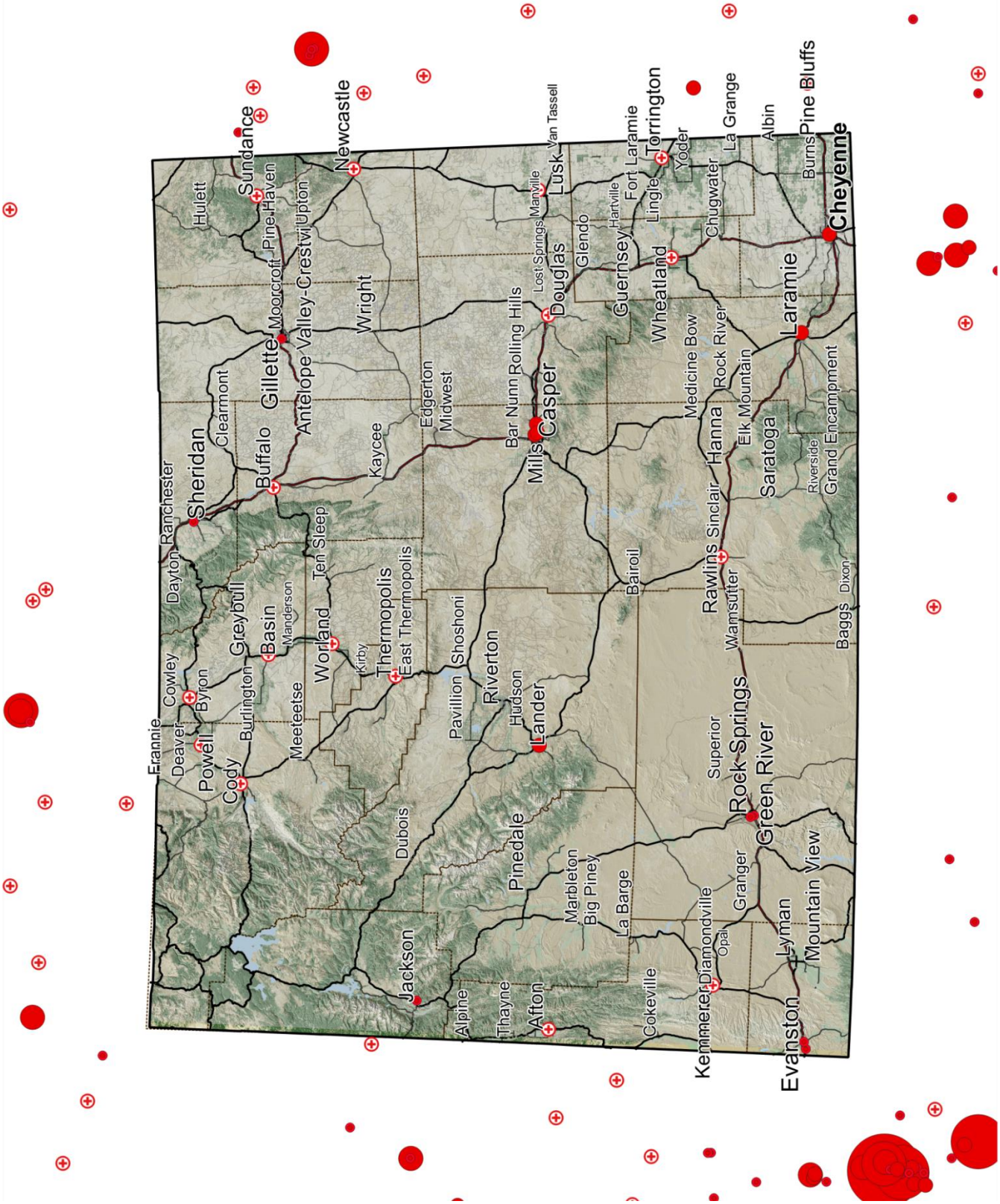
For the purposes of this background section, all Wyoming hospitals are shown on Table 2, on the next page, categorize by the designations summarized above. On the table, columns list the Medicare type (PPS vs. CAH), the management and governance of the hospital, and the number of acute care and long-term care beds.

Table 2: Hospitals in Wyoming[8]

Name	Community	Medicare Type	Governance	Management	Beds	
					Acute	LTC
Wyoming Medical Center Mountain View Campus	Casper	PPS/SCH	Non-profit lease from County		217	
			Recently acquired by WMC		23	
Summit Medical Center		PPS	For-profit - New Manna Augusta		16	
WBI		Psych	For-profit - Universal Health Services		90	
Elkhorn Valley		Rehab	For-profit - Ernest Health		41	
Cheyenne Regional	Cheyenne	PPS/SCH	County memorial	UC Health	206	16
Cheyenne VAMC		-	Veterans' Health Administration		22	42
Evanston Regional	Evanston	PPS/SCH	For-profit - Quorum		42	
Wyoming State Hospital	Evanston	Psych	State of Wyoming		103	
Campbell County	Gillette	PPS/SCH	District		93	160
St. John's	Jackson	PPS/SCH	District		48	60
Sage West	Lander	PPS/SCH	For-profit	LifePoint	89	
	Riverton[9]				70	
Ivinson Memorial	Laramie	PPS/SCH	District	UC Health	90	9
Sweetwater County	Rock Springs	PPS/SCH	County memorial		99	
Aspen Mountain		-	For-profit - Physician-owned		16	
Sheridan County	Sheridan	PPS/SCH	County memorial		88	
Sheridan VAMC		-	Veterans' Health Administration		168	40
Star Valley	Afton	Critical Access Hospitals (CAHs)	District		22	24
South Big Horn	Basin		District		10	37
Johnson County	Buffalo		District		25	44
West Park Hospital	Cody		District	Quorum Mgmt	25	94
Converse County	Douglas		County memorial		25	
South Lincoln	Kemmerer		District		16	24
North Big Horn	Lovell		District	Billings Clinic	15	85
Niobrara Community	Lusk		District	Health Mgmt Svcs	4	20
Weston County	Newcastle		District	Rapid City	12	54
Powell Valley	Powell		District	HealthTech	25	100
Carbon County	Rawlins		County memorial	Quorum Mgmt	25	
Crook County	Sundance		District	Health Mgmt Svcs	16	32
Hot Springs County	Thermopolis		District	HealthTech	25	
Torrington Community	Torrington		For-profit	Banner Health	25	
Platte County	Wheatland		District	Banner Health	25	
Washakie Medical Center	Worland		County memorial	Banner Health	25	

[8] Data courtesy Wyoming Hospital Association; additional non-participating hospitals added.
[9] Anecdotally, many Riverton services have been shifted to the Lander campus.

Map 1: General acute care hospitals in Wyoming and surrounding states. Critical Access Hospitals are denoted with a small white circle with a red cross, and PPS hospitals are shown as solid red circles that are sized proportional to their bed count.



Volume and capability

Hospitals also differ on their capabilities — even among CAHs. Table 3, below, shows three-year average inpatient and outpatient volume, as well as an estimate of the average "cost weight" for inpatient admissions that didn't result in a transfer to another hospital. For the "cost weights," larger numbers (and green shading) denote more intense services being provided on average.

Table 3: Inpatient efficiency metrics for Wyoming hospitals (FY 2016-18 averages)[10]

Name	Community	Type	Outpatient Visits	Inpatient Admits	Inpatient Days	ADC	DRG Cost Weight
Campbell County	Gillette	PPS	54,581	3,220	8,300	22.7	1.10
Sheridan County	Sheridan		38,244	2,043	7,145	19.5	1.23
SageWest	Lander/Riverton		41,913	2,990	7,074	19.4	1.01
Sweetwater County	Rock Springs		41,221	2,375	6,531	17.9	1.00
Wyoming Medical Center	Casper		83,744	9,686	35,212	96.5	1.58
Cheyenne Regional	Cheyenne		144,420	10,820	37,181	101.8	1.24
St. John's	Jackson				5,660	15.5	
Ivinson Memorial	Laramie		38,039	2,480	5,879	16.1	1.19
Evanston Regional	Evanston		21,269	836	1,613	4.4	0.96
South Big Horn	Basin	CAH	1,170	79	268	0.7	0.87
Converse County	Douglas		30,248	922	2,358	6.5	0.98
Weston County	Newcastle		8,223	74	199	0.5	0.84
Hot Springs County	Thermopolis		13,622	505	1,080	2.9	0.86
Platte County	Wheatland		12,147	482	1,128	3.1	0.90
Washakie Medical Center	Worland		11,720	496	1,293	3.5	1.17
Torrington Community	Torrington		15,337	631	1,385	3.8	1.02
Johnson County	Buffalo		18,142	424	1,142	3.1	0.79
North Big Horn	Lovell		12,007	245	743	2.0	0.93
Powell Valley	Powell		23,089	120	1,412	3.8	0.90
Crook County	Sundance				175	0.5	
West Park Hospital	Cody		33,227	2,078[11]	4,945	13.5	1.34
Star Valley	Afton		18,361	905	1,930	5.3	1.52
Niobrara Community	Lusk		5,654	21	119	0.3	0.81
South Lincoln	Kemmerer		3,195	171	300	0.8	0.70
Carbon County Memorial	Rawlins		16,979	633	1,815	4.9	0.96

[10] Inpatient admit and outpatient visit data from the Hospital Discharge Database. Inpatient cost weights from listed DRGs using CMS Final Rule data for FY 2016 - 2018. Inpatient days and ADC from CMS Cost Reports.

[11] Admit numbers for West Park in the Hospital Discharge Database seem too high for a CAH.

3. Hospital financial health

This section illustrates various metrics of financial health to show trends across hospitals and over time. We present ten different metrics broken into five major categories, including:

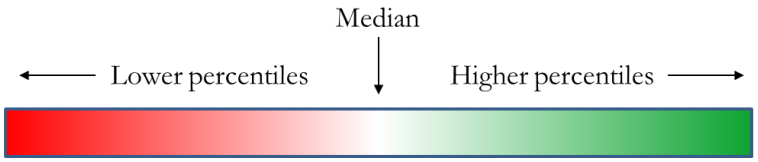
- **Liquidity**, which reflects a hospital's ability to pay short-term bills;
- **Profitability**, or net gain/losses from both patient services and total operations;
- **Cost structure**, which reflects how much hospitals have invested in capital and labor,
- Relationship with **Medicare**; and,
- **Medicaid and uncompensated care**.

All data in this section comes from Medicare's Healthcare Cost Report Information System (HCRIS)[12], known as "hospital cost reports." Using cost report data comes with advantages and disadvantages. The advantages include:

- HCRIS is the only comprehensive dataset for all Medicare-enrolled hospitals;
- The same data structure has been used since 2011, allowing continuity in reporting over time;
- The reports are rich in detail, with over 163 pages of worksheets that range from basic statistical information to detailed cost allocations.[13]

HCRIS comes with some disadvantages. Accuracy is not assured. These reports are not audited, per se, unlike financial statements. Since the purpose of the reporting is to settle up reimbursement from Medicare at the end of the year, the Medicare-related information in the reports tends to be more useful than the "nice to have" statistical information. There are also idiosyncrasies in reporting that make it difficult, for example, to tease out hospital stays from Skilled Nursing Facility stays, when a hospital also operates a SNF.

Each metric for Wyoming hospitals is shown for fiscal years 2012 through 2018. After grouping hospitals into peer groups (hospital type, CAH status, bed range, system ownership, and rural location), the data for each hospital-year is ranked by percentile among its national peers and color-coded accordingly, per the scale below:



[12] https://www.cms.gov/Research-Statistics-Data-and-Systems/Downloadable-Public-Use-Files/Cost-Reports/

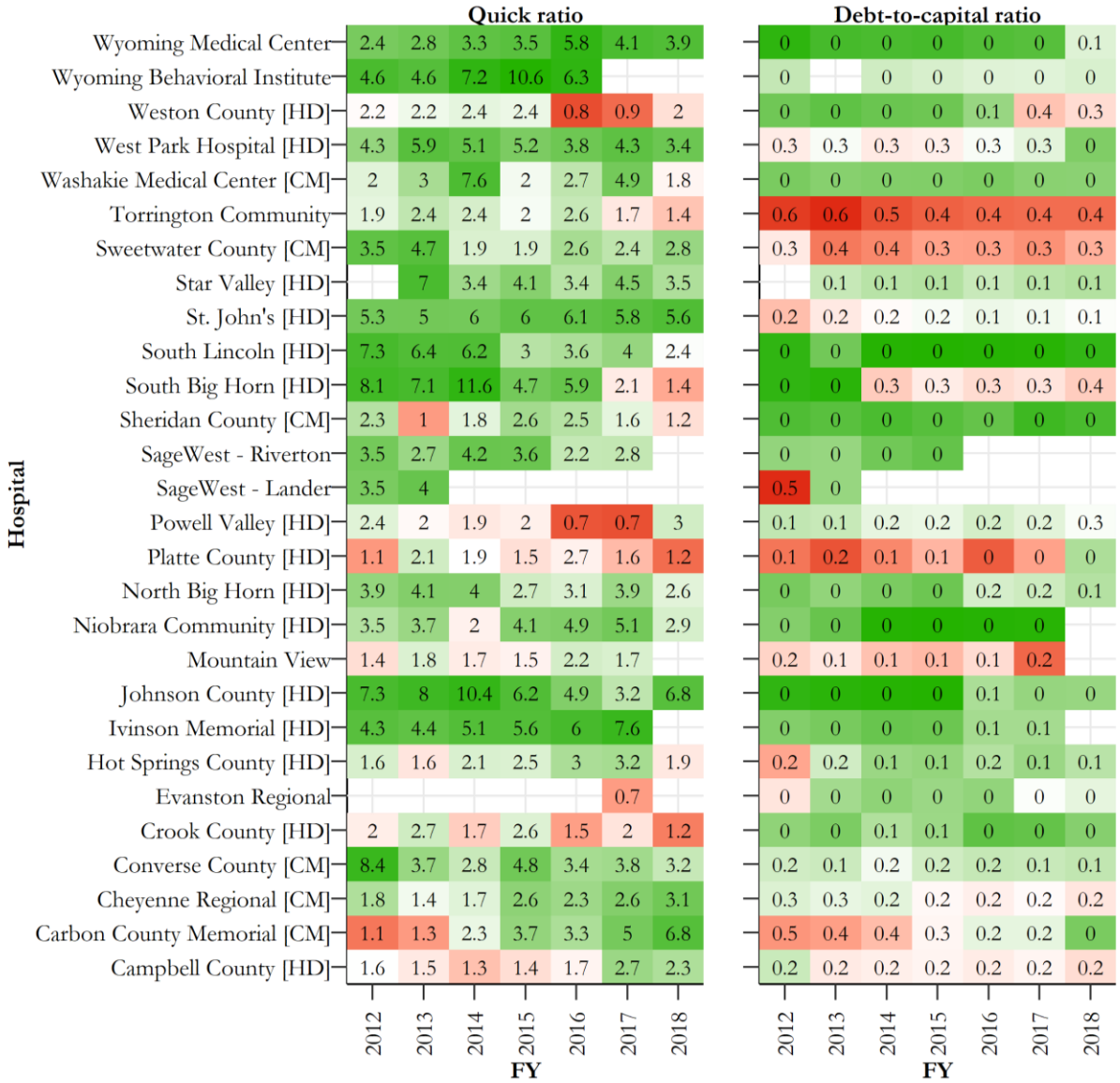
[13] Due to the complexity of the worksheets, the Department contracted with an independent consultant, formerly the CFO of the Colorado Hospital Association, to develop these indicators.

Liquidity

Figure 1, below, shows two indicators that relate to a hospital's ability to meet financial obligations to creditors. On this scale, green means better, red means worse.

- The *quick ratio* is a measure of the ability of current assets to pay off current liabilities.
- The *debt-to-capital ratio* is an indicator of how much a hospital's capital structure is leveraged for long-term debt.

Figure 1: Indicators of hospital liquidity



By these measures, most hospitals in Wyoming seem relatively healthy compared with national peers. But hospitals on the eastern side of the State — Torrington, Wheatland, Newcastle and Sundance — do seem weaker than the rest.

Profitability

Figure 2, below, shows two measures of margin (revenue less cost, over revenue). The measure on the right considers only patient service revenue (i.e., not tax revenue) and costs; the measure on the left considers all sources.

Figure 2: Indicators of hospital profitability

Hospital	Total margin (%) 2012	2013	2014	2015	2016	2017	2018	Patient services margin (%) 2012	2013	2014	2015	2016	2017	2018
Wyoming Medical Center	0	7	1	3	0	10	8	1	6	-5	-1	-4	6	1
Wyoming Behavioral Institute	31	33	33	30	26	19	14	28	37	35	28	23	18	14
Weston County [HD]	7	10	1	6	6	2	5	-5	-2	-14	-13	-21	-25	-12
West Park Hospital [HD]	11	7	5	7	6	8	5	2	-2	-6	0	-2	1	-3
Washakie Medical Center [CM]	7	4	1	-1	-2	-9	-2	6	3	-3	-1	-3	-9	-3
Torrington Community	13	10	16	20	19	0	-2	9	6	13	19	19	0	-4
Sweetwater County [CM]	6	3	1	7	1	-9	3	4	-1	-10	-3	-6	-14	-5
Star Valley [HD]		7	4	9	10	2	4		1	-1	2	6	-5	2
St. John's [HD]	13	18	12	11	9	6	4	-2	3	1	3	2	-3	-5
South Lincoln [HD]	7	3	-3	-1	-4	-15	-13	-20	-24	-27	-15	-16	-33	-30
South Big Horn [HD]	4	8	5	22	-3	-13	-5	-27	-17	-39	-32	-27	-32	-30
Sheridan County [CM]	8	-3	2	1	5	-1	-2	-3	-12	-5	-3	-10	-11	-7
SageWest - Riverton	9	8	13	10	14	10		6	4	12	9	11	6	
SageWest - Lander	11	12						11	12					
Powell Valley [HD]	1	0	-3	-2	-3	-2	-3	-2	-2	-10	-6	-8	-7	-7
Platte County [HD]	11	7	1	8	-3	-10	-8	3	2	-4	3	-6	-12	-10
North Big Horn [HD]	5	7	0	4	7	1	2	-12	-5	-20	-7	-3	-14	-9
Niobrara Community [HD]	4	7	-7	-13	-17	-6	-26	-5	-15	-38		-46	-20	-47
Mountain View	24	30	31	20	3			23	27	27	17	-18	-8	
Johnson County [HD]	16	8	8	6	8	-3	1	-5	-13	-10	-12	-7	-13	-9
Ivinson Memorial [HD]	20	20	23	12	14	21		11	11	12	7	9	13	
Hot Springs County [HD]	3	3	-2	1	3	-3	7	-1	-3	-8	-3	0	-7	-4
Evanston Regional	38	28	37	36	44	28	27	37	27	35	34	43	27	27
Crook County [HD]	0	-4	6	-1	-4	5	-6	-23	-27	-11	-16	-36	-20	-20
Converse County [CM]	9	5	-2	3	-4	0	-3	0	-4	-11	-5	-11	-7	-10
Cheyenne Regional [CM]	2	4	5	3	4	6	3	9	3	-2	4	5	3	4
Carbon County Memorial [CM]	3	7	13	19	9	9	9	-7	-2	4	13	-1	5	-13
Campbell County [HD]	12	6	2	6	4	-1	0	-5	-15	-18	-12	-12	-15	-11

FY

These indicators are important, but should be taken with a grain of salt. Non-profit hospitals are not in the business of being profitable, and excess revenue over cost are typically plowed back into cost structure (new buildings, equipment, staff, etc.).

When seen in conjunction with the liquidity indictors, the profitability of hospitals like Wheatland and Torrington, however, may be of concern.

For-profit hospitals (e.g., Evanston, Sage West, WBI) continue to show healthy margin on patient services.

Cost structure

The two indicators in Figure 3 show how much hospitals have invested in their capabilities.

- *Overall depreciation* measures how much of the hospital's capital has been depreciated; in essence, how new the facilities are.
- *Cost per ADC* attempts to capture annual hospital operating cost per Average Daily Census.

Figure 3: Indicators of cost structure

Hospital	Overall depreciation (%) 2012	2013	2014	2015	2016	2017	2018	Cost per ADC (millions) 2012	2013	2014	2015	2016	2017	2018
Wyoming Medical Center	67	63	61	61	66	69	70	1.8	1.7	1.6	1.6	1.6	1.6	1.6
Wyoming Behavioral Institute	28	32	36	40	43	46	47	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Weston County [HD]	55	58	57	60	64	40	27	9.6						
West Park Hospital [HD]	39	42	46	48	47	50	52	3.5	3.6	3.6	4.2	4.8	5.2	5.6
Washakie Medical Center [CM]	81	76	80	42	29	29	34	1.9	2.4	3.9	3.6	4.5	6.2	5.8
Torrington Community	58	57	60	54	52	59	62	3.4	3.4	3.4	3.8	4.3	5.2	7.2
Sweetwater County [CM]	38	42		42	46		55	2.3	2.4	2.4	2.3	2.6	3	4.1
Star Valley [HD]		58	52	55	52	52	52		4	4.1	4.8	5.5	6.6	7.5
St. John's [HD]	57	59	51	47	49	49	52	2.9	3.2	3.8	4.2	4.6	5.4	5.4
South Lincoln [HD]	65	66	67	66	68	67	70			9.9				
South Big Horn [HD]	48	47	52	56	35	37	37	5.3	7.2	8.2	8.8	9.7		
Sheridan County [CM]	54	49	55	62	67	64	63	2	2.5	2.3	3.1	3.1	3.3	3.7
SageWest - Riverton	53	58	55	57	56	60		1.6	1.7	1.7	1.9	2	2.1	
SageWest - Lander	45	49						1.5	1.8					
Powell Valley [HD]	58	60	59	70	78	78	88	6.1	6.4	8.6	8.4	7.9	9.5	
Platte County [HD]	72	70	74	75	72	78	82	3.7	3.7	4.4	4	4.9	5.9	6.1
North Big Horn [HD]	72	72	75	78	62	62	66	9.3	8.1		9.8	8.4	8.8	8.6
Niobrara Community [HD]	64	67	74	49	60	69	57							
Mountain View	48	54	61	16	35	48		4.7	5.2	5.6	5.9	6.4	7.9	
Johnson County [HD]	33	35	39	43	33	36	40	4.6	4.6	4.7	5.7	6	6	6
Ivinson Memorial [HD]	64	54	44	43	45	41		2.5	2.9	3.1	3.5	3.7	3.7	
Hot Springs County [HD]	70	74	78	83	76	79	76	3.1	2.5	4.1	3.8	4.4	5.3	6.5
Evanston Regional	40	46	50	52	57	61	59	2.9	2.5	2.5	3.2	4.2	4.8	4.5
Crook County [HD]	60	64	61	66	69			9.6		8.6				
Converse County [CM]	46	48	54	51	52	58	61	4.6	5.1	5.7	5.7	5.7	6.5	7
Cheyenne Regional [CM]	64	60	49	51	55	59	63	2	2.1	2.4	2.2	2.2	2.4	2.5
Carbon County Memorial [CM]	73	60	63	65		70	73	3.7	3.6	3.1	3.4	3.7	4	4.5
Campbell County [HD]								3.1	3.4	4	3.9	4.7	5.5	5.6

FY

On average, Wyoming hospitals seem to have newer buildings and spend more per ADC than their peers. While the depreciation indicator is relatively straightforward, a high cost per ADC can indicate different things: either a relatively inefficient hospital or a hospital that has more advanced capabilities (and thus higher cost) than its peers.

Relationship with Medicare

- *Percent Medicare or Medicaid (%)* measures how much of the hospital's volume comes from public payers.
- *Adj. Medicare cost coverage (%)* shows how much Medicare revenue covers Medicare costs, adjusted upwards to include non-reimbursable cost centers.

