Association of Care Management Intensity With Healthcare Utilization in an All-Condition Care Management Program

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A commonly used approach to achieve the Triple Aim of improving the experience of care, improving the health of populations, and reducing per capita costs of healthcare[1] is to identify high-risk patients—often those with multiple chronic conditions (eg, heart disease, cancer, stroke, diabetes)—for team-based case management.[2] Case management programs have become routine within healthcare to coordinate care and address the social and behavioral needs of high-risk patients. The majority of state Medicaid programs now mandate comprehensive managed care programs that include a case management component.[3]

Similarly, adoption of community health worker (CHW) programs has increased. Systematic reviews report mixed effectiveness on outcomes but suggest that certain CHW programs can improve health outcomes, increase appropriate healthcare service use,[4] as well as reduce emergency department (ED) visits and hospitalizations, and achieve cost savings.[5] A key priority of the CMS Equity Plan is to increase the ability of the healthcare workforce, including CHWs, to meet the needs of vulnerable populations.[6] These programs are also consistent with the CDC's recommendation for an integrated and sustainable CHW workforce in public health to prevent and manage chronic diseases.[7]

Within Medicaid populations, some case management or case manager (CM) programs have been effective at reducing outpatient healthcare utilization, including ED visits and hospitalizations.[8-11] Evaluations of certain programs have also documented that greater intensity of intervention was associated with reduced healthcare utilization.[8,12] These programs focused on a single condition, such as diabetes, and generally delivered evidence-based, condition-specific interventions.[12,13]

Few studies have evaluated all-condition, combined CM and CHW programs in routine care among adult Medicaid and Medicare beneficiaries. The present analyses were conducted in the setting of the Johns Hopkins Community Health Partnership (J-CHiP), a Center for Medicare and Medicaid Innovation (CMMI) Healthcare Innovation Awardee. The objectives of this study were to identify care needs among high-risk Medicaid and Medicare patients in the J-CHiP primary care–based care management program involving

ABSTRACT

OBJECTIVES: To identify care needs among Medicaid and Medicare patients in an all-condition care management program involving case managers (CMs) and community health workers (CHWs), and to examine the relationship between intervention intensity and healthcare utilization.

STUDY DESIGN: Retrospective longitudinal evaluation of managed care–hired CMs and CHWs based at 8 primary care sites participating in the Johns Hopkins Community Health Partnership (J-CHiP).

METHODS: Patients at high risk for hospitalization were enrolled in J-CHiP. CMs provided care coordination and CHWs addressed barriers to care. Four program intensity categories were created: low CM–low CHW, low CM–high CHW, high CM–low CHW, and high CM–high CHW. We evaluated the adjusted relative risk (RR) of emergency department (ED) visits, hospitalizations, and 30-day hospital readmissions pre– and post enrollment in the program using CM documentation, electronic health record data, and insurance claims.

RESULTS: Among 1408 Medicaid and 2196 Medicare patients, the predominant barriers to care were lack of transportation, unstable housing, medication payment, and healthy food access. Among Medicaid and Medicare patients, high CM–high CHW and high CM–low CHW intensities were associated with a higher adjusted risk of hospitalization and 30-day hospital readmission after program implementation compared with low CM–low CHW intensity. Among patients with low CM–high CHW intensity, Medicaid patients had a higher risk of readmission (RR, 1.47; $P = .016$) and Medicare patients had a higher risk of ED visit (RR, 1.33; $P = .001$) post program implementation.

CONCLUSIONS: In this longitudinal evaluation of an all-condition, unstructured, managed care organization–led program, preprogram trajectories of healthcare utilization rates among patients increased rather than decreased after program implementation, especially among patients receiving the highest care management program intensity.

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TAKEAWAY POINTS

Higher intensity of care management in an all-condition, combined case manager (CM) and community health worker (CHW) program among high-risk Medicaid and Medicare patients was associated with increased, rather than decreased, emergency department (ED) visits, hospitalizations, and hospital readmissions.

- Observed preprogram patterns in utilization rates continued post program, irrespective of program intensity.
- Findings differ from those of structured, disease-specific programs using CMs and CHWs, which show decreased utilization with higher program intensity.
- Questions raised for future programs include the effectiveness of an all-condition versus disease-specific approach and the potential role for evidence-based CM and CHW interventions for appropriate clinical goals and barriers to care outcomes.

