

APPENDIX A: Data Sources and Measurements

We instantiated our mathematical framework with several types of data, including patient arrivals to hospitals, care practices such as test ordering behavior, and use statistics for the HIE. We used published data sets, extracts from claims data, and publicly available hospital claims data.

In this work, we focused our attention on patients with primary diagnosis of diseases considered “chronic” according to the clinical trial literature.

1. Diabetes
2. Chronic obstructive pulmonary disease (COPD)
3. Asthma

We restricted cases to ED visits from three hospitals participating with the Wisconsin Health Information Exchange (WHIE) for the fiscal year (FY) 2008-2009. The WHA Information Center (Wisconsin Hospital Association 2011) listed the total number of ED visits for the three hospitals during FY 08-09 as 48093, 38949, and 40384 respectively.

1. Emergency Department Patient Statistics

Medicaid/Medicare Overview

Table 1. Visit summary data for ED visits from three hospitals concerning Medicare/Medicaid patients

Medicare/Medicaid (All Diagnosis)				
Provider	ED Visits*	Procedures per visit	Average amt. claimed**	Repeat ED Visits
Hospital 1	22268	n.a.	\$762	n.a.
Hospital 2	11563	n.a.	\$905	n.a.
Hospital 3	13215	n.a.	\$630	n.a.
Medicare/Medicaid (Asthma/COPD/Diabetes)				
Provider	ED Visits*	Procedures per visit*	Average amt. claimed**	Repeat ED Visits*
Hospital 1	1600	1.96	\$2044	134
Hospital 2	981	2.09	\$2323	93
Hospital 3	1066	1.73	\$1815	84

* State of WI Medicare/Medicaid claims: Exact patient, visit and procedure counts

** State of WI Medicare/Medicaid claims: Exact charges for FFS patients and assigned charges for HMO patients

In Wisconsin, Medicare/Medicaid (Badger Care) covers approximately 1.1M residents from 6 broad groups, which include: Children, Pregnant women, Adults with dependent children, Low-income adults without dependent children, Individuals with disabilities, and Elderly individuals below a certain poverty level. The Department of Health Services (State of Wisconsin) maintains a data warehouse which contains billing records of medical (outpatient and inpatient services), drug and long-term care claims for the Medicaid/Medicare patients segmented into Fee for Service (FFS) and Managed Care (HMO). The database is HIPAA compliant. Institutional Review Board clearance has been given for quality analysis usage.

Table 1 summarizes claims data for ED visits concerning Medicare/Medicaid patients from the three hospitals in our study. The ED visit, procedure, and patient counts are accurate at the patient level for both FFS and HMO. The DHS recorded charges concerning FFS patients on an accrual basis at the hospital's established rates, without consideration to any discounts and/or allowances. Charges for the care of patients who are members of a Medicare/Medicaid-HMO are assigned charges to the reported monthly by the M/M HMOs to the State Medicaid Program. These charges are computed by the State based on the rates the State Medicaid Program used to pay Medicaid fee-for-service claims for comparable services. Note that the charges billed to the insurer by the provider are *not* the same as the amount reimbursed by an insurer to the provider.

We identified patients diagnosed with one of the three diseases (Asthma, COPD, Diabetes) using the International Classification for Disease Code-9th revision, Clinical Modification (ICD-9-CM). For the diabetes cohort, we used 250.00-250.90, 250.02-250.92; for the COPD cohort, we used 491, 491.1, 491.2, 491.8, 491.9, 492, 492.0 and 496; and for the asthma cohort, we used 493.[0-9]. We grouped all Medicaid/Medicare patients by frequency of ED visit, and identified repeat ED visits as those taking place within 15 days of the initial visit.

Patient & Payer Mix

We did not have access to a dataset documenting commercial payer claims at the level of detail as Medicare/Medicaid related data, so we used simplifying assumptions. Table 2 details the hospitals' *payer mix*, i.e. the proportion of the total reimbursements, concerning our study population, attributable to different types of insurance coverage. We obtained this information using Pricepoint (WHA Information Center 2011), a system operated by the Wisconsin Hospital Association (WHA). PricePoint allows health care consumers to receive basic, facility-specific information about healthcare services and charges. The *patient mix*, in Table 2, is the proportion of ED visits, (concerning the study population) attributable to patients covered by different types of insurance services. We estimated the patient mix by using information concerning payer mix (Table 2) in combination with the average ED reimbursements (Tables 6-7).