Figure 4: Medicare dependence and cost coverage

Hospital	Percent Medicare or Medicaid (%) 2012	2013	2014	2015	2016	2017	2018	Adj. Medicare cost coverage (%) 2012	2013	2014	2015	2016	2017	2018
Wyoming Medical Center	58	57	55	55	57	58	59	75	79	78	79	80	83	86
Wyoming Behavioral Institute	34	35	34	30	31	38	36							
Weston County [HD]	67	69	60	67	79	75	70	101	101	101	100	94	92	90
West Park Hospital [HD]	66	68	66	62	59	64	62	93	92	91	90	88	89	88
Washakie Medical Center [CM]	69	70	76	71	74	76	79	101	101	101	101	101	101	101
Torrington Community	70	68	73	71	68	72	75	100	100	101	101	101	101	101
Sweetwater County [CM]	49	53	50	48	46	54	53	67	84	63	66	63	52	55
Star Valley [HD]		45	55	58	53	50	52		86	83	83	99	100	98
St. John's [HD]	39	39	39	35	38	36	42	72	93	68	68	67	64	62
South Lincoln [HD]	42	35	54	49	47	45	78	80	79	79	80	79	80	91
South Big Horn [HD]	76	65	90	83	85	79	87	100	101	101	101	101	101	101
Sheridan County [CM]	62	56	50	54	59	60	60	76	85	73	69	75	74	76
SageWest - Riverton	63	66	61	66	64	67		79	86	99	94	87	88	
SageWest - Lander	63	66						106	113					
Powell Valley [HD]	62	49	61	52	62	51	60	99	99	99	99	99	100	100
Platte County [HD]	64	71	72	79	74	81	75	101	101	101	101	101	101	101
North Big Horn [HD]	82	79	81	76	82	86	82	100	100	101	100	100	100	99
Niobrara Community [HD]	90	97	90	94	81	87	62	101	101	101	101	101	101	101
Mountain View	52	52	54	54	55	57		66	68	67	64	43	40	
Johnson County [HD]	76	69	75	71	72	70	80	101	101	101	101	101	101	101
Ivinson Memorial [HD]	59	60	58	58	58	58		90	110	75	63	69	70	
Hot Springs County [HD]	78	66	79	77	74	73	73	100	101	101	101	101	101	99
Evanston Regional	54	60	59	52	60	60	63	87	88	86	89	82	77	80
Crook County [HD]	83	90	92	82	67	87	67	101	101	101	101	101	101	101
Converse County [CM]	63	58	58	57	57	60	60	101	101	101	101	101	100	100
Cheyenne Regional [CM]	63	64	64	65	66	64	63	97	83	79	85	87	88	89
Carbon County Memorial [CM]	54	55	50	51	52	54	51	97	99	100	100	100	100	100
Campbell County [HD]	41	46	46	49	48	54	49	69	82	65	69	69	67	73

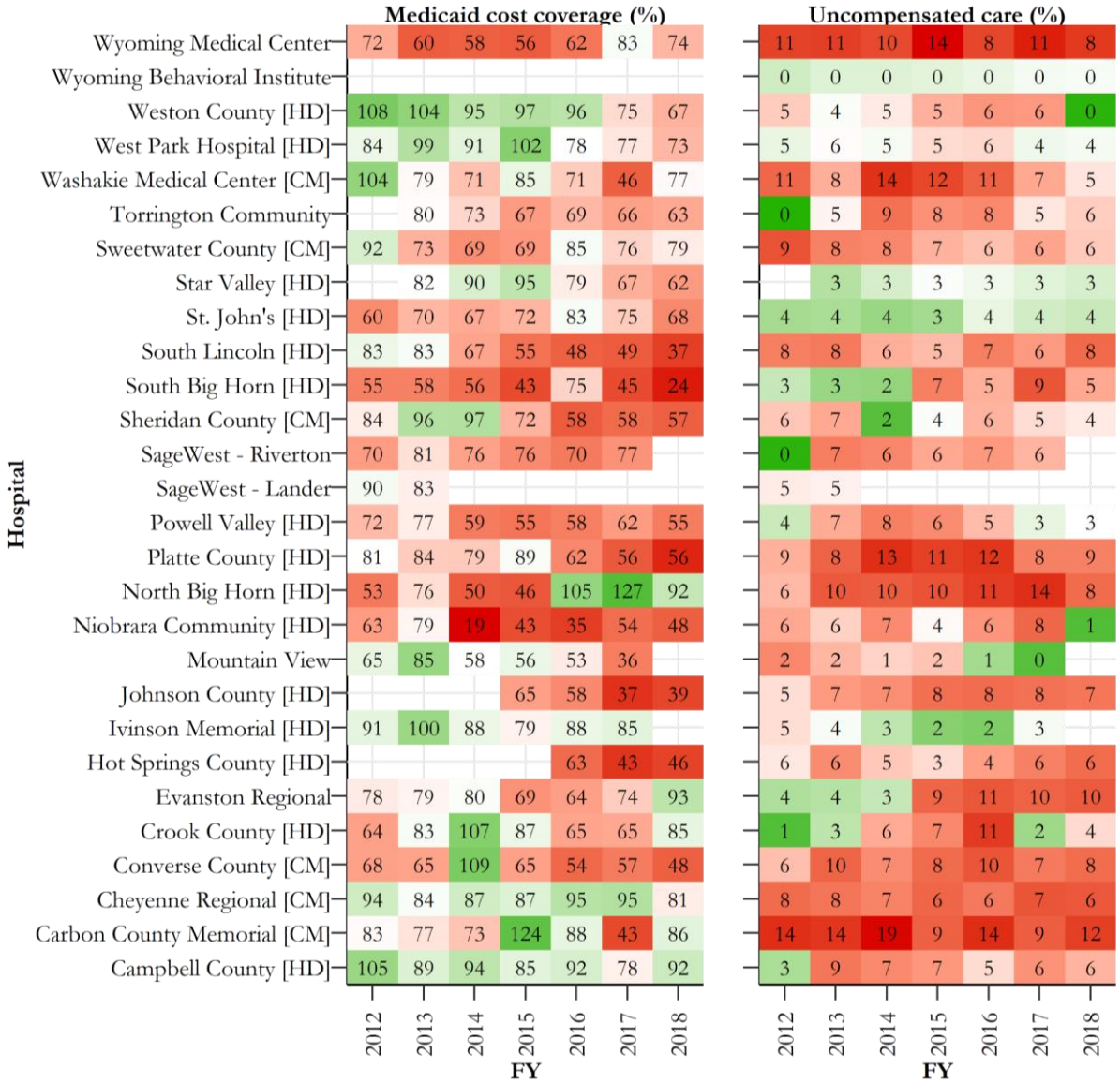
FY

Generally speaking, Wyoming hospitals largely have significantly lower public-payer volume than the national average. Medicare cost coverage also tends to be lower, though most CAHs do receive close to 101% of costs.

Medicaid and net uncompensated care

- *Medicaid cost coverage (%)* shows how Medicaid revenue compares with attributed Medicaid cost.
- *Net uncompensated care (%)* shows total uncompensated care costs (charity care and bad debt) as a percentage of total costs.

Figure 5: Medicaid cost coverage and uncompensated care



On both of these measures, Wyoming is a mixed bag — while numbers vary for each hospital, there is no distinct pattern for the State as a whole.

One important caveat, however, regarding Medicaid cost coverage. It is unclear which hospitals report revenue received through the State's Upper Payment Limit (UPL) programs in the figures above.

Table 4, below, illustrates how these UPL programs inject an additional ~ $16 million of federal money into the system and raise cost coverage from an average of 61% across all hospitals to 81%.

Table 4: SFY 2018 - Actual Wyoming Medicaid cost coverage[14]

Hospital	Medicaid Claims Paid	UPL Paid (Federal share)	Total Paid	Total Cost	Cost coverage	
					w/out UPL	w/ UPL
Wyoming Medical Center	$12,651,267	$2,072,316	$14,723,583	$16,549,465	76%	89%
Wyoming Behavioral Institute	$3,277,758	$0	$3,277,758	$2,655,301	123%	123%
Weston County	$216,076	$113,154	$329,230	$524,039	41%	63%
West Park Hospital	$2,417,898	$302,988	$2,720,886	$3,047,199	79%	89%
Washakie Medical Center	$711,773	$249,797	$961,569	$1,334,247	53%	72%
Torrington Community	$1,305,360	$365,813	$1,671,172	$2,173,215	60%	77%
Sweetwater County	$3,147,168	$1,113,682	$4,260,850	$5,368,524	59%	79%
Summit Medical Center	$19,270	$53,876	$73,146	$68,728	28%	106%
Star Valley	$1,062,269	$183,036	$1,245,305	$1,421,879	75%	88%
St. Johns'	$1,341,403	$407,727	$1,749,130	$2,201,691	61%	79%
South Lincoln	$331,059	$76,352	$407,411	$624,104	53%	65%
South Big Horn	$80,222	$93,761	$173,983	$292,305	27%	60%
Sheridan County	$2,432,357	$703,737	$3,136,094	$4,163,629	58%	75%
Sagewest - Lander	$5,292,037	$744,223	$6,036,260	$6,692,275	79%	90%
Powell Valley	$1,600,854	$734,676	$2,335,530	$3,039,120	53%	77%
Platte County	$771,781	$285,072	$1,056,853	$1,405,205	55%	75%
North Big Horn	$292,444	$40,181	$332,625	$455,115	64%	73%
Niobrara Community	$65,352	$96,649	$162,000	$260,218	25%	62%
Mountain View	$719,483	$591,234	$1,310,717	$1,646,617	44%	80%
Johnson County	$437,856	$107,023	$544,878	$655,646	67%	83%
Ivinson Memorial	$2,720,315	$863,436	$3,583,751	$4,398,758	62%	81%
Hot Springs County	$756,738	$225,269	$982,006	$1,204,956	63%	81%
Evanston Regional	$1,676,105	$812,080	$2,488,185	$3,551,893	47%	70%
Elkhorn Valley	$521,875	$119,324	$641,199	$772,972	68%	83%
Crook County	$38,740	$35,528	$74,267	$128,699	30%	58%
Converse County	$1,695,206	$551,419	$2,246,625	$2,708,984	63%	83%
Cheyenne Regional	$15,358,446	$2,953,496	$18,311,942	$24,230,245	63%	76%
Carbon County	$1,258,879	$331,836	$1,590,715	$2,056,461	61%	77%
Campbell County	$6,588,918	$1,733,575	$8,322,493	$10,461,797	63%	80%
Total	**$68,788,909**	**$15,961,255**	**$84,750,163**	**$104,093,287**	**61%**	**81%**

[14] Data from inpatient and outpatient Upper Payment Limit (UPL) reports sent to CMS, as well as QRA payment analyses.

4. Workforce and access to medical providers

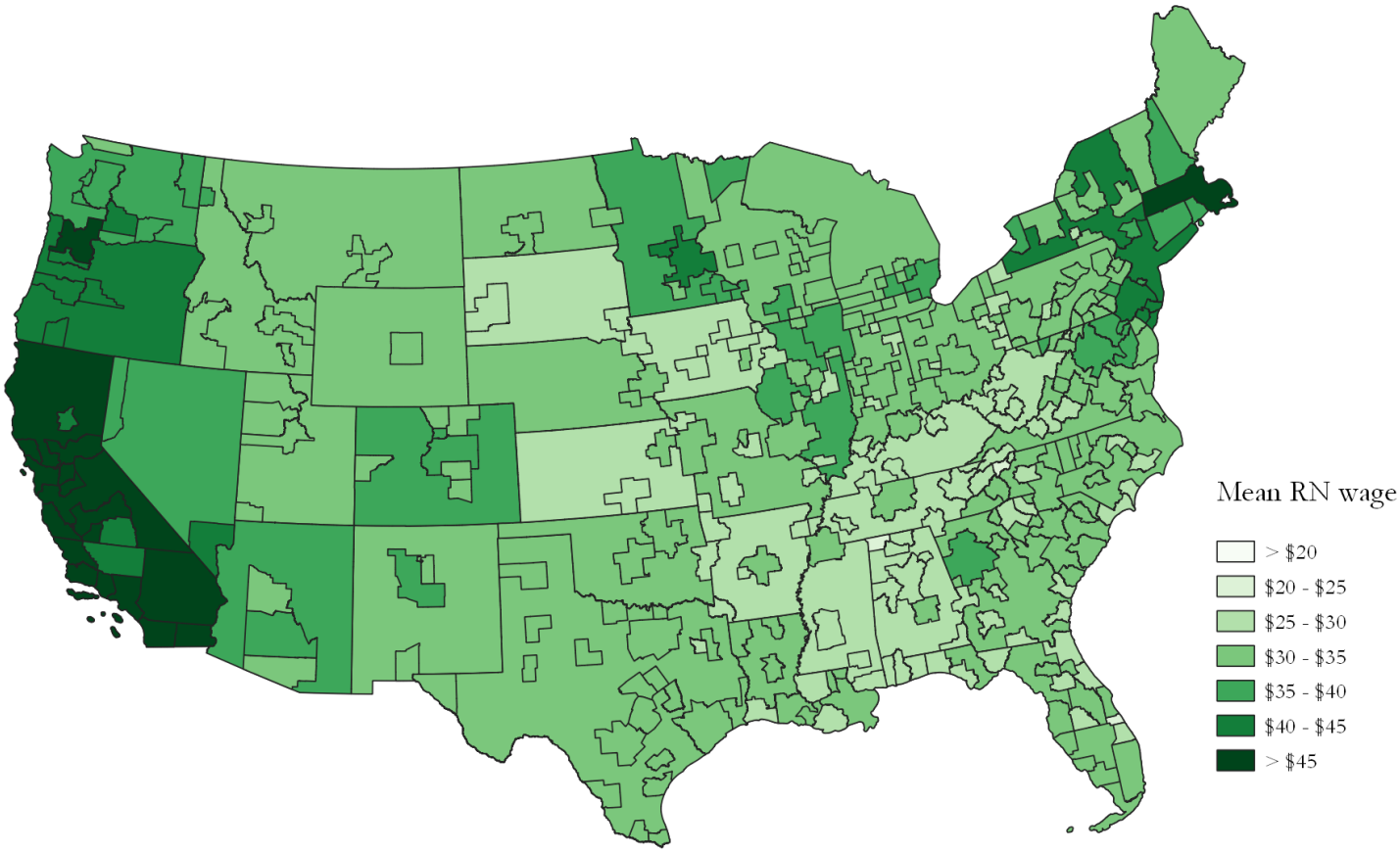
Without medical providers, hospitals are nothing but empty buildings with unused equipment. Both (1) the ability to recruit a workforce to staff the hospital and (2) the availability of physicians and specialists in the local community are critical factors in a hospital's ability to provide services.

Workforce

The single largest component of a hospital's workforce is made up of nurses.[15] How do we measure if hospitals are experiencing a workforce shortage? Basic microeconomics would suggest that the shortest way would be by looking at the price of labor — mean hourly wages for nurses — which should reflect equilibrium between supply and demand.

Interestingly, when considering this measure in a national context (Figure 6, below), Wyoming appears average.

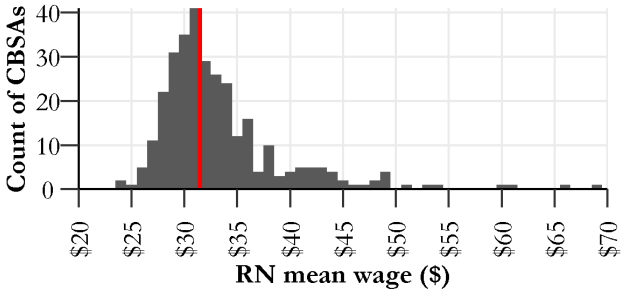
Figure 6: 2018 mean RN wage by state and statistical area[16]



[15] Nurses make up an average 30% of hospital workforce. The next largest categories are Nursing Assistants (6.7%) and Medical Secretaries (2.75%), respectively.
https://www.bls.gov/oes/current/naics4_622100.htm
[16] BLS OES.

This is also clear when looking at how Wyoming wages compare with other states and CBSAs on a distribution, in Figure 7 below. Note that while there is a significant tail for wages nearly out to $70 (representing areas like California, Massachusetts, New York and Oregon), Wyoming falls right in the middle of the bulk of the distribution.

Figure 7: Distribution of 2018 RN mean wages for Core-Based Statistical Areas. Casper is located on the red line. [17]



Wages do vary within this $25 - $35 "hump" by county, shown in Table X, below. It is difficult to conclude from this data, however, that Wyoming is experiencing more of a workforce shortage than other states.

Table 5: Mean RN wage by county. Asterisks denote regional data were used as county-level wage was not available. Teton county is likely significantly higher than its regional average would suggest, so that value has been omitted.[18]

County	Mean Wage
Albany	$31.69
Big Horn	$30.72
Campbell	$32.61*
Carbon	$31.23*
Converse	$31.23*
Crook	$32.61*
Fremont	$32.17
Goshen	$30.77
Hot Springs	$29.48
Johnson	$32.61*
Laramie	$37.77
Lincoln	$32.85

County	Mean Wage
Natrona	$30.78
Niobrara	$31.23*
Park	$34.43
Platte	$31.49
Sheridan	$33.72
Sublette	$28.62
Sweetwater	$28.65
Teton	-
Uinta	$31.76*
Washakie	$32.67*
Weston	$32.61*

[17] Wage data pulled for all geographies, to include states and Core Based Statistical Areas, for Level 9 (levels range from 6 to 11) Registered Nurses. Bureau of Labor Statistics OES.
[18] Wyoming Workforce Services. March 2019.
https://doe.state.wy.us/LMI/LEWISMarch2019ECI/toc000.htm

Local medical providers

It is clear that Wyoming does have fewer higher-level medical providers than other States. Figures 8 and 9, on the next page, show the stark difference here between Wyoming and the rest of the country.

The top graph in Figure 8 shows the number of doctors per capita by state (the grey lines), with the national average highlighted in black and Wyoming highlighted in red.

This figure illustrates two major points:

- The overall number of MDs per capita has increased since 1960, though there has been stagnation since 2005;

- Wyoming continues to rank low nationally. Idaho is the only state with fewer MDs per capita today.

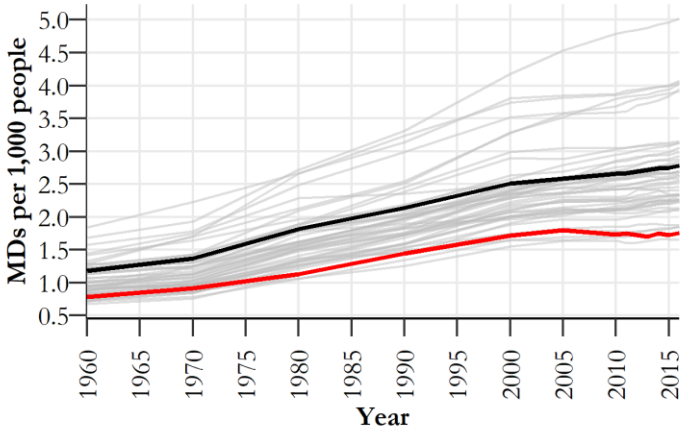
The bottom table in Figure 8 gives a breakdown by county, with values color-coded by population-weighted percentile (e.g., treating each county as if it were a state). Note on this figure the **significant variation** between counties. Teton County, for example, has more MDs per capita than most states. Laramie, Natrona, Park, Fremont and Sheridan counties are similar to the national average. Most other counties are well below average, and counties like Big Horn have even regressed.

On Figure 9, we subset the data by provider type, and look only at those providers who have been determined **to work in patient care** (as opposed to not practicing, employed in government, researching, etc.). This data is more useful, but longitudinal data is not readily available as it is for the MDs/capita indicator.

In Figure 9, the table on the left focuses on primary care and includes non-MD provider types capable of providing primary care services, such as advanced practice registered nurses (APRNs), nurse practitioners (NPs), and physician assistants (PAs).

The table on the right focuses on specialty care, including anesthesiology, radiology, emergency care, obstetrics, and surgical care.

Figure 8: Measure of physician access [non-federal MDs per 1,000 people] by state (top graph) and by county (bottom table)[19] Wyoming is shown in red.



MDs per 1,000 people

County	1960	1970	1980	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016
Weston	0	0.5	0.7	0.5	0.6	0.9	0.7	0.6	0.6	0.6	0.7	0.6	0.4
Washakie	0.4	0.9	0.6	0.8	1	1	0.7	0.7	0.9	0.8	0.8	1	0.9
Uinta	0.9	1.4	0.9	1	1.2	1.4	1.3	1.1	1	0.9	0.9	0.9	0.9
Teton	0.6	1.5	2.7	2.9	3.2	4.2	4.1	4.2	4.3	4.2	4.1	3.9	4.1
Sweetwater	0.6	0.5	0.7	0.8	1	0.9	0.7	0.8	0.8	0.9	0.9	0.9	1
Sublette	0.5	0.5	0.9	0.8	1.4	1	0.8	0.9	0.8	0.8	0.8	0.7	0.7
Sheridan	1	1	1.4	2	1.9	1.8	2.1	2.3	2.4	2.4	2.2	2.2	2.1
Platte	0.6	0.5	0.3	0.7	0.8	0.9	1	1.1	1	1	0.9	0.9	1
Park	0.9	0.9	1.1	1.4	2.3	2.3	2.4	2.3	2.4	2.3	2.6	2.6	2.5
Niobrara	0.8	0.7	0	0.4	0.4	0	0	0	0.4	0.4	0.4	0.4	0.4
Natrona	1	1.1	1.5	2.1	2.3	2.3	2.4	2.5	2.3	2.3	2.3	2.4	2.6
Lincoln	0.7	0.5	0.3	0.8	0.8	0.6	0.6	0.7	0.8	0.8	0.9	0.8	0.6
Laramie	1	1.2	1.6	2	2.3	2.3	2.3	2.4	2.4	2.3	2.3	2.3	2.3
Johnson	0.5	0.5	0.9	0.8	1.3	1.2	1.4	1.5	1.5	1.6	1.6	1.6	1.6
Hot Springs	0.9	1.2	0.9	1	2	1.5	1.2	1.3	1.2	1	1.2	0.8	0.6
Goshen	0.8	0.6	0.8	0.8	0.9	1	0.9	1	1	0.9	1	0.9	1.1
Fremont	0.6	0.7	1.5	1.9	1.9	2.1	1.8	1.8	1.8	1.8	1.9	1.9	1.8
Crook	0.2	0.2	0.4	0.4	0.3	0.6	0.3	0.6	0.7	0.7	0.7	0.7	0.7
Converse	0.5	0.7	0.4	0.5	0.7	1.3	1	1.1	0.9	0.9	1	1	1.1
Carbon	0.8	0.8	0.6	0.8	1	0.8	0.8	0.8	0.6	0.6	0.6	0.5	0.6
Campbell	0.5	0.6	0.9	1.1	1.4	1.5	1.4	1.2	1.2	1.3	1.4	1.3	1.2
Big Horn	0.7	0.9	0.5	0.6	0.4	0.8	0.5	0.4	0.4	0.3	0.3	0.2	0.2
Albany	0.8	0.9	1.2	1.5	2	2.2	2	1.7	1.6	1.6	1.7	1.6	1.6

Year

[19] Data from 2018 Area Health Resources File. HRSA.

Figure 9: Access by provider type in 2015/16, by county.[20]

County	Providers per 1,000 people						Specialists per 1,000 people					
	APRN	DO	MD	NP	PA	Total pat. care	Anesth.	Diag. rad.	Emerg.	Gen. internal	Ob-Gyn	Surg. specs
Weston	0.1	0	0.5	0.1	0.4	1	0	0	0	0	0	0
Washakie	0.6	0.1	0.9	0.5	0.2	2.3	0	0	0	0	0.1	0.2
Uinta	0.8	0.1	0.8	0.4	0.3	2.4	0	0	0.1	0.1	0.1	0.3
Teton	1.3	0.4	3.7	0.6	0.4	6.4	0.2	0.3	0.5	0.5	0.3	1.3
Sweetwater	0.3	0.3	0.8	0.2	0.3	2	0.1	0	0	0.1	0.1	0.3
Sublette	0.5	0.1	0.7	0.5	0.3	2.1	0	0	0.1	0	0	0
Sheridan	0.7	0.2	2.1	0.6	0.5	4.1	0.1	0.1	0.2	0.4	0.2	0.6
Platte	0.7	0	1	0.7	0	2.5	0.1	0	0.2	0	0	0.2
Park	0.6	0.3	2.5	0.2	0.9	4.4	0.1	0	0.1	0.3	0.2	0.7
Niobrara	0.4	0	0.4	0.4	0.2	1.4	0	0	0	0.4	0	0
Natrona	0.8	0.3	2.4	0.8	0.7	5	0.2	0.1	0.1	0.2	0.1	0.6
Lincoln	0.4	0.4	0.7	0.3	0.3	2	0	0	0	0.1	0	0.2
Laramie	1.1	0.3	2.2	1	0.5	5	0.2	0.1	0.1	0.1	0.1	0.4
Johnson	0.5	0.1	1.6	0.3	0.2	2.8	0	0	0.2	0.1	0	0.2
Hot Springs	0.4	0.4	0.7	0	0.6	2.2	0	0	0	0	0	0.3
Goshen	0.4	0	1	0.2	0.1	1.8	0	0	0	0	0	0.1
Fremont	0.7	0.1	1.8	0.5	0.3	3.5	0.1	0.1	0.1	0.2	0.1	0.3
Crook	0.4	0	0.7	0.4	0.3	1.7	0	0.1	0	0	0	0.1
Converse	0.5	0.1	0.9	0.2	0.6	2.4	0	0.1	0	0.1	0	0.4
Carbon	0.4	0.2	0.5	0.2	0.6	2	0.1	0	0.1	0	0	0.1
Campbell	0.5	0.1	1.2	0.3	0.3	2.5	0.1	0	0.1	0.1	0.1	0.3
Big Horn	0.2	0	0.2	0.2	0.2	0.9	0	0	0	0	0	0
Albany	0.9	0.2	1.6	0.8	0.2	3.7	0.2	0.1	0.1	0.3	0.1	0.4

Note on the table above, that Wyoming does make up somewhat for its lack of physicians in increased employment of allied health professionals. It's employment of Physician Assistants, for example, is often higher than average.