CMs and CHWs, and to examine whether program intensity was associated with changes in healthcare utilization from baseline. We hypothesized that as program intensity increased, healthcare utilization would decrease.

METHODS

Study Setting

J-CHiP began in July 2012 as a CMMI Healthcare Innovation Awardee. The initiative was specifically designed to target patients with chronic conditions requiring high utilization of health services. The goal was to achieve the Triple Aim.[14] J-CHiP concurrently implemented 3 care delivery models, each addressing different settings of care: an acute care model, a skilled nursing facilities model, and a community care delivery model.[14] The community care delivery model consisted of 3 delivery programs: care management and 2 programs implemented by community-based nonprofit organizations. This analysis focuses on the care management program, which was delivered at 8 community-based primary care clinical practice sites in Baltimore City, Maryland. At each site, clinic-embedded CMs and CHWs were part of multidisciplinary ambulatory care teams led by primary care physicians.

The Johns Hopkins School of Medicine Institutional Review Board approved this J-CHiP analysis.

Patient Population

Patients were enrolled in the care management program from December 2012 through June 2015. Eligible patients were aged at least 18 years, were enrolled in Priority Partners Managed Care Organization or Medicare, had at least 1 chronic condition, were not pregnant, and received care at 1 of 8 participating primary care clinics. Patients were primarily identified for care management program enrollment using the Johns Hopkins Adjusted Clinical Groups (ACG) System predictive model to assess risk of hospitalization in the next year. This ACG risk stratification was based on clinical and utilization data, including age, comorbidities, and inpatient and outpatient healthcare utilization over the previous 12 months.[15] ACG scores range from 0 to 1.00, with higher scores indicating greater risk of hospitalization. No specific cutoff identified eligible patients; highest-risk patients were prioritized. A second method of patient identification was healthcare provider referral. Patients with end-stage renal disease (ESRD) were ineligible, as they were referred to an existing ESRD-specific care management program.

For this analysis, patients were considered enrolled in the program once a CHW made successful contact with the patient to initiate care management program services.

Description of the Intervention

CMs and CHWs received staff training conducted by Johns Hopkins HealthCare (JHHC). For J-CHiP, CHWs initiated contact with eligible patients by telephone or in person to complete an initial "barriers to care" assessment, with appropriate outreach and follow-up. In-person contacts took place in patients' homes or primary care clinics. The CHWs' primary responsibility was to identify and intervene on identified barriers to care, such as difficulty accessing healthy food, unstable housing, lack of transportation, and insufficient financial resources. CHWs arranged for transportation, assisted with resource insufficiency, improved communication, and ensured treatment comprehension. They also reinforced health education, provided social support, and provided reminders.

After the CHW assessment, a CM contacted enrolled patients via telephone or in person. The CM role followed National Committee for Quality Assurance (NCQA) Health Plan Accreditation Standards for Complex Case Management. CMs performed a baseline assessment to identify healthcare needs, followed by care coordination, monitoring, and evaluation of services. They also assessed the patient's level of health engagement and assisted patients by setting goals, acting as a patient liaison to coordinate care needs, and communicating with the care team to develop a plan to reflect the desired outcome. Due to the all-condition model, CMs did not utilize structured, disease-tailored interventions targeting clinical outcomes. A goal for CMs was to follow up with patients at least once every 3 months per JHHC health plan policy.

CM and CHW staff used an electronic care management documentation system to document patient information and program workflows. Reports of process metrics were reviewed monthly.

Data Sources and Measures

Data for analyses were obtained from the electronic care management documentation system, electronic health record, and insurance claims. CMs and CHWs documented every encounter with patients, including successful and unsuccessful attempts via telephone or in person. For each enrolled patient, the number of successful contacts made by CMs and CHWs was calculated.

Four distinct intervention intensity categories were created based on the distribution of successful CM and CHW contacts and national guidelines. For CM, low intensity was defined as less than 1 successful contact every 3 months based on NCQA and program

goals. High intensity was defined as 1 or more successful contacts per 3 months. Due to a lack of standardized national guidelines for recommended CHW contact frequency, low intensity of CHW contacts was defined as below the 75th percentile in average number of contacts per month enrolled in the program. High CHW contact intensity was defined as above the 75th percentile. Thus, the 4 mutually exclusive categories of program intensity were (1) low CM–low CHW (reference group), (2) low CM–high CHW, (3) high CM–low CHW, and (4) high CM–high CHW (**eAppendix Table 1** [eAppendix available at **ajmc.com**]).