Table 2: Payer & Patient mix by patient type for Asthma/COPD/Diabetes

Patient Type	Hospital 1		Hospital 2		Hospital 3	
	Payer Mix*	Patient Mix**	Payer Mix*	Patient Mix**	Payer Mix*	Patient Mix**
Medicare	23.5%	25.6%	20.0%	25.1%	45.0%	51.1%
Medicaid	53.0%	57.8%	33.0%	41.4%	27.0%	30.6%
Other Government	4.1%	2.5%	3.0%	2.1%	2.0%	1.2%
Commercial	15.3%	9.5%	38.0%	27.9%	22.0%	13.3%
Other	5.3%	4.4%	6.0%	4.3%	4.0%	3.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* WHA PricePoint

** Calculated data

In summary, Table 2 states that *approximately* 27.9% of ED visits, in Hospital 2, concerning Asthma/COPD/Diabetes involve patients covered by commercial insurance, and this accounts for

exactly 38.0% of total ED charges. Table 2 indicates that a fewer proportion of private payers contribute to a larger proportion of the provider's total reimbursement. We extended the analysis above to categorize payer & patient mix by payer type (Table 3).

Table 3: Payer & Patient mix by payer type for Asthma/COPD/Diabetes

Payer Type	Hospital 1		Hospital 2		Hospital 3	
	Payer Mix*	Patient Mix**	Payer Mix*	Patient Mix**	Payer Mix*	Patient Mix**
HMO	60.7%	69.7%	55.9%	62.6%	65.14%	65.1%
Govt. FFS	17.3%	17.3%	13.7%	15.9%	16.92%	16.9%
Commercial FFS	15.3%	9.6%	24.1%	17.2%	13.98%	14.0%
Other	6.8%	3.4%	6.2%	4.3%	3.96%	4.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* WHA PricePoint

** Calculated data

Commercial Insurance Overview

In our study population, we estimated ED visit/patient counts (Table 4) for cases attributed to commercial insurance by extrapolating exact patient/visit counts (Table 1) with patient mix estimates of Table 2 & 3. We assumed that the ratio of ED visits to unique patients remains the same across all payer types for a given hospital and primary diagnosis. We conducted a sensitivity analysis on this assumption (unpublished data) and determined that our results are insensitive (within tolerance) to a factor of 5. In other words, our results are not significantly different if the *true* ratio of ED visits to unique patients concerning commercial insurance (Table 4) is as low/high as a fifth/five times the ratio of ED visits to unique patients of Medicare/Medicaid (Table 1).

Table 4: Commercial insurance claims data for Asthma/COPD/Diabetes

Provider	ED Visits**	Procedures per visit*	Average amt. claimed*	Repeat ED Visits**
Hospital 1	284	1.93	\$2996	24
Hospital 2	494	1.94	\$2902	47
Hospital 3	214	1.92	\$2936	17

* WHA PricePoint

** Calculated data

Miscellaneous Hospital Statistics

We estimated three hospital-ED related statistics; *average reimbursement rates*, *ED-hospitalization ratio* and *operating margin* (Table 5). The average reimbursement rate is the average percentage of charges collected by the provider from an insurer type. The ED-hospitalization ratio is the percentage of ED visits that resulted in a subsequent hospitalization. The operating margin is the ratio of the operating profit to the net revenue. We used PricePoint, the Health Care Data Report 08-09 (Wisconsin Hospital Association 2008), and the Guide to Wisconsin Hospitals FY 08-09 (Wisconsin Hospital Association 2008), all operated by the WHA. These documents provide summary information, including outpatient visits, inpatient visits, staffing levels, occupancy rates, average

length of stay, and the breakdown of the sources of the provider’s revenue by Medicare, BadgerCare, other government, commercial insurance and self-pay. In addition to the summary information, they also provide a percentile breakdown of charges for a range of medical procedures categorized by the type of ICD-9 code illness.

Table 5. Hospital based summary

Provider	Average Reimbursement Rates *			Operating Margin***	ED-Hospitalization Ratio **
	Medicare	Medicaid	Commercial		
Hospital 1	36%	23%	65%	4.1%	11.1%
Hospital 2	30%	23%	62%	9.5%	9.2%
Hospital 3	31%	25%	65%	14.5%	8.8%

* WHA PricePoint

** WHA Health Care Data Report (FY 08-09)

***WHA Guide to Wisconsin Hospitals (FY 08-09)

2. Emergency Department Claims & Reimbursements

We estimated *average charge*, the *average reimbursement* and estimated *average hospital cost* for medical procedures categorized by insurer (Table 6 and 7). The average charge is the average amount billed by the provider to an insurer for an ED visit. The average reimbursement is the average amount reimbursed by an insurer to the provider for the same ED visit. The average hospital cost is the estimated cost incurred to the hospital for provide medical services for the same ED visit.

In Table 6, we used exact visit counts for Medicare/Medicaid patients, exact claims data for Medicare/Medicaid FFS patients, and assigned costs for Medicare/Medicaid HMO patients (explained in Section 1). We estimated the average reimbursement for Medicare/Medicaid patients using average reimbursement rates documented from Table 5.