[20] Data from 2018 Area Health Resources File. HRSA.

5. Ambulance capabilities

In addition to nurses and physicians, Emergency Medical Services (EMS) and their ability to transport patients while providing medical care are important inputs to hospital capabilities. These services are particularly critical in Wyoming due to the long distances we all travel.

Table 6, below, lists the various ground ambulance services around Wyoming, along with the count of registered ambulances and staff (licensure data is available, but not shown due to space). We also categorize each service by type. Services operate along a variety of different business models, ranging from all-volunteer services in smaller communities, to hospital-based ambulances, to fire departments and county/city entities, to fully commercial entities.

Finally, we include the estimated area and population served. While there are not defined "service areas" for these EMS providers per se, the map on subsequent pages attempts to illustrate the areas where certain services have the highest probability of response.[21] We use these regions to calculate the area and populations served in the table below.

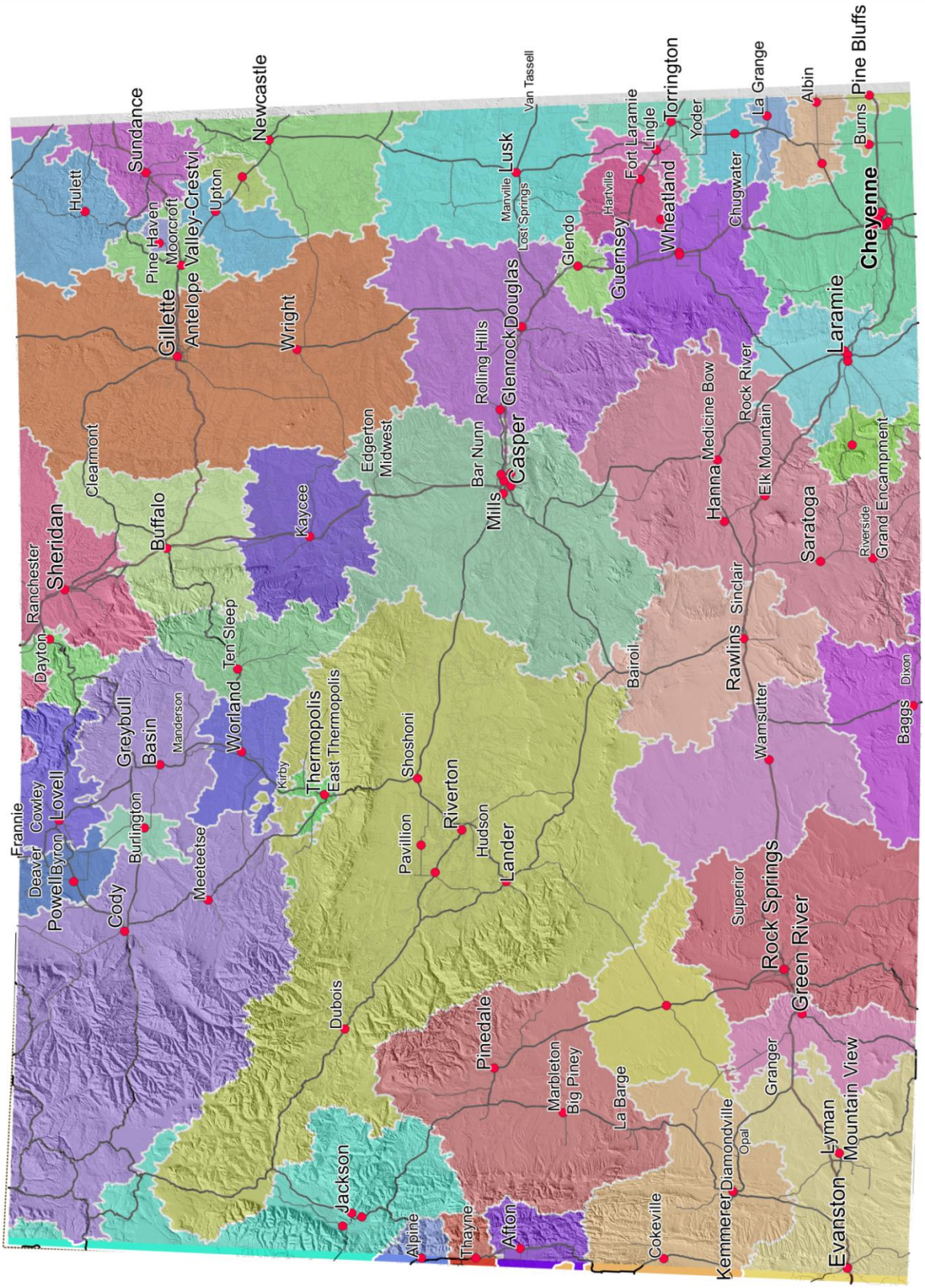
Table 6: Wyoming ground ambulance services[22]

Service	Type	City	Ambulances	Personnel	Service area (sq. miles)	Population (000s, 2010)	Area per ambulance	Pop per ambulance	Personnel per ambulance
Albin Rescue	Volunteer	Albin	2	15	481	0.7	240	369	7.5
Alpine EMS	Fire Dept.	Alpine	2	17	232	2.4	116	1192	8.5
AMR	Commercial	Cheyenne	12	73	2412	89.4	201	7453	6.1
AMR - Fremont County	Commercial	Riverton	17	44	14373	41.1	845	2416	2.6
BHFD #4 Burlington	Fire Dept.	Burlington	2	11	273	0.8	137	394	5.5
Burns EMS	Volunteer	Burns	1	11	26	0.4	26	359	11.0
Campbell County Health EMS	Hospital	Gillette	7	35	6865	46.4	981	6628	5.0
Carbon County EMS	Hospital	Rawlins	4	16	2404	10.2	601	2541	4.0
Castle Rock Ambulance Service	Hospital	Green River	3	32	1087	13.2	362	4394	10.7
Centennial Fire & Rescue	Fire Dept.	Centennial	1	6	481	0.6	481	574	6.0
Cody Regional Health EMS	Hospital	Cody	9	38	9056	23.0	1006	2555	4.2
Dayton Rescue Unit	Volunteer	Dayton	1	3	869	2.6	869	2624	3.0
Eden Valley Ambulance Service	Volunteer	Farson	2	6	397	1.3	199	672	3.0
Evansville Emergency Services	Fire Dept.	Evansville	3	35	1741	0.8	580	280	11.7

[21] See Technical Appendix for more detail.
[22] Data from Wyoming OEMS. Retrieved 9/10/2019.

Service	Type	City	Ambulances	Personnel	Service area (sq. miles)	Population (000s, 2010)	Area per ambulance	Pop per ambulance	Personnel per ambulance
Fort Laramie Volunteer FD	Fire Dept.	Ft. Laramie	1	4	526	1.9	526	1933	4.0
Glendo Volunteer Ambulance	Hospital	Glendo	1	13	328	0.5	328	487	13.0
Hawk Springs Fire Department	Fire Dept.	Hawk Springs	1	5	378	0.6	378	622	5.0
Hulett EMS Inc	Volunteer	Hulett	2	12	1273	1.3	637	673	6.0
Jackson Hole Fire/EMS	Fire Dept.	Jackson	6	76	2920	21.1	487	3516	12.7
Johnson County EMS - Buffalo	Commercial	Buffalo	4	24	1943	8.0	486	1988	6.0
Johnson County EMS - Kaycee	Volunteer	Kaycee	2	19	1698	0.8	849	412	9.5
LaGrange Rescue Unit	Volunteer	LaGrange	1	5	231	0.6	231	630	5.0
Laramie Fire Department	Fire Dept.	Laramie	5	46	1507	35.0	301	7009	9.2
Lingle Fire Department	Fire Dept.	Lingle	1	4	319	1.1	319	1145	4.0
Little Snake River EMS	Volunteer	Baggs	2	15	1464	1.0	732	493	7.5
Lusk EMS	Hospital	Lusk	3	12	2453	2.6	818	860	4.0
Converse County Memorial	Hospital	Douglas	6	25	3534	13.8	589	2306	4.2
Moorcroft Ambulance	Volunteer	Moorcroft	2	11	553	2.3	276	1165	5.5
Mortimore Ambulance Service	Funeral Home	Thermopolis	3	18	169	4.3	56	1447	6.0
Newcastle Ambulance Service	Commercial	Newcastle	4	18	1593	5.3	398	1338	4.5
North Big Horn Hospital	Hospital	Lovell	3	21	896	5.5	299	1843	7.0
Osage Volunteer Ambulance	Volunteer	Osage	2	3	243	0.3	121	162	1.5
Pine Bluffs EMS	Volunteer	Pine Bluffs	2	10	110	1.4	55	695	5.0
Platte County Hosp.	Hospital	Wheatland	7	21	2065	6.8	295	977	3.0
Powell Hospital EMS	Hospital	Powell	5	37	503	10.7	101	2133	7.4
Rocky Mtn. Ambulance Svc.	Commercial	Sheridan	7	38	1667	27.4	238	3915	5.4
South Central WY EMS	Commercial	Elk Mountain	8	27	5621	5.2	703	648	3.4
South Lincoln EMS	Hospital	Kemmerer	5	18	2613	4.7	523	948	3.6
Star Valley Health- EMS	Hospital	Afton	4	24	535	5.8	134	1459	6.0
Sublette County EMS	County/City	Pinedale	6	31	4129	10.8	688	1799	5.2
Sweetwater Medics LLC	Commercial	Rock Springs	7	32	3645	28.7	521	4107	4.6
Ten Sleep Ambulance Service	Volunteer	Worland	2	15	1224	0.7	612	357	7.5
Thayne Ambulance Service	Volunteer	Thayne	2	18	226	4.4	113	2180	9.0
Torrington EMS	County/City	Torrington	3	16	514	10.2	171	3399	5.3
Town of Pine Haven EMS	Volunteer	Pine Haven	1	6	83	0.9	83	852	6.0
Uinta County EMS	County/City	Evanston	8	74	2895	21.5	362	2690	9.3
Upton Fire Department	Fire Dept.	Upton	2	8	666	1.5	333	773	4.0
Wamsutter EMS	County/City	Wamsutter	2	11	2845	0.5	1423	256	5.5
Washakie County EMS	County/City	Worland	4	20	847	7.7	212	1933	5.0
Wyoming Medical Center	Hospital	Casper	10	40	5164	75.3	516	7534	4.0

Map 2: EMS predicted service areas



Air ambulances also play an important role, particularly in two significant use cases:

- Helicopters being able to access areas where ground ambulances can't travel;
- Helicopters and planes transporting patients from hospitals to higher levels of care, without taking a ground ambulance out of service in a local area.

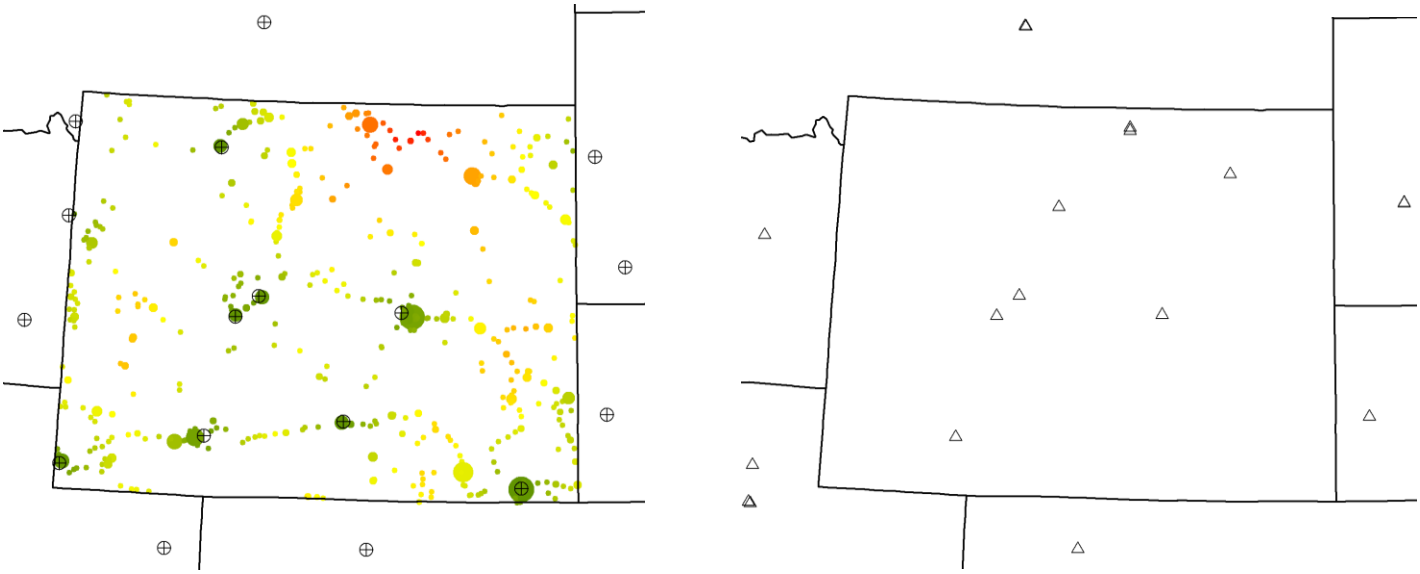
Figure 11, below, illustrates current base locations in and around Wyoming for helicopters (left) and planes (right).

On the helicopter figure, cities and towns in Wyoming are color-coded according to how close they are (as the helicopter flies) to the nearest base.

We do not include this for the fixed-wing figure, since this kind of geography matters less for planes:

- Planes fly faster and go further than helicopters.
- Planes must take off and land from an airstrip. This adds logistical complications (e.g., driving the patient from the hospital to the airstrip) and time.

Figure 11: Air ambulance base locations [23]



For more details on air ambulance patterns in the State, please see the Wyoming Air Ambulance Waiver report also submitted by the Department of Health.

[23] Data from Wyoming Office of Emergency Medical Services, as of June, 2019.

Statewide Access to Time-Sensitive Care

Key Takeaways	
Pages 28-33	**Drive time.** Wyoming's geography poses challenges for access to time-sensitive care. Drive-time to hospitals, as well as service availability, can impact health outcomes for more emergent conditions, like stroke, heart attack, trauma, and childbirth.
Page 31 - 40	**Capabilities.** Not all hospitals in Wyoming have the same capabilities to treat time-sensitive conditions. For example, few hospitals in Wyoming are able to provide services for childbirth when the delivery has significant complications, and there are no Level I trauma centers.
Figures 17, 24	**Access.** In looking at locations for potential new hospitals, Riverton and Pinedale stand out in the data as having worse access than other areas of the State.

1. Overview of time-sensitive conditions

Wyoming's wide open spaces often require people to drive a long way for any services. Most people that live here accept that. But when it comes to certain hospital services, these increased distances can create health risks.

Some of these risks can be mitigated by trained first responders, who can provide an initial assessment and some level of medical intervention. Often, however, patients require interventions which are only available at hospitals, and are only authorized to be performed by personnel in such facilities

Major relevant conditions here include heart attacks, strokes, traumas, and pregnancy/birth complications.

Heart attacks

Heart disease is the leading cause of death in the United States[24] and Wyoming[25], accounting for nearly one in every four deaths. Coronary heart disease, the most common type of heart disease, is also the leading cause of heart attacks. Narrowing or blockage within a heart occurs during a heart attack, and heart muscle begins to die within 23-30 minutes due to a lack of oxygen[26].

Some medications such as aspirin and nitroglycerin may be administered by qualified emergency personnel in the field[27], but patients suffering from heart attacks require interventions such as thrombolytic therapy or percutaneous coronary intervention (PCI), which are only performed in a hospital setting.

[24] https://www.cdc.gov/nchs/data/nvsr/nvsr67/nvsr67_06.pdf
[25] https://www.heart.org/-/media/files/about-us/policy-research/fact-sheets/quality-systems-of-care/quality-systems-of-care-wyoming.pdf?la=en&hash=8B8DEEB25AA5102C6CA3D54D5DB228EE96927E79
[26] J. J. Mistovich & K. J. Karren, Prehospital Emergency Care, 10th ed.
[27] W.S. 33-36-101, OEMS Rules, Chapter 17 "Scopes of Practice"

For every hour in delay in hospital arrival, there is a significant increase in risk of death[28]. Every minute of delay of treatment (including transportation time and time between arriving at a hospital and receiving treatment) has a measureable impact on risk of death[29]. The Wyoming Office of Emergency Medical Services (OEMS) Chapter 15 Rules note that "current evidence shows improved clinical outcomes when the PCI is performed less than 90 minutes from the onset of symptoms".

Stroke

Stroke is the 5th leading cause of death in the United States[14] and in Wyoming[15], and is the third leading cause of death among women[14].

While strokes ultimately kill or debilitate people by depriving the brain of oxygen, there are two main types of stroke that have very different treatment protocols. Being able to quickly distinguish between the two types of stroke by imaging the brain with a CT or MRI scan is therefore critical.

(1) **Ischemic strokes** involve a blood clot blocking the flow of blood to the brain. There are two sub-types of ischemic strokes:

- Thrombotic strokes, which are formed in an artery leading to the brain; and,
- Embolic strokes, where the clot forms elsewhere and migrates.

Ischemic strokes make up the majority (~87%) of stroke cases. Treatment is typically a thrombolytic agent (tissue plasminogen activator, or tPA) administered via IV within a maximum time window of ~ 4 hours, though earlier is better.

(2) With **hemorrhagic strokes**, however, this kind of thrombolytic therapy can make things far worse. These strokes occur when a blood vessel bursts and begins bleeding into the brain. While these strokes are less common (~15% of all cases), they are often deadlier. Treatment depends on the circumstances of the bleed; there is no single accepted therapy.

In both cases, the risk of death increases as the time from onset to treatment widens.[30] OEMS Rules direct personnel to transport stroke patients to the most capable facility which does not increase transport time by 60 minutes or more, and indicate that there is a 6 hour window for the effective treatment of stroke.

Trauma

Trauma is 3rd leading cause of death in the United States[1] and Wyoming[2], and the leading cause of death for individuals under the age of 35[1]. The "golden hour" is the

[28] https://www.ahajournals.org/doi/10.1161/JAHA.119.012188
[29] https://www.ahajournals.org/doi/full/10.1161/01.cir.0000121424.76486.20
[30] https://www.ncbi.nlm.nih.gov/pubmed/23389413

industry standard which recommends critical trauma patients should be assessed and transported in less than 60 minutes[31].

There are some studies which support this practice, indicating that outcomes are improved with a reduced amount of time prior to reaching a hospital[32], and that the risk of death increases significantly when a pre-hospital time exceeds 60 minutes[33] In some trauma cases, there is a marked increase in risk of death after only 30 minutes.[34]

Other studies indicate that longer pre-hospital times are acceptable, given that trained medical professionals are on scene and providing interventions[11]. Similar to stroke patients, OEMS Rules require that trauma patients who meet certain criteria be transported to a facility with the highest level of capability as possible in consideration of the patient's condition and transportation time.

Childbirth

Pregnancy-related complications which can result in maternal or fetal death often need fast interventions, often in a hospital setting. Pulmonary embolism is the leading cause of death in pregnant women, but can the risk of death drops significantly with timely administration of anticoagulants[35]. Hypertensive disorders, which account for about 7% of maternal deaths, necessitate the administration of antihypertensive drugs within 30-60 minutes to reduce the risk of maternal stroke[36]. Antihypertensive medications cannot be administered by emergency medical personnel in the field in accordance with OEMS Chapter 17 Rules.

In the next section, we will examine access to two of these conditions: childbirth and trauma.

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[31] J. J. Mistovich & K. J. Karren, Prehospital Emergency Care, 10th ed.
[32] https://www.ncbi.nlm.nih.gov/pubmed/29617208
[33] http://dx.doi.org/10.1016/j.injury.2014.08.043
[34] https://emsfellowship.com/wp-content/uploads/2018/12/LTOWB20.pdf
[35] http://dx.doi.org/10.1097/AOG.0b013e3182411907
[36] The American College of Obstetrics and Gynecologists, Clinical Guidance & Publications, Committee Opinion 767

2. Childbirth

Giving birth can be a health risk to women and children that often requires hospitalization. Out of the 6,000 - 7,000 total births in Wyoming each year, only 120 to 200 (2 - 2.5%) occur at home.

This is generally a good thing. In the early 20th century, when most births took place at home, approximately 137 out of every 1,000 infants would die before their first birthday.[37] In 2017, the infant mortality rate in the United States was 5.8 per 1,000 — a staggering decrease that represents a triumph of both public health and the medical profession.[38]

The "risk" of childbirth more generally —modeled in this study as the Total Fertility Rate — is largely a function of age. Women's risk begins in the teenage years, peaks in the 20s, and largely ends by the late 40s. Figure 12, on the next page illustrates how the shape of this function varies by county in Wyoming.

Some interesting exceptions to the average trend include:

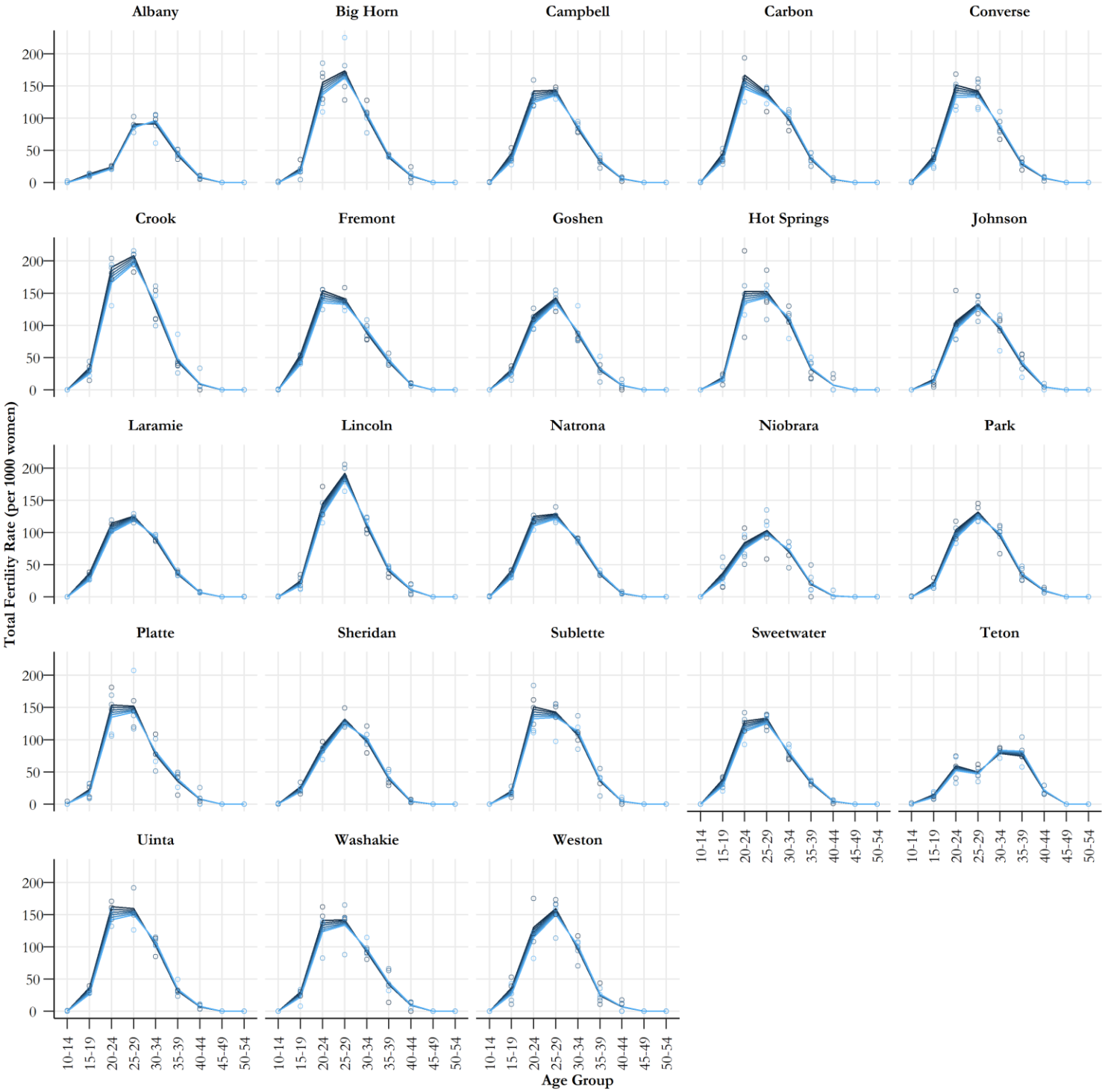
- Albany County, with a lower fertility rate, likely due to the large college-age population at UW.
- Teton County, with an overall lower rate, but higher-than-average rate in the later years, likely reflecting a more affluent population.
- Crook and Lincoln counties having higher-than-average birth rates in women in their early 20s.