Primary outcomes for analyses were the rates of ED visits, hospitalizations, and 30-day hospital readmissions, all obtained from insurance claims data. To obtain a baseline for each patient, utilization rates prior to J-CHiP were obtained for the 12 months prior to program enrollment. Baseline utilization rates are presented per month during that 12-month period. Postprogram utilization rates were analyzed for the 12 months or more following each patient's enrollment in the care management program, through December 31, 2015, the end of J-CHiP. Healthcare utilization rates were monitored while patients were enrolled in the program and are presented per months enrolled in the program.

Statistical Analyses

Baseline characteristics were stratified by health insurance. Mann-Whitney U and χ^2 tests were used to detect differences among continuous and categorical variables, respectively. Barriers to care and risk of hospitalization, via ACG score, were stratified by program intensity and health insurance.

Negative binomial regression models were used to evaluate the risk ratio of ED visits and hospitalizations for each program intensity with the low CM–low CHW category as reference group. A zero-inflated negative binomial model was used to model the risk ratio of readmissions to account for the excessive number of patients with zero readmissions (**eAppendix Figures 1-6**). Because longitudinal data were available at the patient level, a Poisson regression model using generalized estimating equations (GEE) was used to account for within-patient correlations. This approach allows determination of whether program intensity is associated with a difference in each primary outcome and is in contrast to time-series analyses, which are used when only group-level, aggregated data are available.[16] In sensitivity analyses, models were run using a 50th percentile cutoff for CHW contacts and a 90th percentile threshold for CM contacts compared with the NCQA standard. Additional models with baseline rate of healthcare utilization preintervention, clinic site, and comorbidities were also run. All models looked at CM contacts per 3 months, were stratified by Medicaid and Medicare, and adjusted for age at enrollment, sex, ACG score, race, and baseline rate of the primary outcome prior to implementation of J-CHiP. In pre–post analyses, we evaluated the percent change in adjusted healthcare utilization for each primary outcome by modeling the monthly rates during the 12-month period before and in the period after care management program enrollment using GEE with a Poisson distribution.

TABLE 1. Baseline Characteristics of Medicaid and Medicare Patients Enrolled in J-CHiP Care Management Program

Characteristic	Total (N = 3604)	Medicaid (n = 1408)	Medicare (n = 2196)	*P*
Age in years at program enrollment, median (IQR)	60 (49-76)	49 (40-56)	73 (61-82)	<.0001
Female, n (%)	2310 (64)	986 (70)	1324 (60)	<.0001
Race, n (%)				<.0001
African American	1815 (50)	829 (59)	986 (45)	
Caucasian	1574 (43)	409 (29)	1165 (53)	
Other/unknown	215 (6)	170 (12)	45 (2)	
Patient identification for program, n (%)				<.0001
ACG risk prediction	2016 (56)	704 (50)	1312 (60)	
Direct provider referral	1273 (35)	698 (50)	575 (26)	
Both	315 (9)	6 (0)	309 (14)	
Comorbidities, n (%)				
CHF	742 (21)	237 (17)	505 (23)	<.0001
COPD	748 (21)	217 (15)	531 (24)	<.0001
Diabetes	1155 (32)	365 (26)	790 (36)	<.0001
Hypertension	2122 (59)	614 (44)	1508 (69)	<.0001
Lipid disorder	1482 (41)	388 (28)	1094 (50)	<.0001
Obesity	1524 (42)	503 (36)	1021 (46)	<.0001

ACG indicates Adjusted Clinical Groups; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; J-CHiP, Johns Hopkins Community Health Partnership.

RESULTS

Program Enrollment

A total of 4401 patients were determined to be eligible for care management. Of these, 3665 patients (83%) received a structured "barriers to care" assessment and were enrolled in the program. Of those enrolled, 3604 patients (98%) had claims data and were included in this analysis.

Table 1 shows patient characteristics at baseline. Both Medicaid and Medicare patients were predominantly female. The majority of Medicaid patients were African American, and the majority of Medicare patients were Caucasian. As expected, Medicare patients were older than Medicaid patients and had a higher burden of clinical comorbidities.