In Table 7, we estimated the average charge billed to a commercial insurer, by a provider, using the WHA PricePoint system. PricePoint does not document outpatient visits with the same level of detail as inpatient visits. Hence, the average charges in Table 7 are accurate at the hospital level for Asthma and at the Milwaukee county level for COPD and Diabetes. We estimated the average reimbursement for commercial insurance patients by using the average reimbursement rates from Table 5. We extrapolated the ED visit counts for commercial insurance patients using patient mix information in Table 3 in combination with exact ED visit counts for Medicare/Medicaid patients from Table 2. We assumed that the patient mix (Table 3) is uniform across Asthma, COPD and Diabetes.

Often, Medicare & Medicaid reimburse providers at rates that do not cover the costs they incur to provide care. Payments from commercial insured patients generally subsidize the shortfalls created by Medicare and Medicaid. The average *estimated hospital cost* is an indication of whether a patient type is profitable to a hospital. We estimated the hospital cost by using *exact* charges, reimbursements and visit counts for Medicaid/Medicare patients (Table 6), *estimates* of charges, reimbursements and visit counts for commercial insurance patients (Table 7) and the average hospital operating margin (Table 5). We assumed that the hospital operates at the same margin for Asthma, COPD, and Diabetes and that the hospital cost does not depend on the patient insurance type.

Table 6. Claims & Reimbursements for Medicare/Medicaid patients with Asthma/COPD/Diabetes

Diagnosis	Hospital ID	ED Visits *	Total Charge (\$)**	Avg. Charge (\$)**	Avg. Reimbursement (\$)**	Total Reimbursement (\$)**	Avg. ED Hospital Cost (\$)**
Asthma	1	789	1.46M	1845	534	421K	644
	2	491	1.17M	2378	711	349K	952
	3	493	0.87M	1766	566	279K	651
COPD	1	680	1.75M	2571	744	506K	957
	2	407	1.07M	2635	788	321K	1,142
	3	521	1.02M	1961	628	327K	892
Diabetes	1	131	0.07M	500	145	19K	332
	2	83	0.04M	467	140	12K	320
	3	52	0.04M	825	264	14K	446

* State of WI Medicare/Medicaid claims: Exact visit counts

** State of WI Medicare/Medicaid claims: Exact charges for FFS patients & assigned charges for HMO patients

*** Calculated data

Table 7. ED statistics for commercial insurance patients with Asthma/COPD/Diabetes

Diagnosis	Hospital ID	ED Visits *	Total Charge (\$)**	Avg. Charge (\$)**	Avg. Reimbursement (\$)**	Total Reimbursement (\$)**	Avg. ED Hospital Cost (\$)**
Asthma	1	156	0.33M	2092	1360	212.K	644
	2	247	0.68M	2741	1699	420.3K	952
	3	109	0.2M	1816	1180	129.1K	651
COPD	1	134	0.47M	3500	2275	305.7K	957
	2	205	0.72M	3500	2170	444.9K	1,142
	3	116	0.4M	3500	2275	262.9K	892
Diabetes	1	26	0.05M	2100	1365	35.3K	332
	2	18	0.04M	2100	1302	24.K	320
	3	12	0.02M	2100	1365	15.7K	446

* WHA PricePoint

** Calculated data

Table 8 and Table 9 provide statistics concerning medical procedures performed at the ED on patients with Asthma, COPD, and Diabetes covered by Medicare/Medicaid and commercial insurance, respectively. We used an identical set of assumptions and techniques for Tables 8 and 9 as we did for Tables 6 and 7. In summary, we combined *exact* patient-level data concerning Medicare/Medicaid

patients with *estimates* of charges, reimbursements, and visit counts for commercial insurance patients (Table 7) and the average hospital operating margin (Table 5).

Table 8. Statistics concerning medical procedures performed at ED labs on Medicare/Medicaid Patients

Diagnosis	Asthma		COPD		Diabetes	
Provider	Average Charge**	Procedure Count*	Average Charge**	Procedure Count*	Average Charge**	Procedure Count*
Hospital 1	23	544	19	180	20	475
Hospital 2	23	428	23	97	23	358
Hospital 3	26	378	26	127	29	300

* State of WI Medicare/Medicaid claims: Exact procedure counts

** State of WI Medicare/Medicaid claims: Exact charges for FFS patients & assigned charges for HMO

Table 9. Statistics concerning medical procedures performed at ED labs on Medicare/Medicaid Patients

Diagnosis	Asthma		COPD		Diabetes	
Provider	Average Charge**	Procedure Count*	Average Charge**	Procedure Count*	Average Charge**	Procedure Count*
Hospital 1	23	684	19	226	20	597
Hospital 2	23	781	23	177	23	654
Hospital 3	26	684	26	174	29	412

* Calculated data

** WHA PricePoint

3. Hospital Inpatient Service Claims & Reimbursements

We estimated statistics concerning ED Visits resulting in subsequent hospitalizations for patients insured by Medicare/Medicaid (Table 10) and commercial insurance (Table 11). We repeated the estimation analysis performed with outpatient data from Tables 6 and 7 for inpatient data in Tables 10 and 11. That is, we combined *exact* patient level data concerning Medicare/Medicaid patients with *estimates* of charges, reimbursements and visit counts for commercial insurance patients (Table 7) and the average hospital operating margin (Table 5). Again, we assumed that the hospital operates at the same margin for Asthma, COPD, and Diabetes and that the hospital cost does not depend on the patient insurance type.