Over time (2012 - 2017 are shown in darker to lighter blue lines on the figure), rates by age seem to be fairly stable, with the exception of a steady decrease in teen and 20-24 year old birth rates.

On page 33, Figure 13 shows how those fertility rates are combined with population estimates to show the trend in total births across counties and over time.

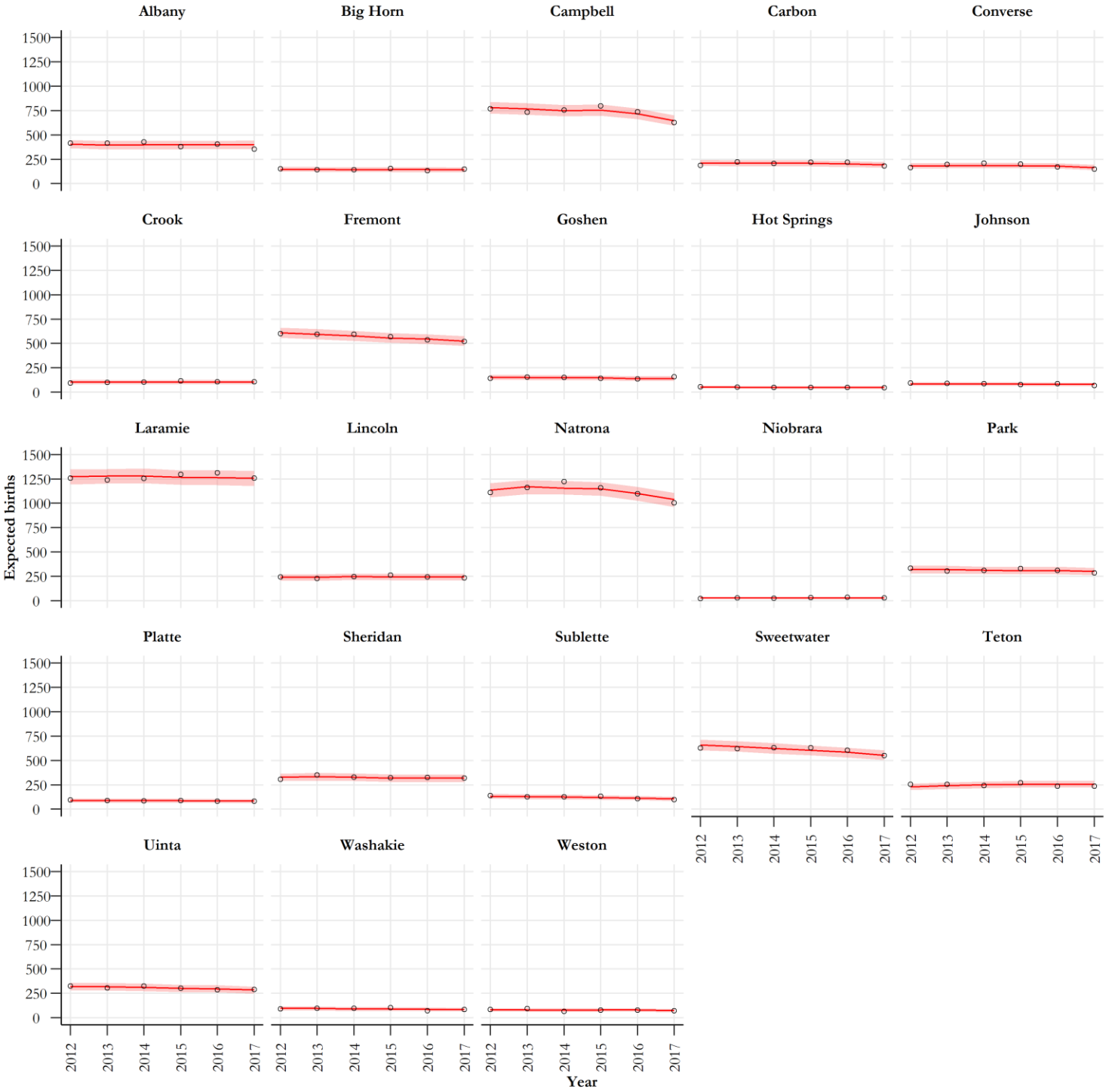
[37] Brosco, Jeffrey. The Early History of the Infant Mortality Rate in America: "A Reflection Upon the Past and a Prophecy of the Future." Pediatrics. Feb. 1999.
[38] https://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm

Figure 12: Total fertility rate by age group, county and year[39]



[39] Birth data from WDH Vital Statistics Service, combined with county and age-group Census estimates. See Technical Appendix for more detail.

Figure 13: Trends in total births by county and year[40]



[40] Predicted births from previous model shown as red lines and shaded 95% credible intervals. Actual births by county are the hollow black points.

Not all hospitals have the same capability to deal with complications in childbirth. This study relies on American Hospital Association survey data to characterize hospitals in three ways:

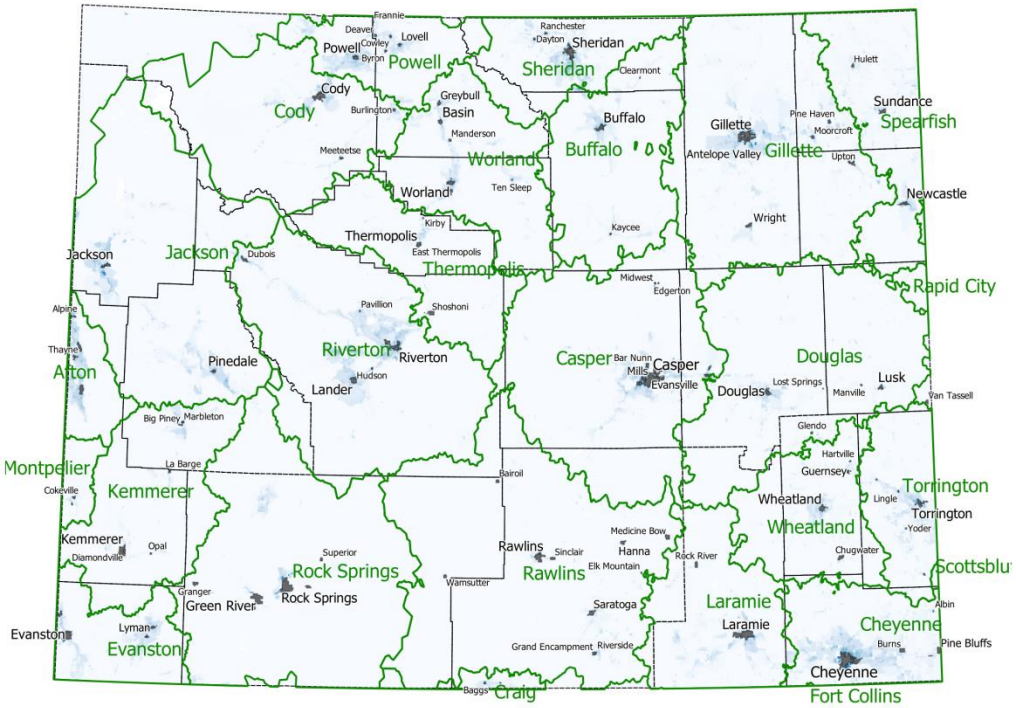
- Those capable of performing **uncomplicated** delivers;
- Those that can deal with **some complications**; and
- Those that can deal with **major complications**, like significantly premature babies that require a Neonatal Intensive Care Unit (NICU).

Figures 14 through 16, below, show how access to these levels varies around the State.[41]

On Figure 14, for example, the green lines indicate regions around the closest hospital (green label) capable of performing uncomplicated deliveries. This is probably the most meaningful figure, since run-of-the-mill births are usually driven to the closest hospital.

Drive times are less relevant for Figures 15 and 6, since complicated deliveries likely begin at a lower-level hospital and mothers are often transported to higher levels of care via air ambulance.

Figure 14: Closest hospitals for uncomplicated deliveries



[41] To create each figure, we calculate a driving distance matrix between every hospital and a gridded population dataset of Wyoming. We used Gridded Population of the World (GPW) v4 for Wyoming and surrounding states (Socioeconomic Data and Applications Center (SEDAC) at Columbia University). Batch drive times were calculated using the Open Source Routing Machine (osrm) and osrmr R package, with a North American Open Street Map dataset accessed from geofabrik.de

Figure 15: Closest hospitals for deliveries with some complications

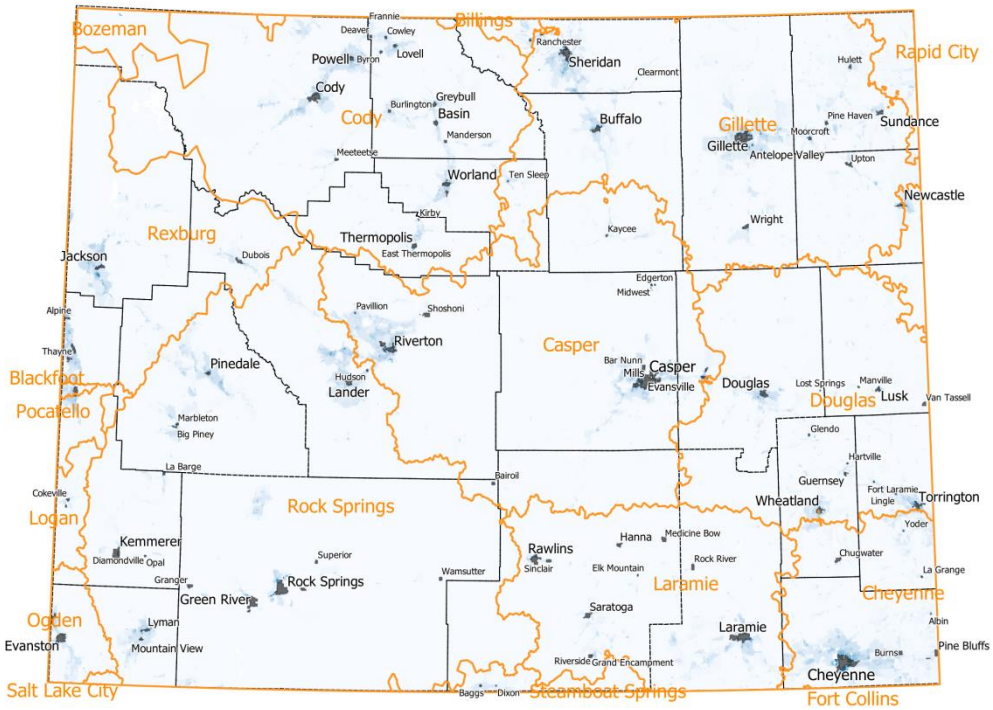


Figure 16: Closest hospitals for deliveries with major complications

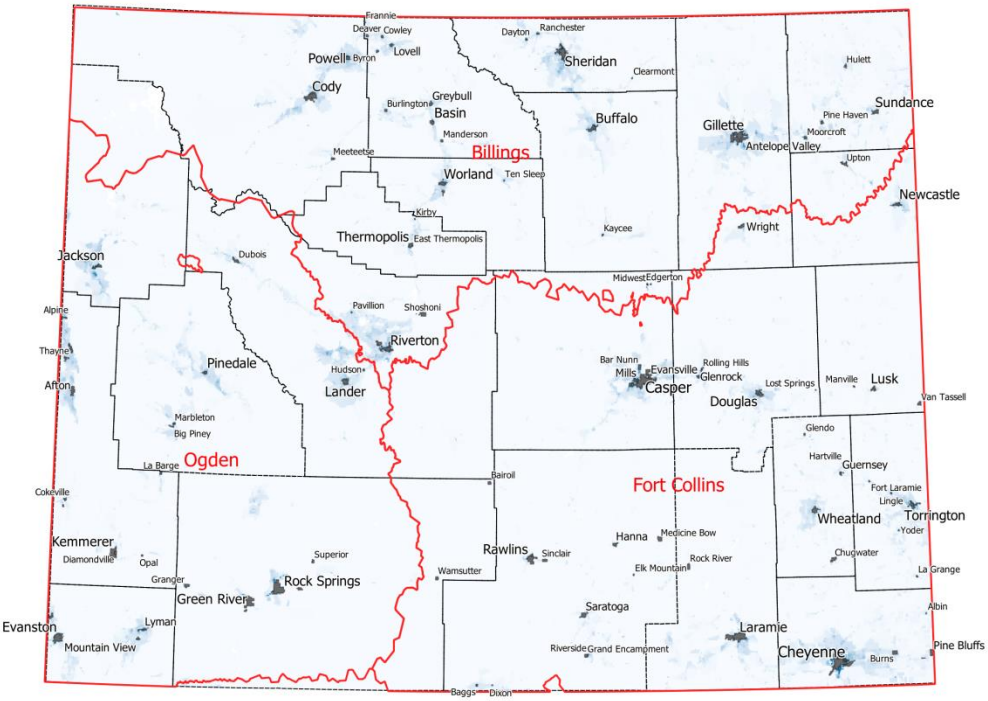
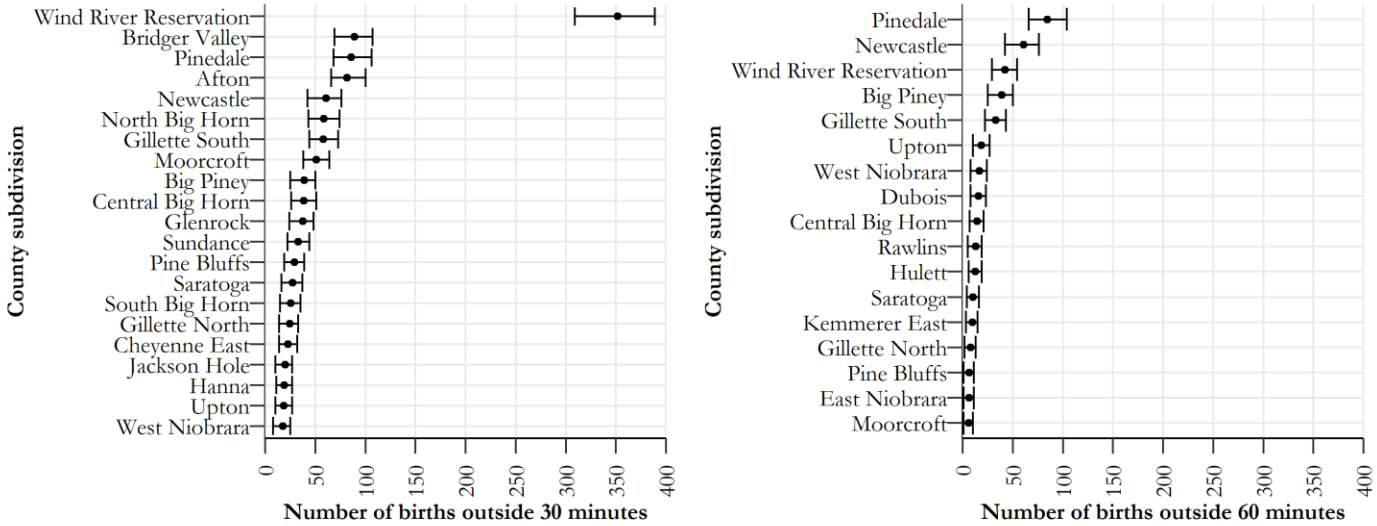


Figure 17 below summarizes a measure of access: drive time to the closest hospital for uncomplicated deliveries. The figure only shows the twenty county subdivisions with the lowest access.

Note on the figure that while the Riverton/Wind River Reservation area has one of the highest numbers of mothers having to drive at least 30 minutes, there are more mothers in the Newcastle and Pinedale/Big Piney areas that have to drive over 60 to 90 minutes.

Figure 17: Estimated count of mothers needing to drive at least 30 minutes (left) and 60 minutes (right) for **uncomplicated deliveries**, worst 20 county subdivisions on each measure.[42]



Note on the figure above that the Riverton area ("Wind River Reservation") has a significant number of women who have to drive at least 30 minutes, and a non-insignificant number that must drive over an hour.

Pinedale and Big Piney both have smaller populations, and thus smaller numbers of births, but rank at the top of mothers having to drive over an hour.

Other areas in the State also have access issues (e.g. Newcastle), but often this relates to the lack of capability at an existing hospital.

[42] The estimates on this figure come from running the Total Fertility Rate model on the gridded population data to estimate the number of births, then taking those points with longer than 30/60/90 minute drive times.

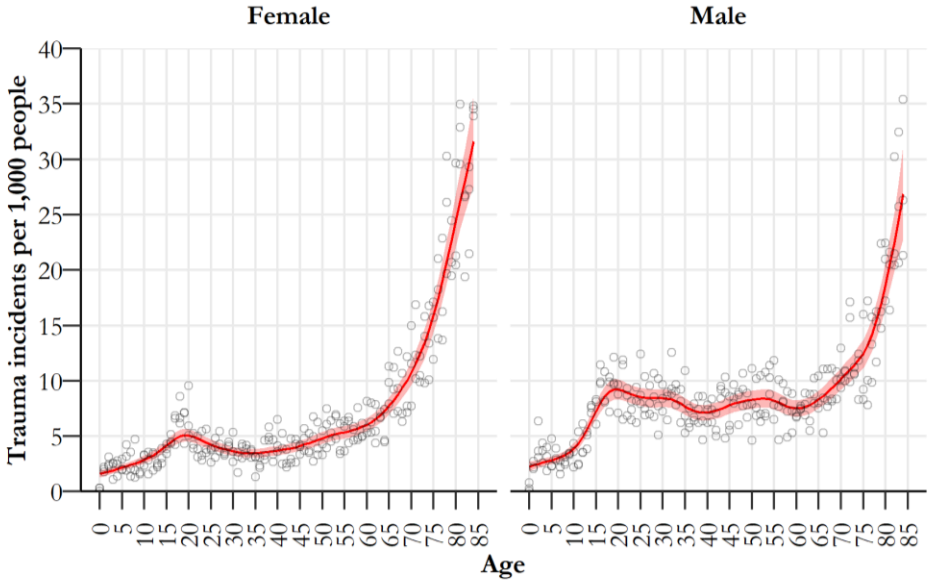
3. Trauma

One of the clearest cases of geographic need for hospital services is in cases of trauma; that is, unintentional or intentional injuries, ranging from motor vehicle crashes to gunshot wounds to falls.

Figure 18, below, uses data from Wyoming's Trauma Registry to estimate the risk of a trauma incident by age and sex. Note a few points on the figure:

- Risk is low for children, but rapidly increases during adolescence and peaks at age 20 for both men and women.
- Risk is higher for men and boys up until age 70.
- After age 70, risk grows significantly for both sexes. Falls are one of the most common sources of trauma in the elderly.

Figure 18: Risk of trauma hospital visit, by age and sex[43]



In an ideal world, severely-injured trauma victims would receive care at a trauma center within the 'golden hour'. Making this happen is the responsibility of a trauma system made up of physicians, hospitals and emergency responders.

[43] Data from Wyoming Trauma Registry, with denominator from US Census population estimates by age and sex. See technical appendix for detail.

As with childbirth, hospital capacity varies widely to deal with trauma. The American College of Surgeons Committee on Trauma **verifies** hospitals as meeting certain standards:

- A **Level I Trauma Center** is capable of providing total care for every aspect of injury, from prevention through rehabilitation. These centers have 24-hour in-house coverage of general surgery as well as rapid availability of specialty care (e.g., orthopedic surgery, anesthesiology, radiology, etc.)

- A **Level II Trauma Center** provides definitive care for all injured patients, to include 24-hour coverage by general surgeons, as well as specialty care coverage.

- A **Level III Trauma Center** has demonstrated ability to assess, resuscitate, and stabilize injured patients, to include 24-hour coverage of emergency medicine physicians and rapid availability of general surgeons and anesthesiologists. Transfer agreements are in place with Level I or Level II centers.

- A **Level IV Trauma Center** provides 24-hour physician coverage for resuscitation and stabilization of injured patients before transfer.

States are also free to **designate** different trauma levels. In Wyoming, there are:

- A **Regional Trauma Center** (RTC) roughly corresponds to a Level II center, providing advanced care to trauma patients and serves as a referral center for lower levels. Casper and Cheyenne are Wyoming's RTCs.

- An **Area Trauma Hospital** (ATH) has the capability to provide care for the majority of trauma patients. Neurosurgeons are not required on staff.

- A **Community Trauma Hospital** (CTH) is a lower level of care that may not have 24-hour coverage of an emergency department, and may only have one surgeon on staff.

- A **Trauma Receiving Facility** (TRF) can range from a hospital with no surgeon to a rural clinic. These facilities can only resuscitate and stabilize before shipping to a higher level.

The figures on the next pages illustrate which regions of Wyoming are closer to these levels of care, beginning with the Community Trauma Hospitals.

Figure 19: Closest Level IV / CTH or higher-level trauma center, driving distance[44]

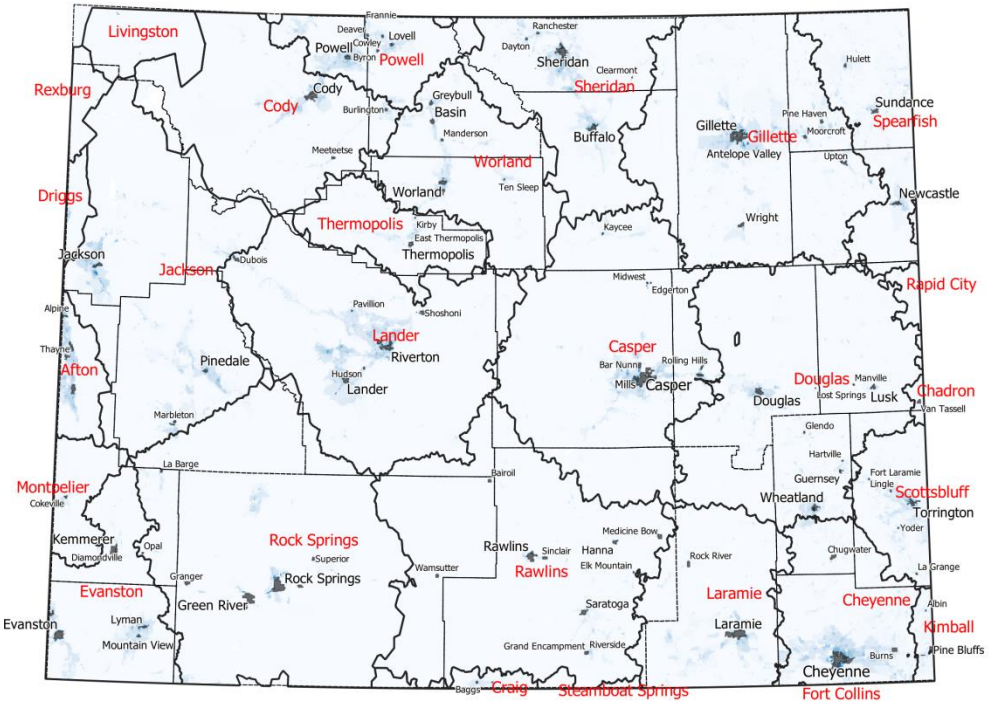
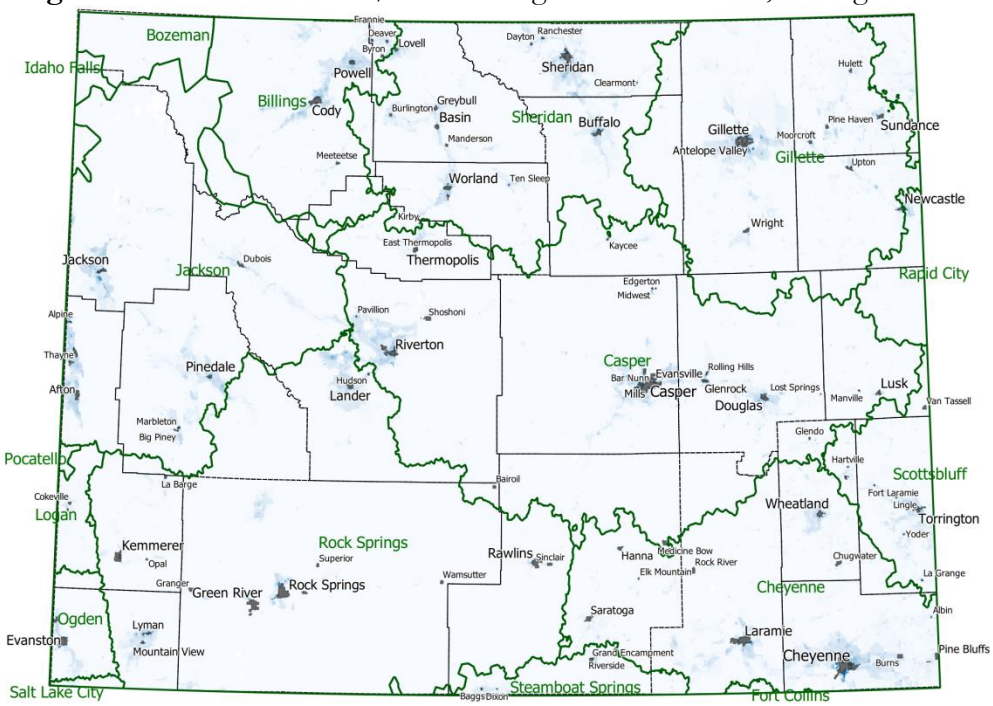


Figure 20: Closest Level III / ATH or higher trauma center, driving distance



[44] Data on this and subsequent travel-time charts is from the American Trauma Society - Trauma Information Exchange Program. Accessed 9/5/2019.