Table 2 shows patient characteristics by program contact intensity. The majority of Medicaid (68%) and Medicare (64%) patients received low CM–low CHW program intensity. Among Medicaid patients, age differed by program intensity, with the highest median age in the high CM–low CHW group. There was no relationship between program intensity and sex, race, or clinical comorbidities. Among Medicare patients, the baseline characteristics differed by program intensity: age, with highest median age in the low CM–low CHW group; race, with the highest percentage of African Americans in the low CM–high CHW group; and clinical comorbidities, as

TABLE 2. Comparison of Baseline Characteristics Among Medicaid and Medicare Patients Enrolled in J-CHiP Care Management, by Program Contact Intensity

Characteristic	Medicaid						Medicare					
	Total (n = 1408)	Low CM–Low CHW (n = 961)	Low CM–High CHW (n = 208)	High CM–Low CHW (n = 138)	High CM–High CHW (n = 101)	*P*	Total (n = 2196)	Low CM–Low CHW (n = 1400)	Low CM–High CHW (n = 255)	High CM–Low CHW (n = 321)	High CM–High CHW (n = 220)	*P*
Age in years at program enrollment, median (IQR)	49 (40-56)	49 (39-55)	50 (42-57)	52 (46-57)	50 (44-57)	<.001	73 (61-82)	74 (65-83)	69 (58-79)	72 (60-83)	68 (55-77)	<.001
Female, n (%)	986 (70)	680 (71)	151 (73)	95 (69)	60 (59)	.093	1324 (60)	834 (60)	166 (65)	189 (59)	135 (61)	.37
Race, n (%)						.24						<.001
African American	829 (59)	557 (58)	129 (62)	87 (63)	56 (55)		986 (45)	587 (42)	151 (59)	154 (48)	94 (43)	
Caucasian	409 (29)	275 (29)	64 (31)	37 (27)	33 (33)		1165 (53)	777 (56)	101 (40)	165 (51)	122 (55)	
Other/unknown	170 (12)	129 (13)	15 (7)	14 (10)	12 (12)		43 (2)	36 (2)	3 (1)	2 (1)	2 (2)	
Patient identification, n (%)						.03						<.001
ACG risk prediction	704 (50)	508 (53)	89 (43)	67 (49)	40 (40)		1311 (60)	893 (64)	109 (43)	215 (67)	94 (43)	
Direct referral[a]	704 (50)	449 (47)	117 (56)	71 (51)	61 (60)		575 (26)	297 (21)	100 (39)	83 (26)	95 (43)	
Both	0	0	0	0	0		309 (14)	210 (15)	46 (18)	23 (7)	30 (14)	
Comorbidities, n (%)												
CHF	237 (17)	157 (16)	30 (14)	32 (23)	18 (18)	.17	505 (23)	321 (23)	56 (22)	73 (23)	55 (25)	.88
COPD	217 (15)	150 (16)	27 (13)	24 (17)	16 (16)	.71	531 (24)	327 (23)	57 (22)	91 (28)	56 (25)	.24
Diabetes	365 (26)	247 (26)	46 (22)	45 (33)	270 (27)	.18	790 (36)	521 (37)	79 (31)	122 (38)	68 (31)	.08
Hypertension	614 (44)	433 (45)	86 (41)	58 (42)	370 (37)	.34	1508 (69)	1034 (74)	145 (57)	216 (67)	113 (51)	<.001
Lipid disorder	388 (28)	267 (28)	51 (25)	45 (33)	25 (25)	.37	1094 (50)	759 (54)	107 (42)	145 (45)	83 (38)	<.001
Obesity	506 (36)	336 (35)	83 (40)	46 (33)	38 (38)	.51	1021 (46)	616 (44)	138 (54)	144 (45)	123 (56)	.001

ACG indicates Adjusted Clinical Groups; CHF, congestive heart failure; CHW, community health worker; CM, case manager; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; J-CHiP, Johns Hopkins Community Health Partnership.

[a]These patients were referred from a physician or healthcare personnel and were not identified using the ACG model.

Medicare patients in the high CM–high CHW category had the highest percentage of obesity (56%), whereas the low CM–low CHW group had the highest percentage of lipid disorder (54%) and hypertension (74%). There was no relationship between sex and program intensity in Medicare. In both Medicaid and Medicare, the highest percentage of direct referrals to the care management program was seen in the high CM–high CHW category. Demographic characteristics stratified by insurance and CM or CHW categories are included in **eAppendix Tables 2** and **3**.