Table 10. Claims and Reimbursements concerning Medicare/Medicaid Patients for ED Visits resulting in subsequent hospitalizations

Diagnosis	Hospital ID	Cases *	Total Charge **	Avg. Charge **	Avg. Reimbursement ***	Total Reimbursement ***	Avg. Hospital Cost ***
Asthma	1	88	0.99M	11.2K	3.2K	286.K	4.K
	2	45	0.51M	11.2K	3.3K	151.1K	4.7K
	3	43	0.49M	11.3K	3.6K	157.5K	4.4K
COPD	1	76	1.19M	15.6K	4.5K	344.6K	5.7K
	2	37	0.59M	15.7K	4.7K	176.1K	6.4K
	3	46	0.69M	15.K	4.8K	220.2K	6.K
Diabetes	1	15	0.19M	13.1K	3.8K	55.4K	4.9K
	2	8	0.1M	13.7K	4.1K	31.2K	5.K
	3	5	0.05M	11.7K	3.8K	17.2K	4.7K

* State of WI Medicare/Medicaid claims: Exact visit counts

** State of WI Medicare/Medicaid claims: Exact charges for FFS & assigned charges for HMO

*** Calculated data

Table 11. Claims and Reimbursements commercial insurance patients for ED Visits resulting in subsequent hospitalizations

Diagnosis	Hospital ID	Cases **	Total Charge *	Avg. Charge *	Avg. Reimbursement **	Total Reimbursement **	Avg. Hospital Cost **
Asthma	1	17	0.23M	13.5K	8.8K	151.9K	4.K
	2	23	0.32M	14.2K	8.8K	200.8K	4.7K
	3	10	0.13M	13.8K	9.K	86.5K	4.4K
COPD	1	15	0.31M	20.4K	13.2K	199.3K	5.7K
	2	19	0.36M	18.8K	11.7K	220.1K	6.4K
	3	10	0.19M	19.1K	12.4K	126.5K	6.K
Diabetes	1	3	0.05M	18.6K	12.1K	35.1K	4.9K
	2	2	0.03M	18.9K	11.7K	11.7K	5.K
	3	1	0.02M	15.7K	10.2K	10.2K	4.7K

* Extracted from WHA PricePoint

** Calculated data

4. Miscellaneous statistics

We estimated the average annual premiums charged by Commercial FFS, Commercial HMO, and Government HMO in FY 08-09 in Table 12 using summary statistics reports filed with the State of WI insurance commissioner on Jan 1, 2009. These reports survey group health insurance providers in Wisconsin every six months to monitor the premiums charged for group health insurance policies.

The operating budget of WHIE was obtained from financial reports obtained by personal communication with Kim R. Pemble, Executive Director and CEO of the Wisconsin Health Information Exchange (WHIE). WHIE provides HIE services to over 22 different hospitals spanning 5 different health systems. The goal of this paper is not to demonstrate sustainability of WHIE from a limited set of patients and hospitals. Instead, we attempt to demonstrate how pricing policy and subscription plans can effect the use of HIE. Moreover, it would be unreasonable for one to expect an HIE to be sustainable with only three hospital subscriptions. Hence, we made simplifying assumptions and scaled down (30% of 500k) the operating budget of WHIE to operations concerning only our patients diagnosed with Asthma, COPD, and Diabetes at the ED of three large sized hospitals. A reader must also note that WHIE (like other not-for-profit HIEs) is partially funded by startup grants from the government.

Table 12. Payer and WHIE summary data

Payer (2)	Agent	ED Visits	Avg. Annual Premiums**		Total Premium**
	HMO		3240 ⁺⁺	Commercial	Govt
			5036	2727	
Govt. FFS		754 ⁺	n.a.		n.a.
Commercial FFS		992 ⁺⁺⁺	6043		7.89M
WHIE (3)	Operating Cost (22 Hospitals) ^{##}		Operating Cost (3 Hospitals) ⁺⁺⁺		
	\$500K		\$150K		

⁺ State of WI Medicare/Medicaid claims: Exact visit counts Exact visit count

⁺⁺ Exact for Govt. HMO and calculated for j HMO

⁺⁺⁺ Calculated data

^{*} Reports filed to State of WI Commissioner

^{**} Personal communication (CEO, WHIE)

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