Figure 21: Closest Level II / RTC or higher trauma center, driving distance

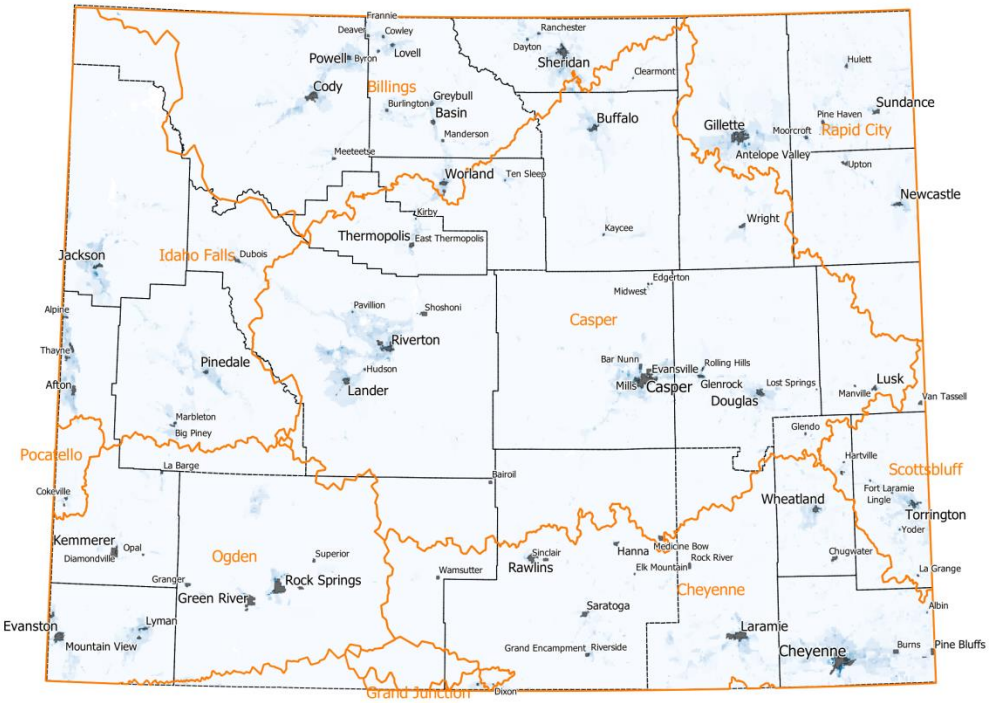


Figure 22: Closest Level I trauma center, driving distance

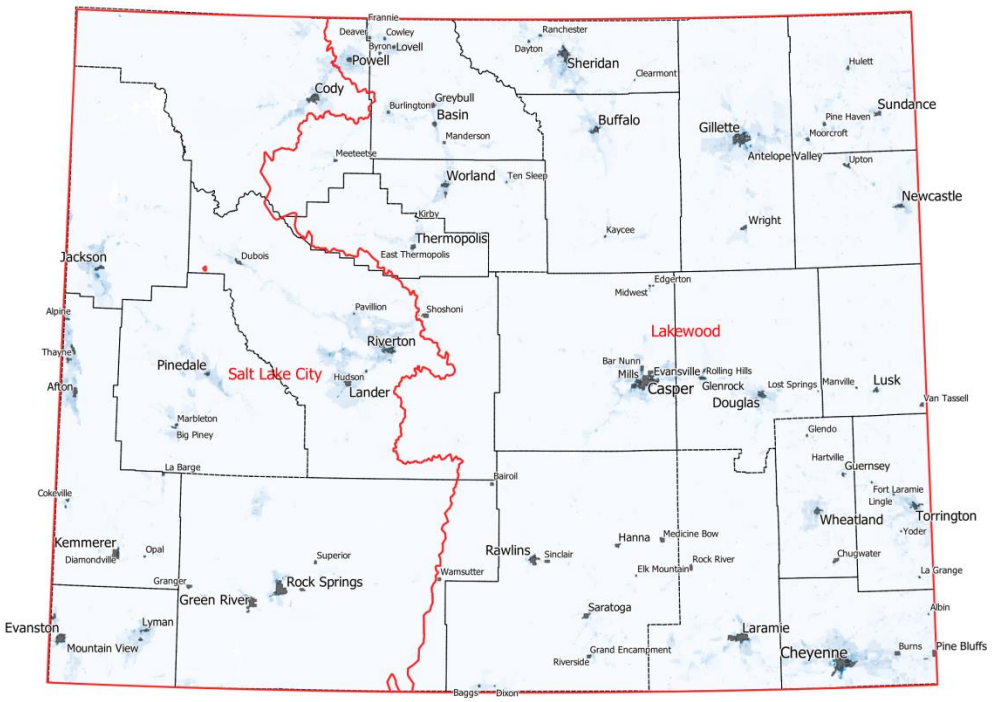
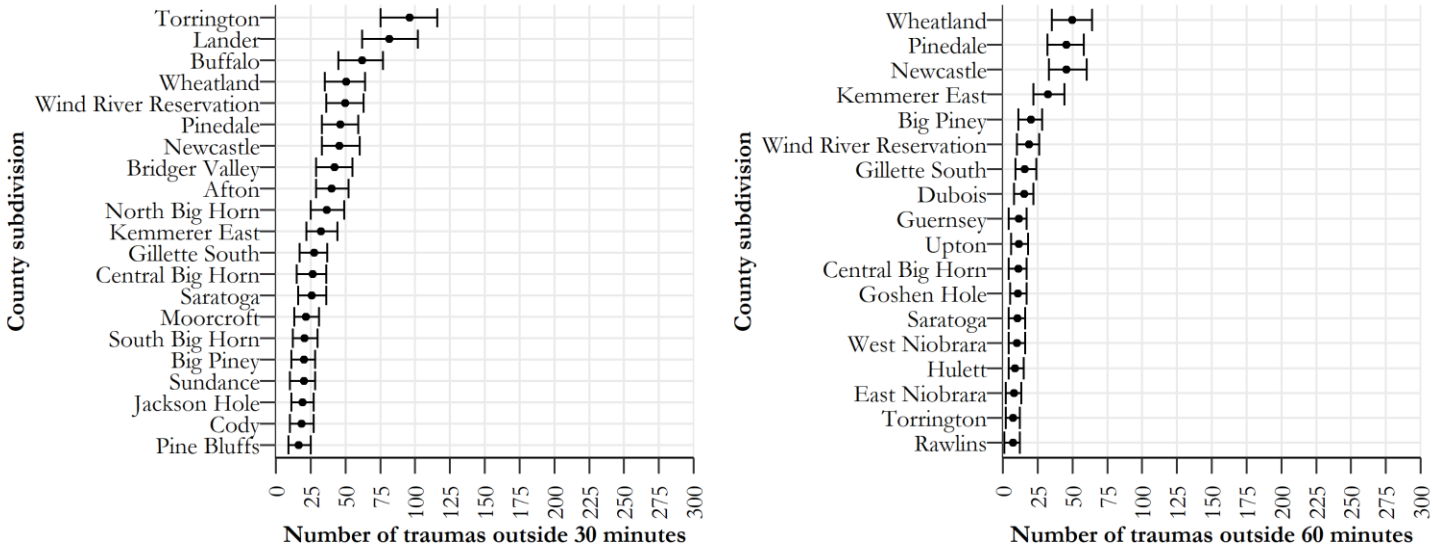


Figure 24: Estimated count of trauma cases needing to drive at least 30 minutes (left), or 60 minutes (right) to a **Level IV** trauma center, worst 20 county subdivisions.



While Riverton and Pinedale rank on both lists, the lack of capacity for the hospitals in Wheatland, Torrington and Newcastle put them at the top of the trauma measure.

Nonetheless, in terms of constructing new hospitals, there appears to be more justification for these two hospitals than for Saratoga.

4. A note on stroke and heart attacks

As with trauma, stroke and heart attacks are clearly time-sensitive conditions where geographic access to care matters.

Unfortunately, available data, either through accrediting bodies or in databases like the American Hospital Association survey or the CMS Cost Reports, is insufficient to categorize hospitals into various levels of care.

- While Wyoming technically has a program to implement recognition of Stroke and Heart Attack designations, only one hospital in the State -- Wyoming Medical Center -- has applied and received this designation. Cheyenne Regional sent the Office of Emergency Medical Services a letter of intent, but never followed through with an application. OEMS has not heard from any other hospital regarding this designation.

- Outside accreditations in this area are also spotty. The Joint Commission recognizes WMC and CRMC as the only "Primary Stroke Centers" in

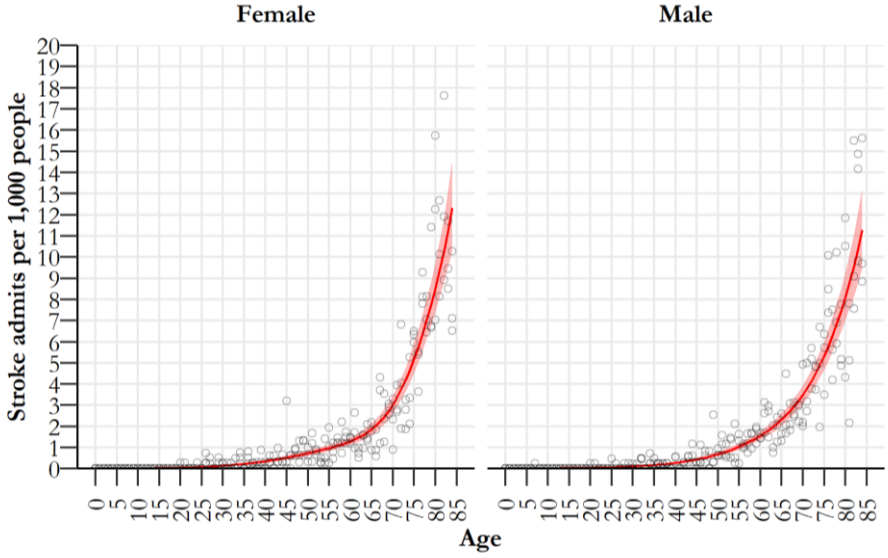
Wyoming. Both also have awards from the American Heart Association under its "Get With The Guidelines" program. However, Evanston and Sage West, for example, are the only accredited "Chest Pain Centers" in Wyoming from the American College of Cardiology. And numerous hospitals throughout the State likely have some degree of capacity to deal with these emergencies.

- A "home grown" ranking from raw data is also impossible. Due to gaps in the AHA survey, for example, we don't even know which hospitals have imaging suitable for stroke diagnosis, much less if they have the trained staff to diagnose ischemic vs. hemorrhagic strokes and administer thrombolytic agents.

This litany of excuses for heart attack/stroke means we cannot generate the kind of travel-time maps shown in previous sections, nor assess areas of the State with lower access. Even data on the risk of stroke in Wyoming is patchy. There is no comprehensive stroke registry, for example, similar to the Wyoming Trauma Registry.

With this caveat, however, Figure 26, below, presents the best estimate for incidence of in-State inpatient stroke-related admissions in Wyoming.

Figure 26: Est. stroke risk, by age and sex [45]



As the figure implies, while stroke is not solely an affliction of the aged, risk of stroke does increase exponentially with age.

[45] Data from the Wyoming Hospital Discharge dataset, with denominator from US Census population estimates by age and sex. These are almost certainly underestimated, due to limitations in the data. See technical appendix for detail.

New Hospital Projections

1. Projected impacts

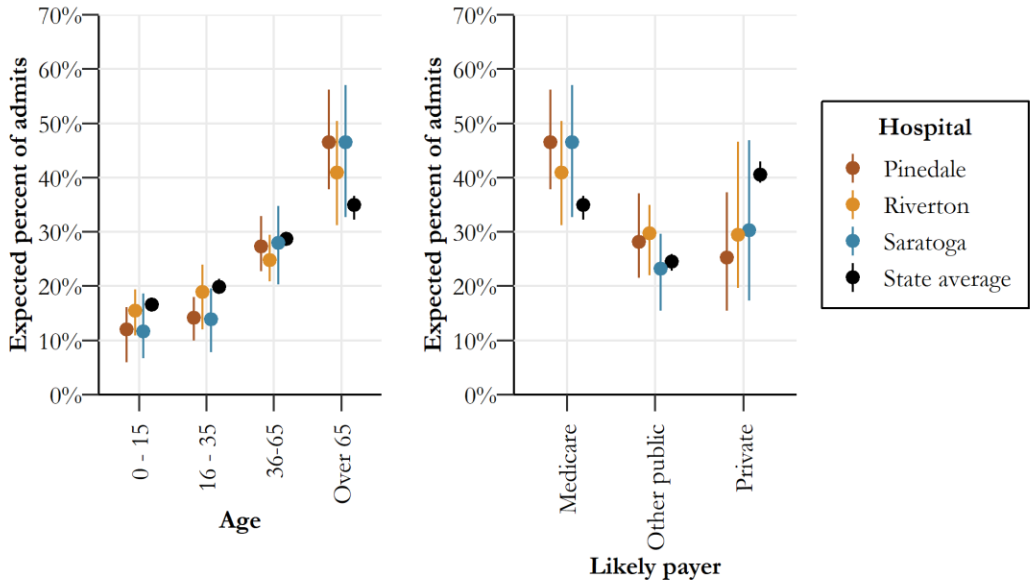
If new hospitals are built in Riverton, Pinedale and Saratoga, we project they will attract the volume shown in Table 7, below:

Table 7: Predicted annual inpatient admissions, new hospitals

City	Expected	Low	High
Riverton	745	470	980
Pinedale	420	150	700
Saratoga	190	110	280

Expected age ranges and payer mixes are shown in Figure 26, below. Generally speaking, Pinedale and Saratoga can expect older patients — and therefore more Medicare admits — than the State average. Riverton can expect more public payers (IHS and Medicaid) due to its proximity to the Wind River Reservation.

Figure 26: Expected percent of inpatient admits by age category and expected payer, new hospitals vs. State average



Since the model assumes no new inpatient volume is generated, the admissions in Table 7 will likely come from existing hospitals.

St. John's will likely lose patients from Sublette County, Carbon County Memorial will lose patients from Saratoga, and SageWest Lander will lose patients from the new Riverton hospital.

In addition, the proximity of the Riverton hospital to Lander may jeopardize the Sole Community Hospital status of SageWest.

2. Methodology

These results came from a model-based simulation illustrated in Figure 27, below. This simulation goes through a series of steps:

1. Starting with a gridded population of Wyoming (see Figure 28 on the next page), divided into age and sex cells, we predict the number of in-state inpatient admissions coming out of each location. The in-state inpatient admission model is based off the Wyoming hospital discharge database. Risk by age and sex cells is shown in Figure 29, on the page after Figure 28.

2. For each inpatient admission, we assign two characteristics based on location (e.g. ZIP code where the point falls into) and demographics. These are the Major Diagnostic Category (MDC) of the admission, and whether or not the payer is private or public. We also calculate drive times from each point to the closest 10 hospitals.

3. Once characteristics are assigned, we use a choice model, built off Medicaid and MPCD claims data, to predict which hospital the admit "chooses", based on drive time from the point to the hospital, the MDC, the payer, and hospital characteristics (see Technical Appendix).

Figure 27: New hospital simulation

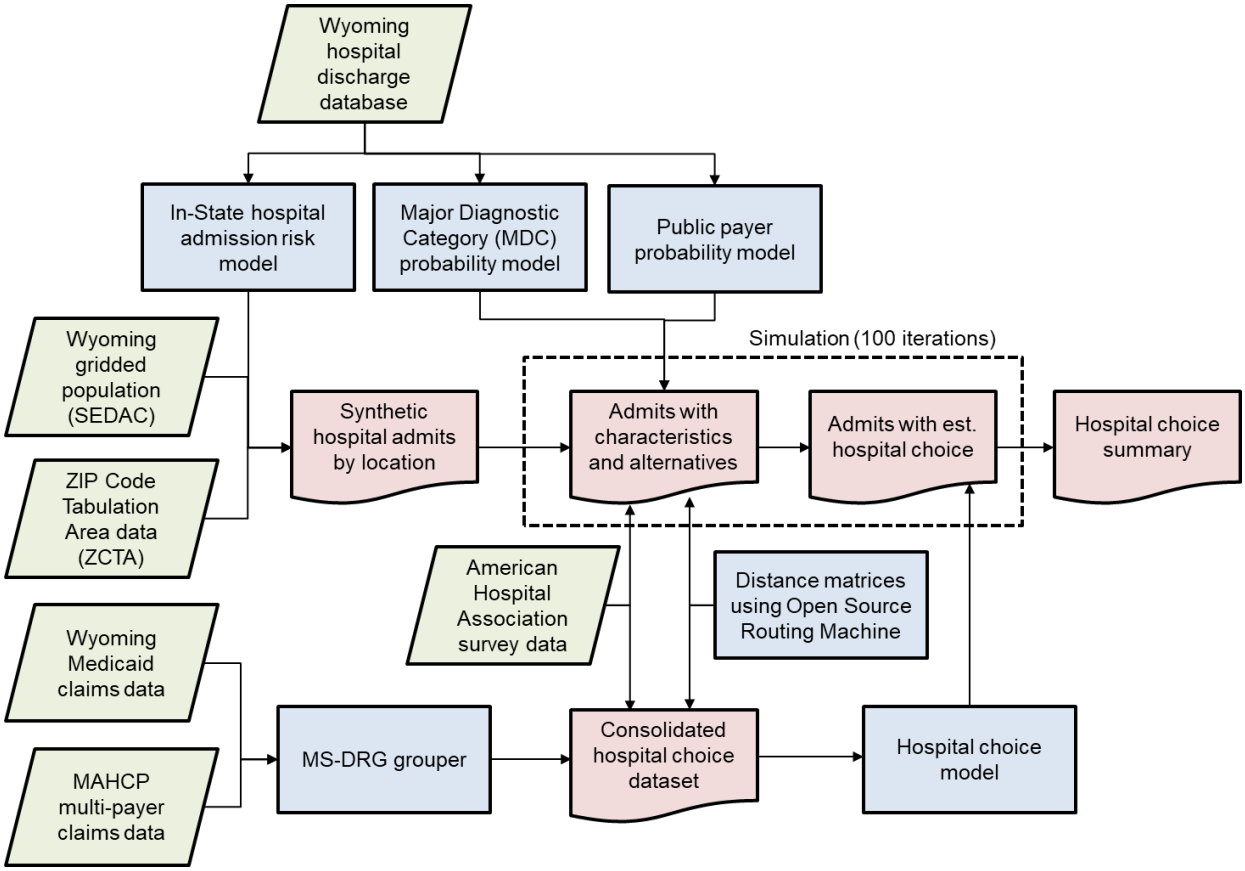
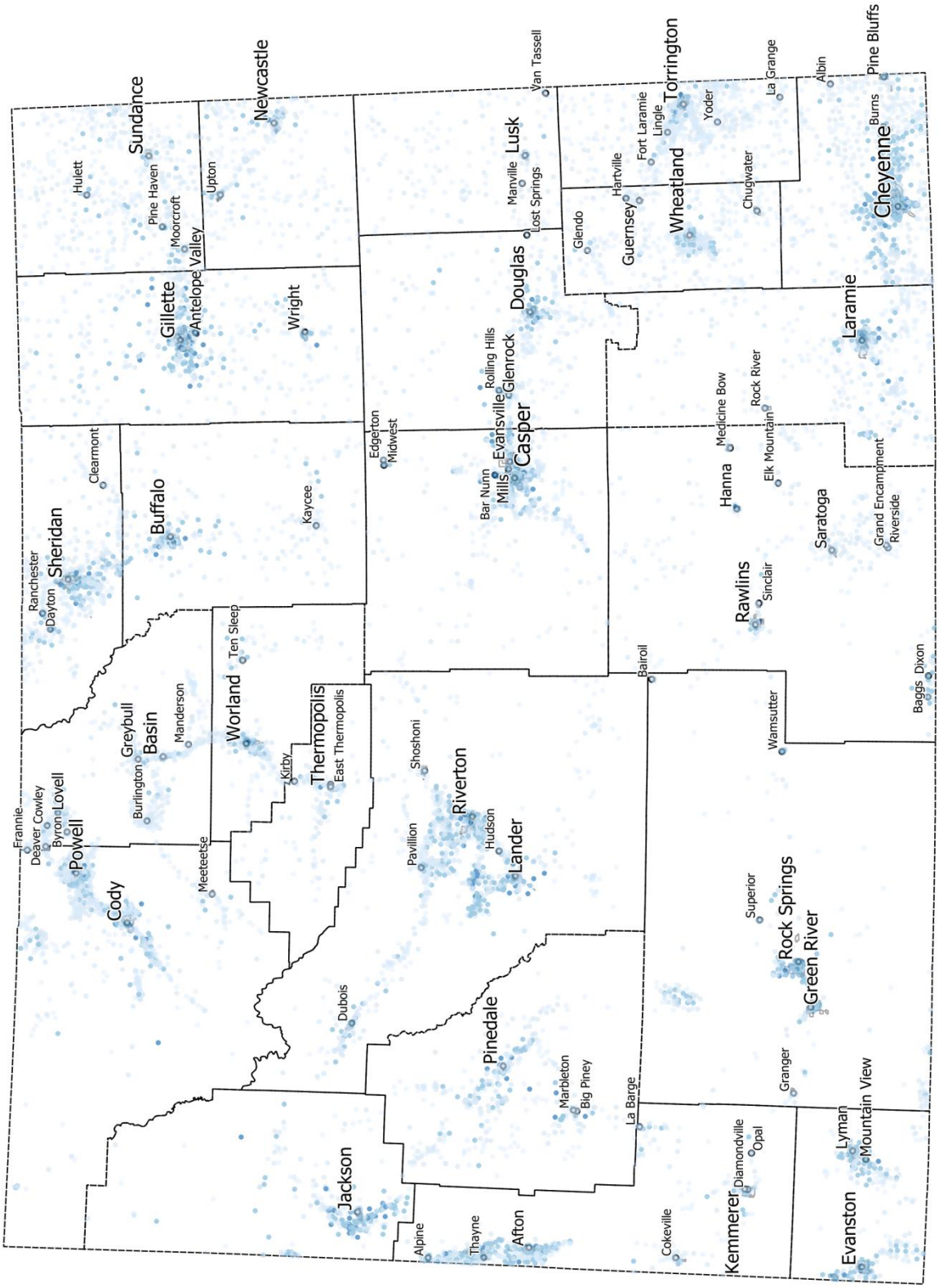
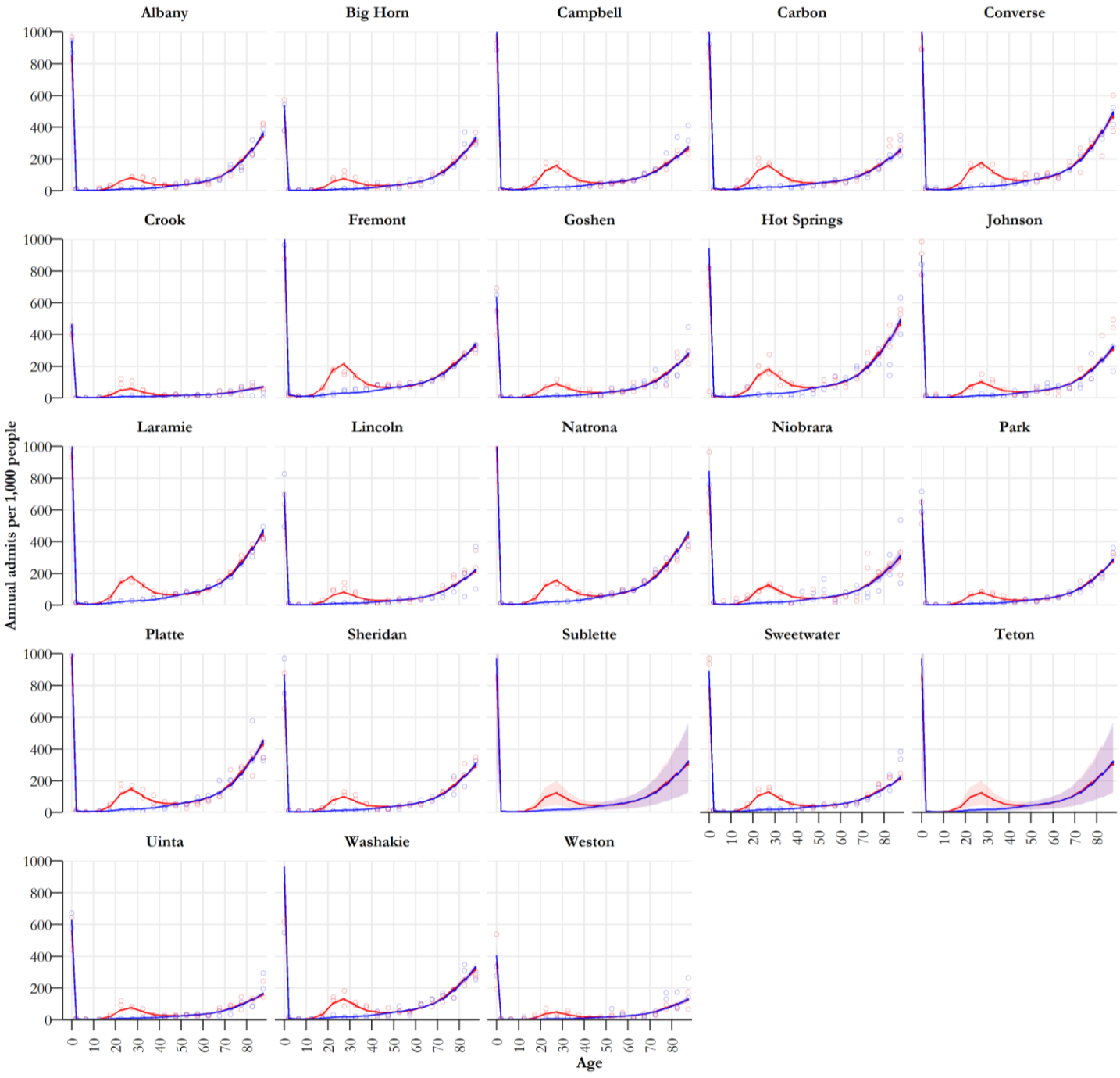


Figure 28: Gridded population of Wyoming[46]



[46] Socioeconomic Data and Applications Center (SEDAC). Administrative Unit Center Points with Population Estimates. Gridded Population of the World. https://sedac.ciesin.columbia.edu/

Figure 29: Est. risk of in-State inpatient admits, by age, sex and county[47]



Note on the figure above that there is significantly more uncertainty for Teton and Sublette counties. Since St. Johns does not report to the HDD, we used the model to predict the risk for these counties based on all the other counties.