Patient Risk of Hospitalization, Barriers to Care, and Program Intensity

Table 3 shows ACG risk scores and barriers to care. The median ACG risk score differed by program intensity within Medicaid ($P = .003$) and Medicare ($P = .007$). For both insurance groups, the most intensive program category, high CM–high CHW, had the highest median ACG risk score, indicating that patients with the highest risk of hospitalization received the highest intensity of program contacts. Transportation was the most common barrier and differed in frequency among program intensity. Unstable housing was common among Medicaid patients, and the inability to pay for medications and accessing healthy food were frequent barriers regardless of health insurance.

Modality and Number of CM and CHW Contacts

The median numbers of successful CM contacts per 12 months enrolled in care management were 5.8 and 5.2 for Medicaid and Medicare patients, respectively (**Table 4**). Similarly, the median total CHW contacts per 12 months enrolled were 6.7 for Medicaid patients and 6.3 for Medicare patients. The majority of successful contacts were via telephone (70% for CM; 68% for CHW). Medicaid patients in the high CM–high CHW group had medians of 17.1 CM contacts and 19.6 CHW contacts per 12 months enrolled. Medicare patients in the high CM–high CHW group had comparable medians of 20.6 CM and 18.8 CHW contacts per 12 months. Data per month are displayed in **eAppendix Table 4**.

Crude Changes in Healthcare Utilization Outcomes From Baseline

Crude rates of ED visits, hospital admissions, and hospital readmissions per month are included in **eAppendix Table 5** (A-C). Overall, the crude hospitalization rate decreased by 10.9% (95% CI, –18.7%

TABLE 3. Baseline Risk Status and Barriers to Care Among Medicaid and Medicare Patients in Care Management, by Program Contact Intensity

Characteristic	Medicaid					Medicare				
	Total (n = 1408)	Low CM–Low CHW (n = 961)	Low CM–High CHW (n = 208)	High CM–Low CHW (n = 138)	High CM–High CHW (n = 101)	Total (n = 2196)	Low CM–Low CHW (n = 1400)	Low CM–High CHW (n = 255)	High CM–Low CHW (n = 321)	High CM–High CHW (n = 220)
ACG risk of hospitalization score, median (IQR)	0.18 (0.09-0.36)	0.18 (0.08-0.34)	0.17 (0.09-0.34)	0.23 (0.10-0.50)	0.27 (0.11-0.45)	0.21 (0.11-0.36)	0.20 (0.11-0.34)	0.22 (0.11-0.38)	0.21 (0.12-0.37)	0.24 (0.13-0.45)
Barriers to care, n (%)										
Getting the food you need?	194 (14)	116 (12)	38 (18)	15 (11)	25 (25)	185 (8)	92 (7)	32 (13)	22 (7)	39 (18)
Is the issue of dependent care itself a barrier to attending clinic visits?	115 (8)	87 (9)	11 (5)	7 (5)	10 (10)	31 (1)	17 (1)	3 (1)	6 (2)	5 (2)
Paying for doctors' visits?	131 (9)	83 (9)	21 (10)	12 (9)	15 (15)	79 (4)	42 (3)	12 (5)	9 (3)	16 (7)
Paying for medications?	196 (14)	120 (13)	38 (18)	21 (15)	17 (17)	207 (9)	104 (7)	29 (11)	39 (12)	35 (16)
Paying for utilities?	105 (8)	68 (7)	16 (8)	10 (7)	11 (11)	105 (5)	51 (4)	15 (6)	21 (7)	18 (8)
Stable housing?	205 (15)	126 (13)	32 (15)	23 (17)	24 (24)	120 (6)	61 (4)	17 (7)	24 (8)	18 (8)
Stable phone?	128 (9)	80 (8)	25 (12)	11 (8)	12 (12)	88 (4)	49 (4)	12 (5)	9 (3)	18 (8)
Transportation?	519 (37)	310 (32)	91 (44)	57 (41)	61 (60)	360 (16)	160 (11)	68 (27)	59 (18)	73 (33)

ACG indicates Adjusted Clinical Groups; CHW, community health worker; CM, case manager; IQR, interquartile range.