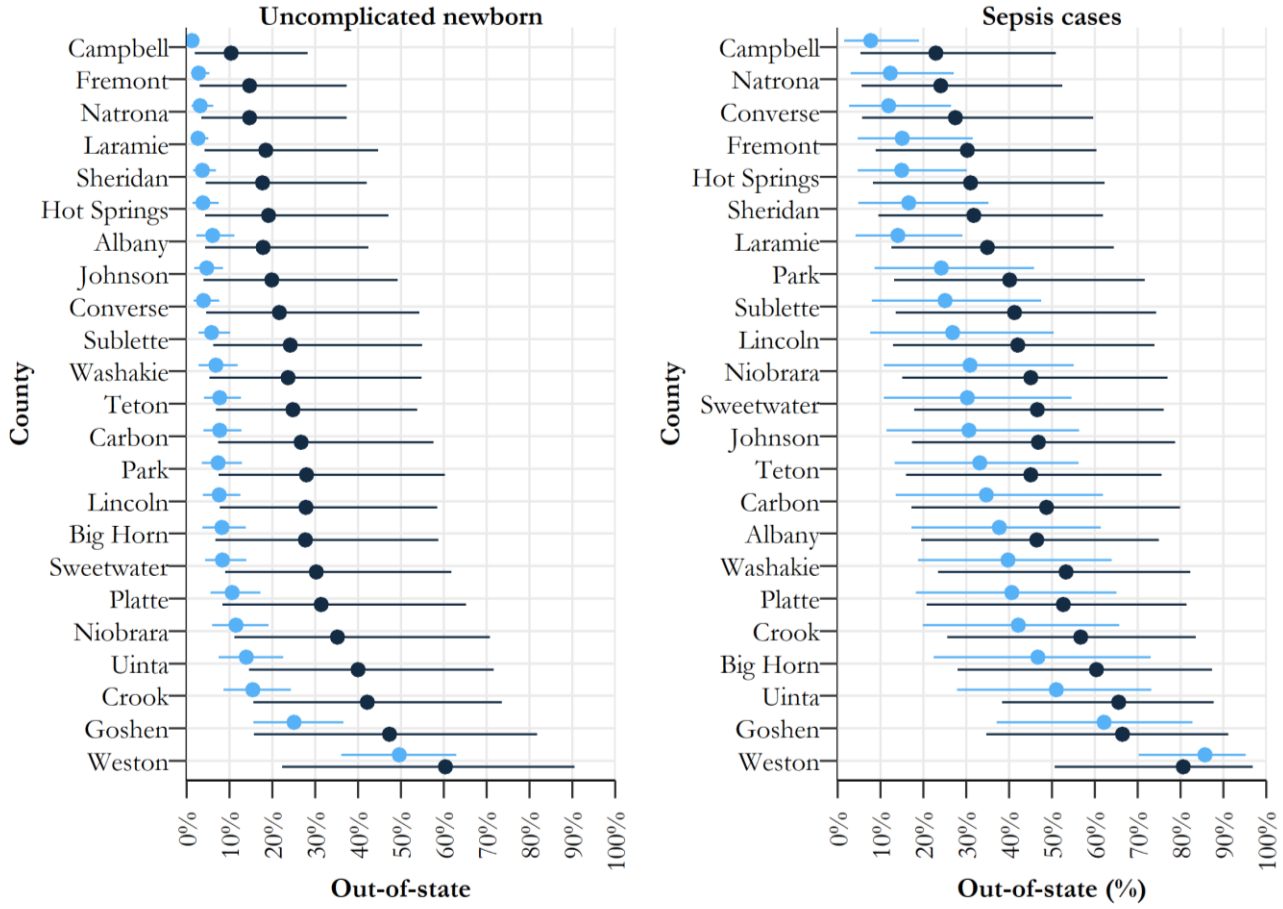
[47] Data from Wyoming Hospital Discharge Database, with denominator from US Census population estimates by age and sex. See Technical Appendix for detail.

Also important to note is that the simulation, both from the risk of inpatient admission and the choice model, consider only **in-State hospitals**. This is because the HDD does not have good data on admits to out-of-State hospitals.

This limitation is likely acceptable for the purposes of projecting volume at newer, small and relatively centrally-located hospitals that are unlikely to divert patients from going out of State.

For situational awareness, however, we can get some estimates of what percent of admits go out of State using a combination of Medicaid claims data and private claims data from the Wyoming Multi-Payer Claims Database. Figure 30, below, illustrates the estimated percent of admits that go out of State, by county and payer, for two common DRG cases: uncomplicated newborns and sepsis.

Figure 30: Est. out-of-State as percent of total inpatient admits, by county. Dark blue represents private-pay patients, light blue represents Medicaid patients.[48]



[48] Data from Wyoming Medicaid claims and Montana Association of Healthcare Purchasers (MAHCP) for members in Wyoming. See Technical Appendix for detail

A second important assumption comes in the capabilities of the new hospitals. The hospital choice model has problems with endogeneity — we're predicting market share based on capabilities measured in terms of ED visits and births; in other words, things that are affected by market share to begin with. While the model is still useful for prediction, we need to be clear we're assuming a certain level of starting capability for the new hospitals.

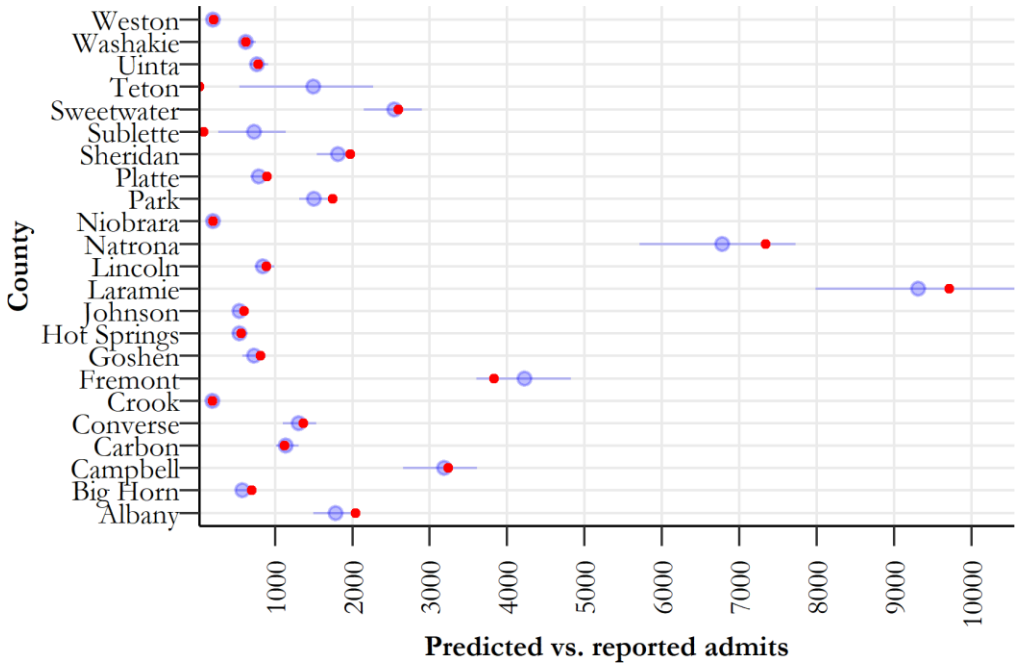
- In the case of Pinedale and Riverton, we assume a hospital comparable to Washakie Medical Center, Torrington, or South Lincoln.

- For Saratoga, we assume a hospital comparable to South Big Horn, Hot Springs, or Johnson County.

"Essentially, all models are wrong, but some are useful."
- George Box (British statistician, 1919 - 2013)

The model sketched out on the previous pages is a simplified representation of how we think reality works, an approximation. One way we can see how useful it is in predicting admits for new hospitals is by looking at where it **fails** in predicting facts on the ground. This also points to ways the model might be improved in the figure to produce better estimates. Figure 31, below, shows how the predicted in-state admits by county (blue) compare with admits reported in the Hospital Discharge Database.

Figure 31: Predicted admits (blue dots with ranges) vs. reported in-State admits in red, by county.



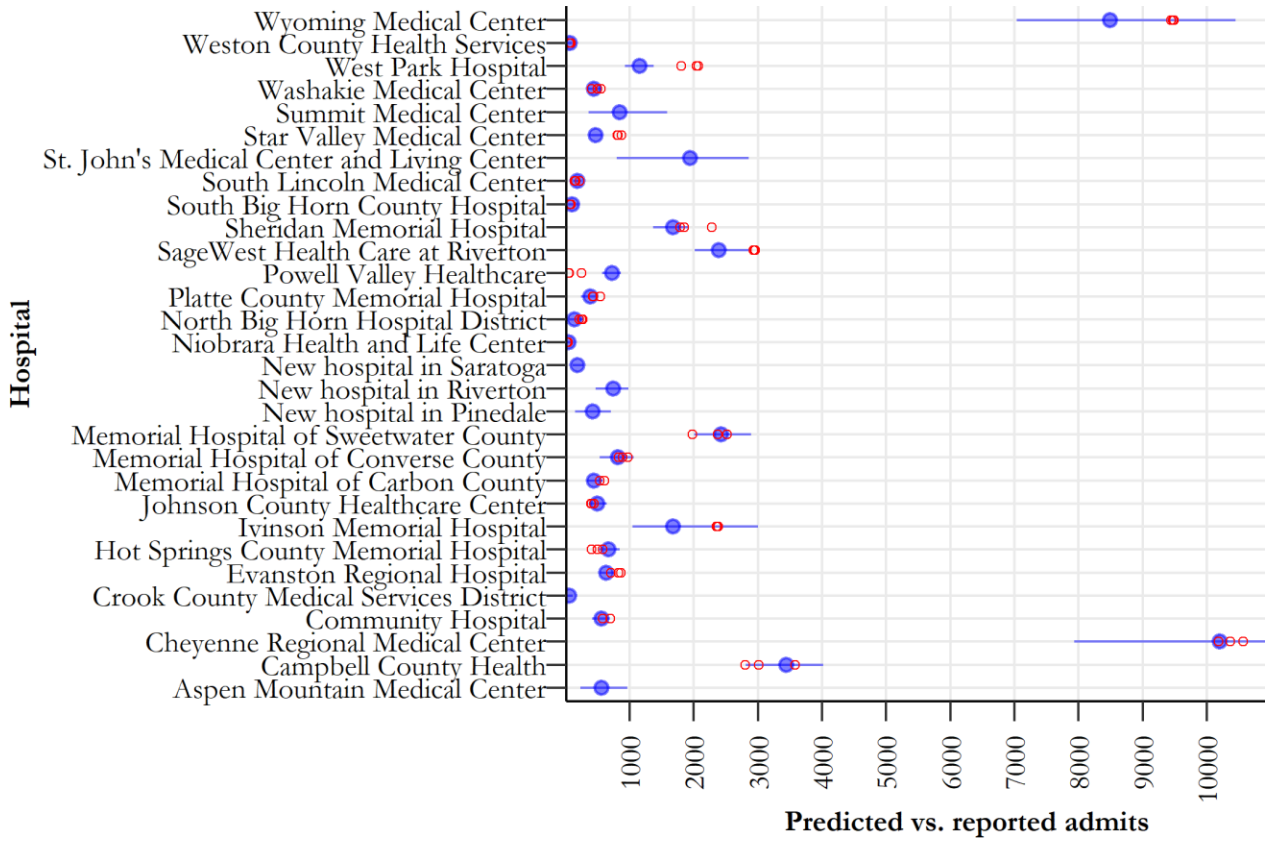
As we mentioned earlier, Teton and Sublette county reported values are definitely inaccurate, since St. Johns does not report data to the HDD. Outside of these two, however, some counties are better predicted than others. Park, Sheridan, Natrona and Laramie seem low, while Fremont seems high.

Some of this difference might come from the gridded population data, which is based on the 2010 census. We attempted to "age" the gridded population using 2017 census estimates by age, sex and county, but this may have worked better in certain areas than in others.

Figure 32, below, takes the same approach, only with all hospitals. Assuming that the new hospitals only poached volume from their immediate surroundings, and taking the county-specific problems (above) into consideration, it's clear the hospital choice model also has some flaws.

Specifically, West Park is under-predicted with respect to Powell, and Summit and Aspen Mountain are almost certainly over-predicted, to the detriment of WMC and Sweetwater.

Figure 32: Predicted admits (blue dots with ranges) vs. reported in-State admits (red dots), by hospital.



While these flaws point to ways the simulation can be improved, we believe the estimates for Riverton, Pinedale and Saratoga are good enough for the purposes of this report.

RECOMMENDATIONS

At its heart, Section 338 requires the Department to provide recommendations to the Legislature on how the State can balance (1) **access** to high-quality hospital services around the State against (2) the **cost-effectiveness** and **efficiency** of providing those services.

1. Navigating the tradeoff between cost and access

Unfortunately, it's impossible to fully maximize both of these goals at the same time. The fundamental tradeoff between cost and access will never go away.

However, if the Legislature deems that there is a role for the State in managing this balance,[49] there may be a creative opportunity to think about optimizing access and cost **separately**, for different services.

This strategy, a version of which was originally expressed in a National Affairs article last January[50], boils down to two major steps:

1. Categorize certain hospital services into two buckets — "time-sensitive" services versus "shoppable" services;

2. Pay for each bucket of services differently.

   - For "time-sensitive" services, pay hospitals directly to maintain a certain level of capability in each community, but prohibit them from billing patients or plans for services rendered.

   - For "shoppable" services, move to a completely free-market: remove regulatory barriers and encourage health plans to give patients both the market information and the incentives to seek the lowest cost and highest quality services — *even if it means going out-of-State*.

The seeming simplicity of these two steps is deceptive; actually implementing either involves a host of complications. This study will not go in-depth in describing the specifics here; we merely intend to outline the reasons why the State might want to consider this kind of strategy in the first place.

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[49] This is clearly not a settled question.

[50] "The Cost of Hospital Protectionism." Chris Pope. Winter 2019. https://www.nationalaffairs.com/publications/detail/the-cost-of-hospital-protectionism. The article's thesis: "The objective of public policy should not be to eliminate the costliest cutting-edge institutions, nor to impose their arrangements on all, but to allow competition wherever possible to eliminate inflated costs while establishing a reasonable floor in access to emergency care. Policymakers should seek to establish a **ring-fenced subsidy for emergency and safety-net services**, along with an **expectation of full competition for elective care**."

2. "Time-sensitive" vs. "shoppable" services

We begin with defining services; this is easier done in a study like this than in practice. But for the purposes of this argument, "**time-sensitive" services** are those hospital capabilities where (a) timely access to care is critical for health care outcomes, and (b) patients do not have the time or ability to "shop around" for these services. Examples include, but are not limited to:

- EMTALA stabilization;
- Emergency Department care;
- Trauma stabilization and transport; and
- Stroke/heart attack diagnosis and treatment.

On the other hand, **"shoppable" services** are those where patients do have the time and ability to make informed decisions on cost and quality. As a matter of practice, they should also be services that are expensive for health plans to provide, either due to unit price, volume, or both. Examples would include:

- Elective surgeries, particularly joint replacements and back operations;
- High-cost imaging and laboratory procedures.

Other services, like childbirth, fall somewhere in-between these extremes. In some cases, mothers can "shop around" for a hospital, particularly when delivery is scheduled via C-section, but in most cases, either the closest hospital or the most appropriate level of care (e.g. NICU) are used.

3. Why cross-subsidies are a problem

Most hospitals provide a mix of "time-sensitive" and "shoppable" services. And, in most cases, the "shoppable" services often cross-subsidize the "time-sensitive" ones, which can be money losers.

In other words, hospitals are able to support an emergency department or a trauma surgeon in certain areas **because of** the high-dollar "shoppable" business that they do.

But even though they make money for the hospital, "shoppable" services are often less efficiently provided in Wyoming, simply due to low volumes from the State's rural and frontier nature. This is evident in the "cost per Average Daily Census" financial indicator earlier in this report, for example, and this volume issue is also not a problem that will go away in the foreseeable future.

In a market environment where hospitals are more effective at setting prices, lower efficiency increases costs to employer plans and private insurers. This is quite evident

in both overall cost and price comparisons with other payers nationally in Wyoming's multi-payer database.[51] Ultimately, these increased prices are passed along to employees and insureds in the form of increased premiums and cost-sharing — and today Wyoming is among the top states in terms of health insurance costs.

Cross-subsidization is the fundamental problem that the State needs to confront if it intends to optimize either access or cost. Without separating "time sensitive" from "shoppable" services, access to care will continue to be inefficiently cross-subsidized through free-riding on private payers.

4. Losing access under a "full" free market

Free market competition is an ideal tool to reduce cost and improve quality in any industry. This is evident in many sectors outside health care, from air transportation to hamburgers.

However, the free market is mostly broken in health care. The Department has more fully explored these problems in previous reports[52], so we won't elaborate here, but briefly, "consumers" have little information on price and quality, and they also have little incentive to shop for more value, particularly if they are insured.

Let's assume these barriers could be overcome. Let's assume employer plans could give their employees both the information and the strong incentive to "shop around" for care. What would likely happen to hospital services in Wyoming?

(1) Costs would likely decrease and quality of care would likely increase for "shoppable" procedures.

- In a free market, patients would choose lower-cost and higher-value providers.

- These providers would likely be larger regional "Centers of Excellence" whose sheer volume would allow them to charge lower prices (i.e., fixed costs can be spread over more volume) while improving quality, because surgical outcomes have been positively linked to high volume for most procedures[53].

(2) Access to "time-sensitive" care would decrease.

- More patients leaving the State for more efficient providers would mean lower "shoppable" volume for smaller in-State hospitals.

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[51] See the "prices" section of the Wyoming Multi Payer Claims Database (mpcd.wyo.gov).
[52] State Options for Increasing Value in Healthcare. WDH. October 1, 2016.
[53] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5129247/

- Lower "shoppable" volume jeopardizes the cross-subsidies that sustain access to "time-sensitive" care across the State.

5. What if we paid for "time sensitive" services separately?

So how can the State encourage more free market activity that would drive improvements on the "shoppable" side without endangering access to care around the State?

It's easier said than done, but developing a system to pay hospitals for "time-sensitive" care that is **decoupled** from free-market activity on the "shoppable" side may be the best way to accomplish this.

The objective of this system would be to ensure access around the State to critical services at a reasonable cost, while allowing the free-market to drive cost and quality improvements where it can. There are five important principles here:

(1) Payments should pay for capacity, not volume. The State or local entities need to determine the requirements for a system of 'time sensitive care' (e.g., trauma referral regions, where it makes sense to have stroke imaging, etc.), and then pay for that capacity to just be there, regardless of how many patients are served.

(2) Payments should be prospective. The State should avoid "cost-based" reimbursement, which tends to just reinforce and inflate cost. Prospective payments do, however, involve significant work on figuring out what it "should" cost to provide certain services; i.e., how much *should* it cost to operate a Level IV trauma center? How much *should* it cost to have an MRI machine?

(3) Payment and services for "time sensitive" care should be isolated. Hospitals must therefore be regulated in billing private payers for these services to prevent "free riding" on employers and insurers.

(4) Group purchasing of services may reduce cost. If the State coordinated the purchase of MRI machines for all hospitals in the State, for example, it would likely get a better deal than small hospitals negotiating by themselves.

(5) Funding could come from a combination of (a) existing tax revenue (e.g. hospital district), (b) new tax revenue (e.g. premium taxes or assessments on employers) or (c) some kind of Medicare or Medicaid waiver, or both. Medicare, in particular, is such a large player that any plan of this type would need to involve participation by the Federal government.

6. Conclusion and next steps

As we have hammered on repeatedly in this report, the tradeoff between access and cost will never go away. This is just like the "iron triangle" of contracting or project management: "you can have things good, fast, or cheap — pick two."

Extending that metaphor, what the proposed recommendation attempts to do is isolate the "fast" part of the triangle — for things we absolutely need to be "fast" — and let the free market figure out the "good" vs. "cheap" for everything else.

If the Legislature agrees (1) that there is a role for the State to play in this balance and (2) that this recommendation makes sense, the Department of Health can explore more of the details in a later report.

TECHNICAL APPENDIX

This appendix describes the statistical models that were used in developing this study. They are presented in the order they were used.

All models were constructed using the R package brms, which generates code to pass through RStan to the Stan engine.[54] Stan is a Bayesian probabilistic programming language that uses "No-U-Turn" Hamiltonian Monte Carlo techniques to draw samples from the joint posterior probability distribution of all the model parameters.

Generally speaking, regularizing Gaussian priors were applied to all parameters before fitting, with means set at zero and standard deviations scaled to the potential range of the outcomes. Logit models, for example, used Normal(0,4) or Normal(0,2) priors, since the outcome domain is typically between -4 and 4. For count models with log links we often use a Normal(0,10) prior on intercepts and a Normal(0,1) on parameters.

1. EMS choice model

We use this model to predict EMS services areas in the background section. The question here is simple: what ambulance service is most likely to show up at any given scene?

Travel time from each service to the scene is obviously the primary consideration. It's very unlikely, for example, that AMR in Cheyenne would drive all the way to Wheatland when the Platte County EMS service is much closer.

But the model also attempts to incorporate a measure of ambulance service capacity — count of ambulances — because in some cases (e.g. between Cheyenne and Burns), AMR is indeed more likely to respond to calls further away from its bases.

The model shown below is a conditional logistic model that estimates how likely each scene is likely to "choose" a given service, out of the closest five services that are available, based on these two factors.

This model was fit using Wyoming Ambulance Trip reporting system data for SFY 2018 and 2019, stratified to include 100 observations per scene incident city. Drive times were calculated between "average" EMS service location (the data doesn't

[54] The brms package was written by Paul-Christian Bürkner (2017) <doi:10.18637/jss.v080.i01>. Rstan is a product of the Stan Development Team (2019). RStan: the R interface to Stan. R package version 2.19.2. http://mc-stan.org/.

indicate which specific location responded) and incident city using the Open Source Routing Machine engine.

Model 1: EMS choice model

```
Family: categorical
  Links: muSvc1 = logit; muSvc2 = logit; muSvc3 = logit; muSvc4 = logit; muSvc5 = logit
Formula: ChosenRank ~ 1
         muSvc1 ~ bAmbulances * Ambulances.Svc1 + bzTime * zTime.Svc1 + bAmbzTime * Ambulances.Svc1 * zTime.Svc1
         muSvc2 ~ bAmbulances * Ambulances.Svc2 + bzTime * zTime.Svc2 + bAmbzTime * Ambulances.Svc2 * zTime.Svc2
         muSvc3 ~ bAmbulances * Ambulances.Svc3 + bzTime * zTime.Svc3 + bAmbzTime * Ambulances.Svc3 * zTime.Svc3
         muSvc4 ~ bAmbulances * Ambulances.Svc4 + bzTime * zTime.Svc4 + bAmbzTime * Ambulances.Svc4 * zTime.Svc4
         muSvc5 ~ bAmbulances * Ambulances.Svc5 + bzTime * zTime.Svc5 + bAmbzTime * Ambulances.Svc5 * zTime.Svc5
         bAmbulances ~ 1
         bzTime ~ 1
         bAmbzTime ~ 1
   Data: complete_sample_strat (Number of observations: 5370)
Samples: 4 chains, each with iter = 2000; warmup = 500; thin = 1;
         total post-warmup samples = 6000

Population-Level Effects:
                      Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
bAmbulances_Intercept     0.63      0.08     0.47     0.78       1240 1.00
bzTime_Intercept        -10.35      0.38   -11.10    -9.61       1302 1.00
bAmbzTime_Intercept       0.24      0.05     0.13     0.34       1252 1.00
```

2. Total Fertility Rate model

This model is used to illustrate how the fertility rate (total annual births per woman) varies by age group, county, and year in Wyoming. The model is actually estimating the count of births, conditional on these variables, with the underlying population used as an offset. Birth data for this model came from Vital Statistics. We merged this data with population estimates by county, age group and year.

We did attempt to fit other, more elegant (parametric and semi-parametric) models to capture the characteristic age curves shown in the figures. Unfortunately, the best fit came from the non-parametric model shown below that throws a "kitchen sink" of variables at the problem. While the fit works for the study, the actual model output is tedious and not easily interpretable without context.

We use this model to estimate the number of births by location predicted by the demographic information in the gridded population data.

Model 2: Total fertility rate model

```
Family: poisson
  Links: mu = log
Formula: Births ~ 1 + AgeGrp + County + zCY + County * AgeGrp + zCY * AgeGrp + offset(log(Count))
   Data: birth_data (Number of observations: 1242)
Samples: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
         total post-warmup samples = 4000

Population-Level Effects:
                              Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Intercept                        -8.93      0.74   -10.48    -7.54        241 1.02
```

AgeGrp15M19	4.47	0.75	3.08	6.01	243	1.02
AgeGrp20M24	5.15	0.74	3.75	6.67	242	1.02
AgeGrp25M29	6.50	0.74	5.13	8.06	241	1.02
AgeGrp30M34	6.56	0.74	5.19	8.12	242	1.02
AgeGrp35M39	5.82	0.74	4.42	7.35	242	1.02
AgeGrp40M44	4.15	0.75	2.73	5.72	253	1.02
AgeGrp45M49	-20.74	5.57	-32.72	-11.03	2623	1.00
AgeGrp50M54	-15.44	4.03	-23.75	-8.04	2369	1.00
CountyBigHorn	0.46	1.37	-2.53	2.85	427	1.01
CountyCampbell	0.12	1.05	-2.02	2.16	445	1.01
CountyCarbon	0.40	1.30	-2.42	2.72	642	1.01
CountyConverse	1.30	1.05	-0.83	3.31	501	1.01
CountyCrook	-2.05	2.53	-7.74	2.12	1133	1.00
CountyFremont	0.82	0.95	-1.04	2.66	355	1.02
CountyGoshen	-2.35	2.53	-8.24	1.76	959	1.00
CountyHotSprings	-1.81	2.69	-7.92	2.45	1082	1.00
CountyJohnson	-2.26	2.59	-7.85	2.04	1085	1.00
CountyLaramie	0.08	0.93	-1.77	1.85	351	1.01
CountyLincoln	0.11	1.29	-2.74	2.42	653	1.01
CountyNatrona	1.27	0.82	-0.28	2.92	291	1.02
CountyNiobrara	-1.59	2.85	-7.92	2.98	1285	1.00
CountyPark	-0.08	1.32	-2.99	2.26	493	1.01
CountyPlatte	1.03	1.34	-1.97	3.45	705	1.00
CountySheridan	0.76	1.06	-1.42	2.73	383	1.02
CountySublette	-2.28	2.54	-7.96	1.85	1151	1.00
CountySweetwater	-3.38	2.34	-8.63	0.33	976	1.00
CountyTeton	0.24	1.39	-2.79	2.65	605	1.01
CountyUinta	-0.04	1.28	-2.78	2.27	595	1.01
CountyWashakie	-2.32	2.58	-7.98	1.78	770	1.00
CountyWeston	-2.13	2.57	-7.71	2.02	1266	1.00
zCY	0.16	0.19	-0.20	0.53	1391	1.00
AgeGrp15M19:CountyBigHorn	0.04	1.38	-2.33	3.04	435	1.01
AgeGrp20M24:CountyBigHorn	1.40	1.37	-1.00	4.40	435	1.01
AgeGrp25M29:CountyBigHorn	0.19	1.37	-2.20	3.22	436	1.01
AgeGrp30M34:CountyBigHorn	-0.36	1.37	-2.78	2.64	440	1.01
AgeGrp35M39:CountyBigHorn	-0.55	1.38	-3.02	2.46	416	1.02
AgeGrp40M44:CountyBigHorn	-0.22	1.40	-2.70	2.79	460	1.01
AgeGrp45M49:CountyBigHorn	-0.88	9.04	-19.17	16.01	7431	1.00
AgeGrp50M54:CountyBigHorn	-1.74	9.04	-20.73	14.02	5255	1.00
AgeGrp15M19:CountyCampbell	1.09	1.05	-0.95	3.23	446	1.01
AgeGrp20M24:CountyCampbell	1.65	1.05	-0.38	3.80	443	1.01
AgeGrp25M29:CountyCampbell	0.34	1.05	-1.72	2.47	446	1.01
AgeGrp30M34:CountyCampbell	-0.21	1.05	-2.26	1.91	447	1.01
AgeGrp35M39:CountyCampbell	-0.40	1.05	-2.44	1.73	445	1.01
AgeGrp40M44:CountyCampbell	-0.44	1.06	-2.47	1.72	461	1.01
AgeGrp45M49:CountyCampbell	-1.07	9.19	-20.31	15.54	7252	1.00
AgeGrp50M54:CountyCampbell	-1.73	8.74	-20.12	13.75	5569	1.00
AgeGrp15M19:CountyCarbon	0.80	1.30	-1.54	3.60	655	1.01
AgeGrp20M24:CountyCarbon	1.52	1.30	-0.79	4.32	644	1.01
AgeGrp25M29:CountyCarbon	0.03	1.30	-2.31	2.84	644	1.01
AgeGrp30M34:CountyCarbon	-0.34	1.30	-2.65	2.47	640	1.01
AgeGrp35M39:CountyCarbon	-0.59	1.30	-2.88	2.25	648	1.01
AgeGrp40M44:CountyCarbon	-0.90	1.33	-3.32	1.91	660	1.01
AgeGrp45M49:CountyCarbon	-1.01	9.03	-19.27	15.10	6776	1.00
AgeGrp50M54:CountyCarbon	-1.64	9.06	-20.05	14.17	5450	1.00
AgeGrp15M19:CountyConverse	-0.18	1.06	-2.19	2.00	495	1.01
AgeGrp20M24:CountyConverse	0.53	1.05	-1.49	2.65	501	1.01
AgeGrp25M29:CountyConverse	-0.85	1.05	-2.86	1.30	507	1.01
AgeGrp30M34:CountyConverse	-1.39	1.05	-3.40	0.77	505	1.01
AgeGrp35M39:CountyConverse	-1.72	1.06	-3.76	0.39	513	1.01
AgeGrp40M44:CountyConverse	-1.49	1.09	-3.60	0.67	527	1.01
AgeGrp45M49:CountyConverse	-1.24	9.35	-20.78	15.17	6082	1.00
AgeGrp50M54:CountyConverse	-1.80	8.60	-19.41	13.27	4771	1.00
AgeGrp15M19:CountyCrook	2.95	2.54	-1.25	8.71	1139	1.00
AgeGrp20M24:CountyCrook	4.10	2.53	-0.04	9.82	1133	1.00
AgeGrp25M29:CountyCrook	2.87	2.53	-1.28	8.58	1132	1.00
AgeGrp30M34:CountyCrook	2.37	2.53	-1.78	8.06	1135	1.00
AgeGrp35M39:CountyCrook	2.06	2.53	-2.11	7.80	1132	1.00
AgeGrp40M44:CountyCrook	2.09	2.55	-2.17	7.76	1153	1.00
AgeGrp45M49:CountyCrook	-0.55	9.46	-19.56	17.40	7839	1.00
AgeGrp50M54:CountyCrook	-0.96	8.93	-18.79	15.04	6702	1.00
AgeGrp15M19:CountyFremont	0.58	0.95	-1.26	2.43	356	1.02
AgeGrp20M24:CountyFremont	1.03	0.95	-0.81	2.90	354	1.02

AgeGrp25M29:CountyFremont	-0.38	0.95	-2.22	1.50	357	1.02
AgeGrp30M34:CountyFremont	-0.85	0.95	-2.70	1.01	356	1.02
AgeGrp35M39:CountyFremont	-0.81	0.95	-2.67	1.06	355	1.02
AgeGrp40M44:CountyFremont	-0.83	0.97	-2.71	1.08	367	1.01
AgeGrp45M49:CountyFremont	-1.31	9.09	-20.10	15.26	6622	1.00
AgeGrp50M54:CountyFremont	-2.03	8.59	-20.23	12.62	6013	1.00
AgeGrp15M19:CountyGoshen	3.21	2.54	-0.91	9.13	957	1.00
AgeGrp20M24:CountyGoshen	3.92	2.53	-0.17	9.79	959	1.00
AgeGrp25M29:CountyGoshen	2.81	2.53	-1.29	8.66	962	1.00
AgeGrp30M34:CountyGoshen	2.29	2.53	-1.84	8.15	958	1.00
AgeGrp35M39:CountyGoshen	2.00	2.53	-2.10	7.87	957	1.00
AgeGrp40M44:CountyGoshen	2.10	2.55	-2.04	8.01	966	1.00
AgeGrp45M49:CountyGoshen	-0.51	9.53	-19.21	17.19	6581	1.00
AgeGrp50M54:CountyGoshen	-0.88	8.93	-19.01	15.37	6149	1.00
AgeGrp15M19:CountyHotSprings	2.15	2.70	-2.14	8.13	1093	1.00
AgeGrp20M24:CountyHotSprings	3.65	2.69	-0.64	9.72	1062	1.00
AgeGrp25M29:CountyHotSprings	2.32	2.69	-1.97	8.43	1100	1.00
AgeGrp30M34:CountyHotSprings	1.96	2.69	-2.30	8.01	1095	1.00
AgeGrp35M39:CountyHotSprings	1.49	2.69	-2.80	7.48	1092	1.00
AgeGrp40M44:CountyHotSprings	1.59	2.74	-2.83	7.72	1113	1.00
AgeGrp45M49:CountyHotSprings	-0.54	9.41	-19.33	16.93	6918	1.00
AgeGrp50M54:CountyHotSprings	-1.04	9.15	-19.52	16.18	6504	1.00
AgeGrp15M19:CountyJohnson	2.43	2.59	-1.95	8.08	1094	1.00
AgeGrp20M24:CountyJohnson	3.73	2.59	-0.54	9.30	1083	1.00
AgeGrp25M29:CountyJohnson	2.64	2.59	-1.64	8.23	1082	1.00
AgeGrp30M34:CountyJohnson	2.28	2.59	-2.01	7.89	1082	1.00
AgeGrp35M39:CountyJohnson	2.17	2.59	-2.12	7.78	1090	1.00
AgeGrp40M44:CountyJohnson	1.51	2.62	-2.82	7.21	1121	1.00
AgeGrp45M49:CountyJohnson	-0.93	9.54	-20.56	16.90	6648	1.00
AgeGrp50M54:CountyJohnson	-0.93	9.04	-19.34	15.60	7538	1.00
AgeGrp15M19:CountyLaramie	0.92	0.93	-0.88	2.76	352	1.01
AgeGrp20M24:CountyLaramie	1.48	0.93	-0.31	3.31	350	1.01
AgeGrp25M29:CountyLaramie	0.25	0.93	-1.53	2.12	352	1.01
AgeGrp30M34:CountyLaramie	-0.10	0.93	-1.88	1.75	352	1.01
AgeGrp35M39:CountyLaramie	-0.27	0.93	-2.03	1.59	351	1.01
AgeGrp40M44:CountyLaramie	-0.23	0.95	-2.04	1.63	367	1.01
AgeGrp45M49:CountyLaramie	-1.27	8.74	-19.08	14.55	6178	1.00
AgeGrp50M54:CountyLaramie	14.42	4.11	6.91	23.06	2568	1.00
AgeGrp15M19:CountyLincoln	0.51	1.30	-1.81	3.39	657	1.01
AgeGrp20M24:CountyLincoln	1.68	1.29	-0.61	4.53	652	1.01
AgeGrp25M29:CountyLincoln	0.64	1.30	-1.68	3.50	654	1.01
AgeGrp30M34:CountyLincoln	0.07	1.30	-2.25	2.93	655	1.01
AgeGrp35M39:CountyLincoln	-0.17	1.30	-2.50	2.68	651	1.01
AgeGrp40M44:CountyLincoln	0.16	1.31	-2.16	3.08	672	1.01
AgeGrp45M49:CountyLincoln	-1.08	8.99	-18.76	15.42	6169	1.00
AgeGrp50M54:CountyLincoln	-1.55	8.73	-20.09	13.81	5486	1.00
AgeGrp15M19:CountyNatrona	-0.15	0.83	-1.81	1.42	294	1.02
AgeGrp20M24:CountyNatrona	0.38	0.82	-1.26	1.90	290	1.02
AgeGrp25M29:CountyNatrona	-0.92	0.82	-2.57	0.63	291	1.02
AgeGrp30M34:CountyNatrona	-1.33	0.82	-2.99	0.21	290	1.02
AgeGrp35M39:CountyNatrona	-1.48	0.82	-3.13	0.08	292	1.02
AgeGrp40M44:CountyNatrona	-1.63	0.84	-3.32	-0.05	304	1.02
AgeGrp45M49:CountyNatrona	-1.47	8.90	-20.26	14.12	5689	1.00
AgeGrp50M54:CountyNatrona	-2.18	8.31	-19.58	11.75	5201	1.00
AgeGrp15M19:CountyNiobrara	2.56	2.87	-2.12	8.92	1250	1.00
AgeGrp20M24:CountyNiobrara	2.83	2.86	-1.87	9.16	1275	1.00
AgeGrp25M29:CountyNiobrara	1.71	2.86	-2.93	8.00	1302	1.00
AgeGrp30M34:CountyNiobrara	1.32	2.85	-3.29	7.58	1291	1.00
AgeGrp35M39:CountyNiobrara	0.76	2.86	-3.90	7.10	1319	1.00
AgeGrp40M44:CountyNiobrara	-0.50	3.03	-5.82	5.91	1397	1.00
AgeGrp45M49:CountyNiobrara	-0.55	9.08	-19.33	16.46	6952	1.00
AgeGrp50M54:CountyNiobrara	-1.03	9.44	-20.29	16.44	7389	1.00
AgeGrp15M19:CountyPark	0.57	1.33	-1.77	3.51	506	1.01
AgeGrp20M24:CountyPark	1.54	1.33	-0.81	4.46	492	1.01
AgeGrp25M29:CountyPark	0.45	1.33	-1.87	3.39	493	1.01
AgeGrp30M34:CountyPark	0.11	1.33	-2.21	3.02	497	1.01
AgeGrp35M39:CountyPark	-0.17	1.33	-2.48	2.76	494	1.01
AgeGrp40M44:CountyPark	0.20	1.34	-2.16	3.14	512	1.01
AgeGrp45M49:CountyPark	-0.98	8.92	-18.96	15.19	6706	1.00
AgeGrp50M54:CountyPark	-1.60	8.74	-19.90	13.65	5244	1.00
AgeGrp15M19:CountyPlatte	-0.52	1.36	-2.98	2.49	714	1.00
AgeGrp20M24:CountyPlatte	0.82	1.34	-1.60	3.83	702	1.00
AgeGrp25M29:CountyPlatte	-0.52	1.34	-2.95	2.48	709	1.00

AgeGrp30M34:CountyPlatte	-1.21	1.34	-3.63	1.84	709	1.00
AgeGrp35M39:CountyPlatte	-1.22	1.35	-3.68	1.81	716	1.00
AgeGrp40M44:CountyPlatte	-1.15	1.38	-3.68	2.02	767	1.00
AgeGrp45M49:CountyPlatte	-1.10	9.33	-20.56	15.60	6740	1.00
AgeGrp50M54:CountyPlatte	-1.77	8.86	-20.53	13.59	5108	1.00
AgeGrp15M19:CountySheridan	-0.08	1.06	-2.04	2.13	392	1.02
AgeGrp20M24:CountySheridan	0.56	1.06	-1.41	2.74	384	1.02
AgeGrp25M29:CountySheridan	-0.38	1.06	-2.36	1.79	386	1.02
AgeGrp30M34:CountySheridan	-0.70	1.05	-2.68	1.48	385	1.02
AgeGrp35M39:CountySheridan	-0.85	1.06	-2.85	1.35	387	1.02
AgeGrp40M44:CountySheridan	-1.38	1.08	-3.40	0.86	404	1.02
AgeGrp45M49:CountySheridan	-1.26	8.74	-19.19	15.02	6482	1.00
AgeGrp50M54:CountySheridan	-1.92	8.79	-20.67	12.89	4904	1.00
AgeGrp15M19:CountySublette	2.67	2.55	-1.49	8.39	1152	1.00
AgeGrp20M24:CountySublette	4.11	2.54	-0.03	9.78	1151	1.00
AgeGrp25M29:CountySublette	2.73	2.54	-1.42	8.41	1152	1.00
AgeGrp30M34:CountySublette	2.44	2.54	-1.71	8.12	1152	1.00
AgeGrp35M39:CountySublette	2.09	2.54	-2.09	7.79	1149	1.00
AgeGrp40M44:CountySublette	1.57	2.57	-2.65	7.40	1166	1.00
AgeGrp45M49:CountySublette	-0.66	9.73	-20.05	17.62	8208	1.00
AgeGrp50M54:CountySublette	-0.71	8.96	-19.18	14.93	6606	1.00
AgeGrp15M19:CountySweetwater	4.43	2.34	0.70	9.67	971	1.00
AgeGrp20M24:CountySweetwater	5.05	2.34	1.32	10.29	977	1.00
AgeGrp25M29:CountySweetwater	3.76	2.33	0.05	8.99	975	1.00
AgeGrp30M34:CountySweetwater	3.20	2.34	-0.52	8.41	976	1.00
AgeGrp35M39:CountySweetwater	3.10	2.34	-0.61	8.33	977	1.00
AgeGrp40M44:CountySweetwater	2.75	2.35	-1.02	7.95	980	1.00
AgeGrp45M49:CountySweetwater	-0.74	9.70	-19.92	17.19	6754	1.00
AgeGrp50M54:CountySweetwater	-1.06	9.08	-19.92	15.16	5569	1.00
AgeGrp15M19:CountyTeton	-0.17	1.40	-2.61	2.92	629	1.01
AgeGrp20M24:CountyTeton	0.65	1.39	-1.76	3.70	600	1.01
AgeGrp25M29:CountyTeton	-0.84	1.39	-3.27	2.20	604	1.01
AgeGrp30M34:CountyTeton	-0.39	1.39	-2.81	2.66	604	1.01
AgeGrp35M39:CountyTeton	0.33	1.39	-2.09	3.35	603	1.01
AgeGrp40M44:CountyTeton	0.65	1.40	-1.82	3.70	613	1.01
AgeGrp45M49:CountyTeton	-1.06	9.24	-20.25	15.63	6231	1.00
AgeGrp50M54:CountyTeton	-1.79	8.79	-20.46	13.86	5501	1.00
AgeGrp15M19:CountyUinta	1.04	1.29	-1.29	3.76	596	1.01
AgeGrp20M24:CountyUinta	1.94	1.28	-0.37	4.70	597	1.01
AgeGrp25M29:CountyUinta	0.61	1.28	-1.73	3.35	600	1.01
AgeGrp30M34:CountyUinta	0.15	1.28	-2.16	2.89	594	1.01
AgeGrp35M39:CountyUinta	-0.26	1.28	-2.55	2.47	601	1.01
AgeGrp40M44:CountyUinta	-0.11	1.30	-2.47	2.66	614	1.01
AgeGrp45M49:CountyUinta	-0.99	8.95	-20.15	15.10	7268	1.00
AgeGrp50M54:CountyUinta	-1.40	8.89	-20.52	14.02	5814	1.00
AgeGrp15M19:CountyWashakie	3.11	2.59	-1.00	8.79	778	1.00
AgeGrp20M24:CountyWashakie	4.08	2.58	-0.06	9.74	772	1.00
AgeGrp25M29:CountyWashakie	2.77	2.58	-1.33	8.42	771	1.00
AgeGrp30M34:CountyWashakie	2.32	2.58	-1.80	7.94	773	1.00
AgeGrp35M39:CountyWashakie	2.28	2.58	-1.82	7.98	771	1.00
AgeGrp40M44:CountyWashakie	2.43	2.60	-1.73	8.08	779	1.00
AgeGrp45M49:CountyWashakie	-0.62	9.74	-20.10	17.07	6080	1.00
AgeGrp50M54:CountyWashakie	-0.99	9.34	-19.79	15.73	5181	1.00
AgeGrp15M19:CountyWeston	3.11	2.57	-1.08	8.67	1254	1.00
AgeGrp20M24:CountyWeston	3.81	2.57	-0.34	9.41	1269	1.00
AgeGrp25M29:CountyWeston	2.69	2.57	-1.46	8.24	1265	1.00
AgeGrp30M34:CountyWeston	2.18	2.57	-1.93	7.73	1268	1.00
AgeGrp35M39:CountyWeston	1.56	2.57	-2.61	7.13	1273	1.00
AgeGrp40M44:CountyWeston	1.88	2.61	-2.42	7.44	1279	1.00
AgeGrp45M49:CountyWeston	-0.64	9.55	-20.52	17.11	6961	1.00
AgeGrp50M54:CountyWeston	-0.82	8.94	-18.72	15.43	6909	1.00
AgeGrp15M19:zCY	-0.27	0.19	-0.64	0.09	1401	1.00
AgeGrp20M24:zCY	-0.20	0.19	-0.57	0.16	1397	1.00
AgeGrp25M29:zCY	-0.18	0.19	-0.55	0.18	1392	1.00
AgeGrp30M34:zCY	-0.14	0.19	-0.51	0.22	1394	1.00
AgeGrp35M39:zCY	-0.12	0.19	-0.50	0.23	1398	1.00
AgeGrp40M44:zCY	-0.12	0.19	-0.50	0.24	1422	1.00
AgeGrp45M49:zCY	-0.22	3.56	-7.53	6.74	3367	1.00
AgeGrp50M54:zCY	0.26	0.82	-1.31	1.97	6448	1.00

3. Trauma risk model

This model estimates the risk of trauma by age and sex. We use the model to predict the number of trauma incidents by spatial location in order to illustrate which regions have less 'access' to a Level III Trauma Center.

The model is a Generalized Additive Model (GAM) that estimates smooth terms for age by sex. We include varying effects for calendar year and the estimated population for that age-sex-year cell as an offset.

Data for incidents came from the Wyoming Trauma Registry for 2016 through 2018. All incidents were included; we did not filter by Injury Severity Score, which may be more appropriate in future analysis. Population estimates came from Wyoming Economic Analysis.[55]

Model 3: Trauma rate model

```
Family: poisson
  Links: mu = log
Formula: Incidents ~ 1 + Gender + s(zAge, by = Gender, k = 30) + (1 | cCY) + offset(log(Pop))
   Data: trauma_risk (Number of observations: 510)
Samples: 4 chains, each with iter = 1000; warmup = 500; thin = 1;
         total post-warmup samples = 2000

Smooth Terms:
                         Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sds(szAgeGenderFemale_1)     2.52      0.54     1.62     3.74        704 1.01
sds(szAgeGenderMale_1)       3.12      0.55     2.15     4.31        860 1.00

Group-Level Effects:
~cCY (Number of levels: 3)
              Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)     0.07      0.04     0.02     0.17        790 1.01

Population-Level Effects:
                     Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Intercept               -5.22      0.05    -5.33    -5.12        826 1.00
GenderMale               0.36      0.02     0.32     0.40       2935 1.00
szAge:GenderFemale_1     1.53      0.45     0.63     2.40        995 1.00
szAge:GenderMale_1       1.76      0.49     0.83     2.72       1123 1.00
```

[55] http://eadiv.state.wy.us/pop/ST_AS18.htm

4. Stroke risk model

Like the trauma model, we're attempting to estimates the risk of stroke by age and sex. Since the stroke regions are not as developed, the model is only used to show the relative risk in the figure, not actually used to predict counts.