TABLE 4. Type and Number of Successful CM and CHW Contacts, by Program Contact Intensity, Among Medicaid and Medicare Patients, per 12 Months Enrolled

Type of CM or CHW Contact	Medicaid Median (IQR)					Medicare Median (IQR)				
	Total (n = 1408)	Low CM–Low CHW (n = 961)	Low CM–High CHW (n = 208)	High CM–Low CHW (n = 138)	High CM–High CHW (n = 101)	Total (n = 2196)	Low CM–Low CHW (n = 1400)	Low CM–High CHW (n = 255)	High CM–Low CHW (n = 321)	High CM–High CHW (n = 220)
Successful CM contacts	5.8 (2.6-10.5)	4.0 (1.8-7.3)	8.9 (5.5-14.0)	12.9 (7.8-19.2)	17.1 (10.6-27.7)	5.2 (1.7-11.0)	2.8 (1.3-6.0)	8.6 (5.3-13.4)	12.5 (7.5-22.4)	20.6 (13.6-32.5)
Telephone contacts	3.4 (1.3-6.7)	2.4 (0.9-4.4)	5.2 (2.5-9.0)	8.4 (4.8-13.5)	11.3 (6.8-20.6)	3.4 (1.4-7.7)	1.9 (1.0-4.1)	5.7 (3.3-9.7)	9.1 (4.8-15.6)	14.9 (8.0-24.0)
In-person contacts	1.8 (0.6-3.8)	1.4 (0.4-2.8)	3.0 (1.7-5.5)	3.5 (1.5-6.0)	4.3 (2.0-8.6)	1.3 (0-3.3)	0.6 (0-1.7)	2.4 (1.2-4.3)	3.3 (1.3-6.0)	5.0 (3.2-8.0)
Successful CHW contacts	6.7 (3.3-11.6)	5.1 (2.7-8.0)	16.4 (13.9-20.4)	6.0 (3.0-9.2)	19.6 (15.7-25.3)	6.3 (2.7-12.0)	4.0 (1.8-7.4)	16.0 (14.1-20.0)	6.9 (4.0-9.6)	18.8 (16.0-28.2)
Telephone contacts	4.2 (2.1-7.5)	3.2 (1.7-5.2)	11 (8.1-14.1)	3.0 (1.5-5.8)	12.0 (9.5-16.0)	4.0 (1.7-8.0)	2.7 (1.2-5.1)	12.0 (9.8-14.3)	4.0 (1.7-6.5)	13.2 (10.0-18.0)
In-person contacts	2.0 (0.7-4.2)	1.3 (0.5-2.6)	6.0 (3.7-8.9)	1.9 (0-4.0)	7.2 (3.9-11.0)	1.7 (0.5-3.8)	1.2 (0-2.2)	4.6 (2.7-8.3)	2.2 (1.0-4.0)	7.2 (4.2-10.9)

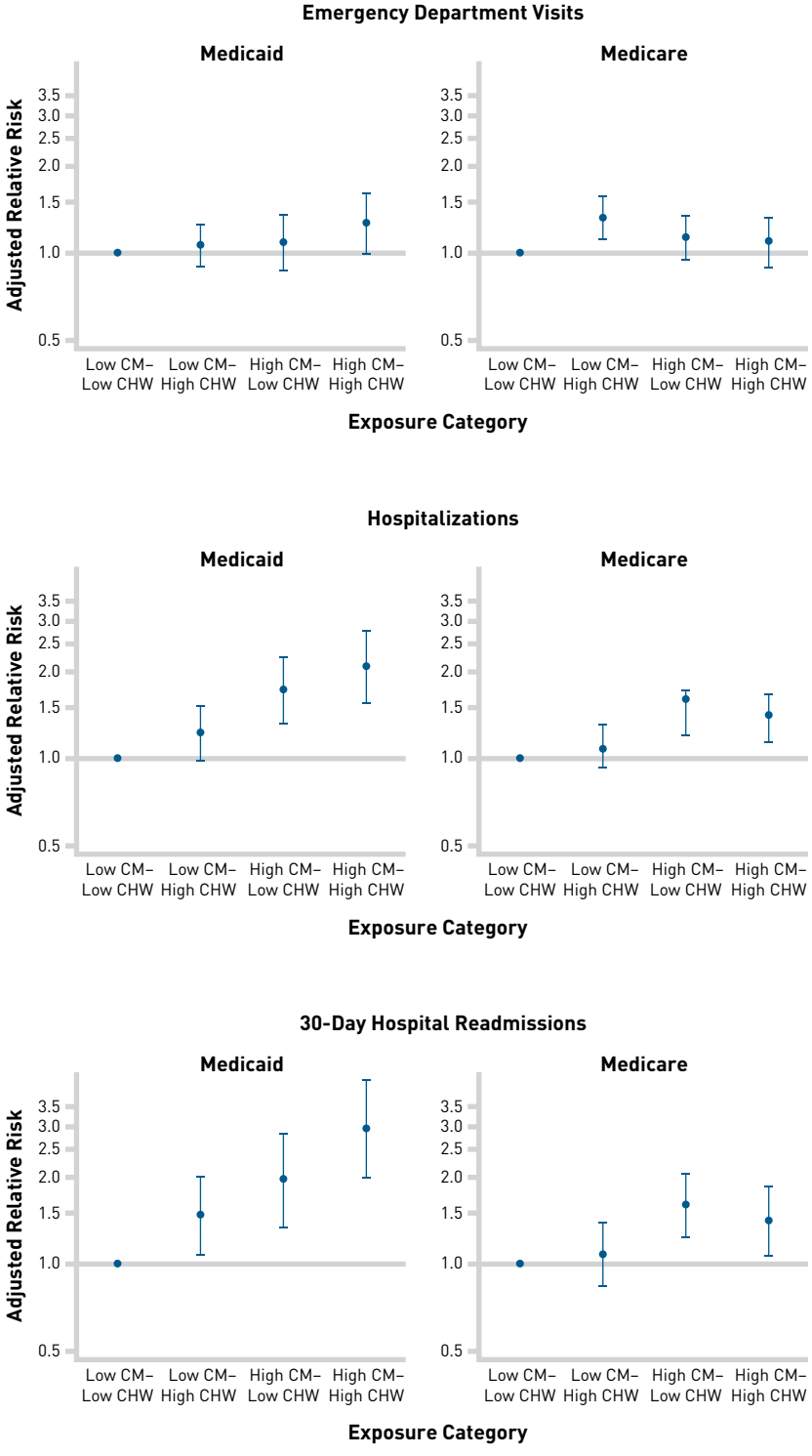
CHW indicates community health worker; CM, case manager; IQR, interquartile range.

to –2.3%) among Medicaid patients and increased by 12.6% (95% CI, 4.2%-21.7%) among Medicare patients.

Adjusted Changes in Healthcare Utilization Outcomes From Baseline

The **Figure** displays the adjusted relative risk (RR) of ED visits, hospitalizations, and 30-day readmissions in Medicaid and Medicare by program intensity. Medicaid patients in the high CM–high CHW and high CM–low CHW program intensities had a higher adjusted risk of hospitalization (RR, 2.08 and 1.72, respectively [both $P < .001$]) after program implementation compared with the reference group. Meanwhile, Medicaid patients in the high CM–high CHW program intensity had a higher adjusted risk of 30-day hospital readmission (RR, 2.19; $P = .01$) compared with the reference group (**eAppendix Table 6**). The latter effect remained after controlling for comorbidities and clinic site (**eAppendix Table 7**).

FIGURE. Adjusted Relative Risk of Emergency Department Visits, Hospitalizations, and 30-Day Readmissions, Based on Program Intensity[a]



ACG indicates Adjusted Clinical Groups; CHW, community health worker; CM, case manager.

[a]Models are adjusted for age, gender, ACG risk of hospitalization score, African American race, and baseline rates of healthcare utilization. The low CM–low CHW program intensity category serves as the reference category.

Among Medicare patients, those who received the low CM–high CHW program intensity had a higher adjusted risk of ED visits (RR, 1.33; $P = .001$) than the reference group. Patients in the high CM–high CHW and high CM–low CHW program intensities had a higher adjusted risk of hospitalization (RR, 1.39 [$P = .001$] and 1.44 [$P < .001$], respectively), whereas those in the high CM–low CHW program intensity had a higher adjusted risk of 30-day hospital readmission (RR, 2.20; $P = .01$) than the reference group.