This is also a Generalized Additive Model (GAM) that estimates smooth terms for age by sex. We include varying effects for calendar year and the estimated population for that age-sex-year cell as an offset.

Data for incidents came from the Wyoming Hospital Discharge Database for 2016 through 2018, using DRGs 61 through 72 as "strokes."

Wyoming does not maintain a Stroke Registry, so this is the most comprehensive dataset available for this purpose. It does come with some caveats that ultimately mean the overall risk is estimated too low, though the shape for the age/sex curves is probably close to reality.

- It only captures hospital admissions where the diagnosis (and DRG) clearly indicate a stroke. This could potentially exclude both "microstrokes" as well as immediate deaths, where no inpatient admission happened.

- The discharge database only includes data from participating hospitals. Most in-State hospitals participate, but not all, and there is limited data for out-of-State admissions.

Model 4: Stroke risk model

```
Family: poisson
  Links: mu = log
Formula: Admits ~ 1 + SEX + s(zAge, by = SEX) + (1 | cFY) + offset(log(Pop))
   Data: stroke_risk (Number of observations: 510)
Samples: 4 chains, each with iter = 1000; warmup = 500; thin = 1;
         total post-warmup samples = 2000

Smooth Terms:
                  Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sds(szAgeSEXF_1)     1.68      0.59     0.67     2.90       1254 1.00
sds(szAgeSEXM_1)     0.65      0.49     0.03     1.83        852 1.01

Group-Level Effects:
~cFY (Number of levels: 3)
              Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)     0.10      0.05     0.03     0.21       1431 1.00

Population-Level Effects:
             Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Intercept       -8.08      0.14    -8.38    -7.82       1716 1.00
SEXM            -0.03      0.17    -0.37     0.30       1216 1.00
szAge:SEXF_1     2.21      0.49     1.19     3.13       1106 1.00
szAge:SEXM_1     2.11      0.28     1.48     2.71       1113 1.00
```

5. Out-of-state admission model

This model is used to estimate the fraction of admissions that go out-of-State. We do not use this model directly, but two examples are presented showing the estimated rates for (a) normal newborns and (b) sepsis.

Data for this model was drawn from two sources: Medicaid claims data, and claims data from the Multi-Payer Claims Database maintained by the Montana Association of Health Care purchasers. After subsetting the data for Wyoming residents, we further subsampled by county to ensure that claims data from Casper and Cheyenne didn't drown out the model to the detriment of Niobrara or Crook counties.

The model itself is a simple logistic regression that flags whether the Wyoming resident went in-state or not for an admission. Predictors include age, whether or not the data came from Medicaid or the MPCD, the Major Diagnostic Category and DRG of the admission, and the county.

Model 5: Inpatient admission out-of-state probability model

```
Family: bernoulli
  Links: mu = logit
Formula: InState ~ 1 + zAge + PublicPayer + (1 + PublicPayer | MDC) + (1 +
PublicPayer | DRG) + (1 + zAge + PublicPayer | County)
   Data: ip_subsample (Number of observations: 2070)
Samples: 4 chains, each with iter = 1000; warmup = 500; thin = 1;
         total post-warmup samples = 2000

Group-Level Effects:
~County (Number of levels: 23)
                           Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)                  0.82      0.21     0.39     1.25        720 1.00
sd(zAge)                       0.24      0.14     0.01     0.53        616 1.01
sd(PublicPayer)                0.50      0.26     0.05     1.01        411 1.01
cor(Intercept,zAge)            0.14      0.34    -0.58     0.73       1270 1.00
cor(Intercept,PublicPayer)     0.17      0.33    -0.50     0.78       1209 1.00
cor(zAge,PublicPayer)          0.12      0.39    -0.65     0.78        750 1.00

~DRG (Number of levels: 293)
                           Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)                  1.14      0.26     0.60     1.62        400 1.01
sd(PublicPayer)                0.46      0.30     0.02     1.12        158 1.02
cor(Intercept,PublicPayer)     0.15      0.39    -0.66     0.84       1211 1.00

~MDC (Number of levels: 32)
                           Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)                  0.76      0.25     0.22     1.26        599 1.00
sd(PublicPayer)                0.85      0.30     0.19     1.42        421 1.01
cor(Intercept,PublicPayer)     0.21      0.35    -0.46     0.85        663 1.00

Population-Level Effects:
            Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Intercept       0.22      0.38    -0.52     0.92        985 1.00
zAge            0.76      0.14     0.49     1.04       1277 1.00
PublicPayer     0.75      0.38    -0.02     1.49        727 1.01
```

6. Hospital admit model

This model is one of four models that drive the counterfactual hospital market simulation of the last section. The goal of this model is to predict the number of annual **in-State** admits generated by a given population. As explained in the methodology section, we use the gridded population data to estimate the spatial locations and characteristics of each simulated admission.

As with the trauma and stroke models, this is a Generalized Additive Model (GAM) that predicts the average count of in-state admissions for a given population based on age, sex and newborn status.

Data from this model came from the Wyoming Hospital Discharge Database. As noted previously, this database is not comprehensive; St. Johns, for example, does not participate. We therefore excluded Teton and Sublette counties from the model, and use information from other counties to estimate in-State hospital rates for these two counties.

Model 6: Inpatient admission counts model

```
Family: MV(poisson, poisson)
  Links: mu = log
         mu = log
Formula: Admits ~ 1 + SEX + (1 | cFY) + s(zAge, by = SEX) + Newborn + Newborn * SEX + offset(log(Pop))
         Days ~ 1 + SEX + (1 | cFY) + s(zAge, by = SEX) + Newborn + Newborn * SEX + offset(log(Pop))
   Data: hosp_risk (Number of observations: 510)
Samples: 4 chains, each with iter = 1000; warmup = 500; thin = 1;
         total post-warmup samples = 2000

Smooth Terms:
                        Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sds(Admits_szAgeSEXF_1)     5.75      0.48     4.93     6.78        944 1.00
sds(Admits_szAgeSEXM_1)     4.38      0.47     3.52     5.35       1008 1.00
sds(Days_szAgeSEXF_1)       8.82      1.32     6.56    11.71        572 1.00
sds(Days_szAgeSEXM_1)       7.75      1.25     5.67    10.53        685 1.00

Group-Level Effects:
~cFY (Number of levels: 3)
                      Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Admits_Intercept)     0.06      0.04     0.02     0.16        896 1.00
sd(Days_Intercept)       0.08      0.04     0.03     0.18       1348 1.00

Population-Level Effects:
                    Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Admits_Intercept       -2.90      0.04    -2.98    -2.82       1155 1.00
Days_Intercept         -1.62      0.05    -1.72    -1.51       1027 1.01
Admits_SEXM            -0.44      0.01    -0.45    -0.42       3288 1.00
Admits_Newborn          3.90      0.07     3.77     4.03       1673 1.00
Admits_SEXM:Newborn    -0.16      0.09    -0.33     0.02       2030 1.00
Days_SEXM              -0.31      0.01    -0.33    -0.30       3621 1.00
Days_Newborn            3.95      0.05     3.86     4.05       1585 1.00
Days_SEXM:Newborn      -0.17      0.06    -0.30    -0.05       1897 1.00
Admits_szAge:SEXF_1    -2.74      0.16    -3.06    -2.42       1648 1.00
Admits_szAge:SEXM_1    -2.50      0.18    -2.86    -2.14       2949 1.00
Days_szAge:SEXF_1      -1.88      0.10    -2.08    -1.68       1672 1.00
Days_szAge:SEXM_1      -2.50      0.11    -2.71    -2.29       3185 1.00
```

7. Major Diagnostic Category (MDC) model

This model is the second of four models that drive the counterfactual hospital market simulation of the last section. Here, the goal is to characterize each admission with a likely Major Diagnostic Category, or MDC. MDCs are used in the Diagnosis-Related Grouping logic to assign clinical categories to the (much larger number) of DRGs. Table X, below, lists the 26 MDCs and what DRGs generally will fall into which category.

Table X: MS-DRG Major Diagnostic Categories

MDC	Description	MS-DRGs
0	Pre-MDC	001 - 017
1	Diseases and Disorders of the Nervous System	020 - 103
2	Diseases and Disorders of the Eye	113 - 125
3	Diseases and Disorders of the Ear, Nose, Mouth And Throat	129 - 159
4	Diseases and Disorders of the Respiratory System	163 - 208
5	Diseases and Disorders of the Circulatory System	215 - 316
6	Diseases and Disorders of the Digestive System	326 - 395
7	Diseases and Disorders of the Hepatobiliary System And Pancreas	405 - 446
8	Diseases and Disorders of the Musculoskeletal System And Connective Tissue	453 - 566
9	Diseases and Disorders of the Skin, Subcutaneous Tissue And Breast	573 - 607
10	Diseases and Disorders of the Endocrine, Nutritional And Metabolic System	614 - 645
11	Diseases and Disorders of the Kidney And Urinary Tract	652 - 700
12	Diseases and Disorders of the Male Reproductive System	707 - 730
13	Diseases and Disorders of the Female Reproductive System	734 - 761
14	Pregnancy, Childbirth And Puerperium	765 - 782
15	Newborn And Other Neonates (Perinatal Period)	789 - 795
16	Diseases of the Blood and Blood Forming Organs and Immunological Disorders	799 - 816
17	Myeloproliferative DDs (Poorly Differentiated Neoplasms)	820 - 849
18	Infectious and Parasitic DDs (Systemic or unspecified sites)	853 - 872
19	Mental Diseases and Disorders	876 - 887
20	Alcohol/Drug Use or Induced Mental Disorders	894 - 897
21	Injuries, Poison And Toxic Effect of Drugs	901 - 923
22	Burns	927 - 935
23	Factors Influencing Health Status and Other Contacts with Health Services	939 - 951
24	Multiple Significant Trauma	955 - 965
25	Human Immunodeficiency Virus Infection	969 - 977

The MDC model below is fit on a random sample (8,000 admits) from the Wyoming Hospital Discharge Database. We use 5-year age categories, sex, and ZIP code as predictors — ZIP codes being parameterized as varying effects so we can estimate the 'population' distribution in case certain ZIPs were not included in the sample, but are in the simulation.

We have truncated the model output after the intercepts, since it would go on for an additional five to ten pages.

Model 7: MDC Model

```
Family: categorical
  Links: mu1 = logit; mu10 = logit; mu11 = logit; mu12 = logit; mu13 = logit; mu14 = logit; mu15
= logit; mu16 = logit; mu17 = logit; mu18 = logit; mu19 = logit; mu2 = logit; mu20 = logit; mu21
= logit; mu22 = logit; mu23 = logit; mu24 = logit; mu25 = logit; mu3 = logit; mu4 = logit; mu5 =
logit; mu6 = logit; mu7 = logit; mu8 = logit; mu9 = logit
Formula: MDC ~ 1 + Male + AgeCat + Male * AgeCat + (1 | ZIP)
   Data: complete_wide_sample (Number of observations: 8000)
Samples: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
         total post-warmup samples = 4000

Group-Level Effects:
~ZIP (Number of levels: 151)
                    Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(mu1_Intercept)       0.20      0.10     0.02     0.41       1110 1.00
sd(mu10_Intercept)      0.10      0.08     0.00     0.29       1874 1.00
sd(mu11_Intercept)      0.11      0.08     0.01     0.28       1775 1.00
sd(mu12_Intercept)      0.28      0.22     0.01     0.82       1749 1.00
sd(mu13_Intercept)      0.32      0.23     0.01     0.84       1524 1.00
sd(mu14_Intercept)      0.40      0.10     0.22     0.61       1655 1.00
sd(mu15_Intercept)      0.35      0.16     0.04     0.67       1161 1.00
sd(mu16_Intercept)      0.25      0.19     0.01     0.70       1440 1.00
sd(mu17_Intercept)      0.97      0.42     0.23     1.87        989 1.00
sd(mu18_Intercept)      0.46      0.11     0.26     0.71       1281 1.00
sd(mu19_Intercept)      1.11      0.19     0.77     1.54       1301 1.00
sd(mu2_Intercept)       0.68      0.51     0.03     1.90       1745 1.00
sd(mu20_Intercept)      0.55      0.18     0.19     0.92        808 1.00
sd(mu21_Intercept)      0.30      0.18     0.01     0.68       1133 1.00
sd(mu22_Intercept)      0.62      0.47     0.03     1.73       2230 1.00
sd(mu23_Intercept)      0.65      0.17     0.35     1.02       1452 1.00
sd(mu24_Intercept)      0.68      0.43     0.05     1.66       1237 1.00
sd(mu25_Intercept)      0.71      0.55     0.04     2.04       2624 1.00
sd(mu3_Intercept)       0.27      0.20     0.01     0.76       1479 1.00
sd(mu4_Intercept)       0.11      0.07     0.01     0.27        903 1.01
sd(mu5_Intercept)       0.30      0.08     0.15     0.47       1247 1.00
sd(mu6_Intercept)       0.09      0.06     0.00     0.23       1568 1.00
sd(mu7_Intercept)       0.15      0.10     0.01     0.39       1564 1.00
sd(mu8_Intercept)       0.30      0.07     0.18     0.46       1400 1.00
sd(mu9_Intercept)       0.40      0.16     0.11     0.75       1376 1.00

Population-Level Effects:
                      Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
mu1_Intercept             0.96      0.39     0.17     1.71        839 1.01
mu10_Intercept            1.55      0.35     0.85     2.23        667 1.01
mu11_Intercept            0.72      0.40    -0.06     1.51        947 1.01
mu12_Intercept           -4.74      1.01    -6.83    -2.85       3404 1.00
mu13_Intercept            0.13      0.48    -0.87     1.04        979 1.00
mu14_Intercept            3.92      0.27     3.39     4.44        951 1.00
mu15_Intercept           -3.26      0.81    -4.96    -1.75       2955 1.00
mu16_Intercept           -0.37      0.50    -1.42     0.55       1262 1.00
mu17_Intercept           -2.62      0.78    -4.22    -1.18       2246 1.00
mu18_Intercept            0.57      0.41    -0.27     1.40        709 1.00
mu19_Intercept            1.98      0.36     1.26     2.67       1035 1.01
mu2_Intercept            -3.41      0.87    -5.25    -1.82       3053 1.00
mu20_Intercept           -0.37      0.49    -1.35     0.59        949 1.00
mu21_Intercept            0.90      0.40     0.08     1.64       1248 1.00
```

```
mu22_Intercept           -4.64      1.05    -6.82    -2.75       3737 1.00
mu23_Intercept           -0.86      0.54    -1.93     0.17        941 1.00
mu24_Intercept           -3.27      0.79    -4.90    -1.78       2877 1.00
mu25_Intercept           -5.48      1.24    -8.11    -3.34       4195 1.00
mu3_Intercept            -0.65      0.51    -1.69     0.32       1757 1.00
mu4_Intercept             1.41      0.35     0.71     2.09        710 1.00
mu5_Intercept             0.44      0.43    -0.43     1.24        837 1.00
mu6_Intercept             1.36      0.37     0.63     2.11        738 1.00
mu7_Intercept             0.82      0.39     0.07     1.59        844 1.00
mu8_Intercept             1.22      0.36     0.50     1.93        792 1.00
mu9_Intercept            -0.07      0.46    -0.99     0.79       1048 1.00

[truncated]
```

8. Public payer model

This model is the third of four models that drive the counterfactual hospital market simulation of the last section.

The objective of this model is to characterize the pay source of each admission as either "public" or "private," using age, sex, MDC and ZIP code as predictors.

The Hospital Discharge Database served as the base data for this model. "Public" payers were considered as Medicare, Medicaid, Workers Compensation, and "Other government." "Private" payers included everything else, as well as "Free/indigent."

Aside from the number of predictors, the model is a comparatively simple logistic regression, shown below.

Model 8: Public payer model

```
Family: bernoulli
  Links: mu = logit
Formula: PublicPayer ~ 1 + Male + AgeCat + Male * AgeCat + (1 | MDC) + (1 | ZIP)
   Data: complete_wide_sample (Number of observations: 8000)
Samples: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
         total post-warmup samples = 4000

Group-Level Effects:
~MDC (Number of levels: 26)
              Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)     0.30      0.08     0.18     0.48       1530 1.00

~ZIP (Number of levels: 153)
              Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(Intercept)     0.45      0.06     0.34     0.58       1391 1.00

Population-Level Effects:
                 Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
Intercept            0.10      0.19    -0.27     0.47        995 1.00
Male                -0.74      0.27    -1.26    -0.23        692 1.00
AgeCat1924          -0.39      0.20    -0.77     0.01       1288 1.00
AgeCat2429          -0.59      0.19    -0.95    -0.21       1300 1.00
AgeCat2934          -1.08      0.20    -1.46    -0.70       1316 1.00
AgeCat3439          -0.76      0.21    -1.19    -0.35       1448 1.00
AgeCat3944          -0.74      0.25    -1.21    -0.24       1644 1.00
AgeCat49            -0.34      0.55    -1.40     0.72       4106 1.00
AgeCat4449          -0.64      0.26    -1.15    -0.13       1688 1.00
AgeCat4954          -0.88      0.24    -1.36    -0.41       1564 1.00
```

AgeCat5459	-0.60	0.22	-1.02	-0.16	1342	1.00
AgeCat5964	-0.34	0.22	-0.75	0.09	1269	1.00
AgeCat6469	1.75	0.24	1.27	2.23	1554	1.00
AgeCat6974	2.05	0.25	1.55	2.56	1554	1.00
AgeCat7479	2.54	0.28	1.98	3.10	1772	1.00
AgeCat7984	1.87	0.25	1.38	2.36	1510	1.00
AgeCat84120	2.22	0.25	1.74	2.72	1524	1.00
AgeCat914	-0.64	0.41	-1.43	0.17	3074	1.00
AgeCat04	-0.32	0.24	-0.78	0.18	1413	1.00
Male:AgeCat1924	-0.32	0.44	-1.21	0.53	1469	1.00
Male:AgeCat2429	-0.41	0.43	-1.24	0.42	1628	1.00
Male:AgeCat2934	1.03	0.36	0.33	1.74	1131	1.00
Male:AgeCat3439	0.65	0.37	-0.09	1.39	1181	1.00
Male:AgeCat3944	0.35	0.38	-0.37	1.09	1208	1.00
Male:AgeCat49	0.18	0.71	-1.23	1.55	3238	1.00
Male:AgeCat4449	0.45	0.39	-0.30	1.22	1267	1.00
Male:AgeCat4954	1.20	0.36	0.50	1.90	1049	1.00
Male:AgeCat5459	0.53	0.32	-0.10	1.16	976	1.00
Male:AgeCat5964	0.39	0.32	-0.23	1.01	953	1.00
Male:AgeCat6469	0.51	0.36	-0.18	1.21	1113	1.00
Male:AgeCat6974	0.43	0.36	-0.26	1.15	1161	1.00
Male:AgeCat7479	0.16	0.40	-0.64	0.90	1231	1.00
Male:AgeCat7984	1.24	0.40	0.45	2.05	1167	1.00
Male:AgeCat84120	0.64	0.39	-0.12	1.40	1122	1.00
Male:AgeCat914	1.38	0.61	0.18	2.59	2665	1.00
Male:AgeCat04	0.81	0.29	0.23	1.38	770	1.00

9. Hospital choice model

This model is a more complex version of the EMS choice model. The objective is to predict the probability of a certain patient "choosing" a certain hospital for each hospital admission, assuming all admissions are in-state.

Earlier versions included choice among out-of-state hospitals, but estimates for total inpatient admission risk relying on the hospital discharge data limit reliable data to in-state hospitals.

The two major predictors here are (1) drive time from the patient admission source to the hospital and (2) the hospital's capabilities, measured here as the log of total Emergency Department (ED) visits, births, and whether or not the hospital is a Level II or lower trauma center. We also include admission-level predictors of (3) whether or not the payer was public, (4) the ZIP code of the admission, and (4) the Major Diagnostic Category (MDC) of the admission.

Underlying data for this model came from combining a public-payer dataset (Wyoming Medicaid inpatient claims data) and a private-payer dataset (the multi-payer claims database, curated by the Montana Association of Health Care Purchasers (MAHCP). All claims were run through an MS-DRG grouper to assign Major Diagnostic Categories (MDC). Travel times to available hospitals (Medicaid and American Hospital Association data) were calculated using the Open Source Routing Machine.

Model 9: Hospital Choice Model

```
Family: categorical
  Links: muHOSP1 = logit; muHOSP10 = logit; muHOSP2 = logit; muHOSP3 = logit; muHOSP4 = logit; muHOSP5 = logit;
muHOSP6 = logit; muHOSP7 = logit; muHOSP8 = logit; muHOSP9 = logit
Formula: ChosenRank ~ 1
         muHOSP1 ~ bBirths * LogBirths.HOSP1 + bED * LogED.HOSP1 + bzTime * zTime.HOSP1 + bTrauma *
Trauma12.HOSP1
         muHOSP2 ~ bBirths * LogBirths.HOSP2 + bED * LogED.HOSP2 + bzTime * zTime.HOSP2 + bTrauma *
Trauma12.HOSP2
         muHOSP3 ~ bBirths * LogBirths.HOSP3 + bED * LogED.HOSP3 + bzTime * zTime.HOSP3 + bTrauma *
Trauma12.HOSP3
         muHOSP4 ~ bBirths * LogBirths.HOSP4 + bED * LogED.HOSP4 + bzTime * zTime.HOSP4 + bTrauma *
Trauma12.HOSP4
         muHOSP5 ~ bBirths * LogBirths.HOSP5 + bED * LogED.HOSP5 + bzTime * zTime.HOSP5 + bTrauma *
Trauma12.HOSP5
         muHOSP6 ~ bBirths * LogBirths.HOSP6 + bED * LogED.HOSP6 + bzTime * zTime.HOSP6 + bTrauma *
Trauma12.HOSP6
         muHOSP7 ~ bBirths * LogBirths.HOSP7 + bED * LogED.HOSP7 + bzTime * zTime.HOSP7 + bTrauma *
Trauma12.HOSP7
         muHOSP8 ~ bBirths * LogBirths.HOSP8 + bED * LogED.HOSP8 + bzTime * zTime.HOSP8 + bTrauma *
Trauma12.HOSP8
         muHOSP9 ~ bBirths * LogBirths.HOSP9 + bED * LogED.HOSP9 + bzTime * zTime.HOSP9 + bTrauma *
Trauma12.HOSP9
         muHOSP10 ~ bBirths * LogBirths.HOSP10 + bED * LogED.HOSP10 + bzTime * zTime.HOSP10 + bTrauma *
Trauma12.HOSP10
         bBirths ~ 1 + PublicPayer + (1 | MDC) + (1 | ZIP)
         bED ~ 1 + PublicPayer + (1 | MDC) + (1 | ZIP)
         bzTime ~ 1 + PublicPayer + (1 | MDC) + (1 | ZIP)
         bTrauma ~ 1 + PublicPayer + (1 | MDC) + (1 | ZIP)
   Data: final_sample (Number of observations: 3998)
Samples: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
         total post-warmup samples = 4000

Group-Level Effects:
~MDC (Number of levels: 34)
                      Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(bBirths_Intercept)     0.42      0.11     0.23     0.66       1202 1.00
sd(bED_Intercept)         0.56      0.17     0.25     0.94        908 1.01
sd(bzTime_Intercept)      0.83      0.19     0.52     1.26       1553 1.00
sd(bTrauma_Intercept)     1.53      0.32     0.99     2.25       1347 1.00

~ZIP (Number of levels: 103)
                      Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
sd(bBirths_Intercept)     0.14      0.08     0.01     0.32        516 1.01
sd(bED_Intercept)         0.12      0.08     0.01     0.31        925 1.00
sd(bzTime_Intercept)      1.41      0.25     0.97     1.96       1029 1.00
sd(bTrauma_Intercept)     1.80      0.36     1.18     2.62       1143 1.00

Population-Level Effects:
                     Estimate Est.Error l-95% CI u-95% CI Eff.Sample Rhat
bBirths_Intercept       1.52      0.42     0.72     2.37        881 1.00
bBirths_PublicPayer    -1.10      0.41    -1.93    -0.31        901 1.00
bED_Intercept          -0.51      0.35    -1.19     0.18        912 1.00
bED_PublicPayer         0.89      0.29     0.32     1.48        918 1.00
bzTime_Intercept       -4.74      0.42    -5.59    -3.94       1366 1.01
bzTime_PublicPayer      0.04      0.28    -0.51     0.61       3021 1.00
bTrauma_Intercept       1.41      0.60     0.23     2.58       1453 1.00
bTrauma_PublicPayer     0.62      0.43    -0.23     1.47       2166 1.00
```