DISCUSSION

In this evaluation, higher J-CHiP care management program intensity was associated with increased healthcare utilization. In the crude analyses, hospitalization rates decreased among Medicaid patients and increased among Medicare patients compared with the 12 months prior to program enrollment, with no significant changes in rates of ED visits or readmissions. However, after adjusting for age, sex, ACG score, race, and rate of healthcare utilization in the 12 months prior to the program, higher intensity of contacts by CMs, CHWs, or both was not associated with a reduced risk of ED visits, hospitalizations, or readmissions among either Medicaid or Medicare patients.

These findings differ from those of other studies. For example, urban patients with diabetes who were randomized to an intensive CM–CHW intervention had a 23% reduction in ED visits at 24 months compared with patients receiving minimal intervention intensity (outreach once every 6 months), and the rate reduction in utilization was strongest for the patients who received the highest CM and CHW visit frequencies.[12] Similarly, an integrated case management program among high-risk Virginia Medicaid patients showed a higher percentage reduction in ED visits as the number of monthly contacts increased.[8]

The disparate findings may be explained, in part, by differences in the J-CHiP care management program structure. First, whereas the successful programs mentioned previously utilized comprehensive, structured, disease-specific intervention protocols,[12,13,17] J-CHiP was an all-condition intervention program without disease-specific interventions. CMs followed generalized processes, without a targeted

clinical disease outcome focus. Second, the primary roles of CMs and CHWs in J-CHiP were focused on care coordination and barriers to care, whereas other studies have utilized personnel in expanded, more clinically oriented roles to address disease status.[7,12,17] Third, J-CHiP was a health service occurring in real time, administered by a managed care organization, rather than a controlled research trial. Hence, J-CHiP likely experienced more variability, compared with a controlled trial, in aspects of intervention fidelity and personnel. Fourth, the average length of patient follow-up for J-CHiP was shorter on average than for the programs mentioned previously, which collected data for 2 years.

Strengths and Limitations

This evaluation has several strengths. It evaluated a population-based program in a high-risk setting. Baltimore City has a 30% higher mortality rate than the rest of the state of Maryland, and life expectancy varies up to 20 years between neighborhoods in the city.[18] Additionally, it tested an all-condition care management approach, instead of implementing several disease-specific interventions, which has had appeal as an efficient means to deliver care management. Moreover, the evaluation utilized primary data sources and employed rigorous analytic methodologies not routinely applied to program evaluation.

This evaluation also has important limitations. First, there is not a control group that was unexposed to the intervention—an inherent difficulty in real-world healthcare delivery. Still, there are several limitations and considerations with use of control groups in this context.[19] Second, we were unable to distinguish between avoidable and unavoidable healthcare utilization due to data limitations. Consequently, we cannot determine whether the increase in utilization following program implementation was a result of CM and CHW detection of increased appropriate need for ED visits and hospitalizations among patients receiving the higher intensity of CM and CHW contacts. Third, the program did not collect data to enable analysis of whether specific patient-level behavioral variables (eg, busy vs at home, adherence patterns) influenced contact frequency with CMs and CHWs.

Despite these limitations, we are reassured by our sensitivity analyses. The overall trends in RRs of healthcare utilization were consistent when comparing models with and without adjusting for baseline utilization rate, clinical site, and comorbidities (**eAppendix Tables 7-9**). We investigated additional cut points between high and low categories for both CHW and CM exposure. We found that results were consistent when using a 50th percentile cutoff for CHW contacts compared with the original 75th percentile threshold. Results remained consistent when using a 90th percentile cutoff for CM contacts compared with the NCQA standard, which was near the 50th percentile (**eAppendix Tables 10-12**).

We suspect that other care management programs employ similar intervention approaches. Therefore, future programs should test whether structured, evidence-based, disease-specific protocols within an all-condition model reduce healthcare utilization and cost of care. Such programs may benefit from incorporating standardized guidance on frequency of patient contact that is based on clinical disease state(s), barriers, and responsiveness to program intervention.

CONCLUSIONS

Evaluation of the J-CHiP care management program provides a meaningful addition to the literature as a real-world, all-condition program implemented in a high-risk population within a large healthcare organization. It raises new questions about the utility of a nonspecific, unstructured approach to care management among Medicaid and Medicare patients. The value of this evaluation is that the results can be used to inform decisions about program effectiveness and quality improvement opportunities.[20] ■

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eAppendix

eAppendix Table 1A. Categorization of J-CHiP Care Management Program Intensity Based on Intensity of Contacts by Case Managers and Community Health Workers

	CM Contact Intensity[a]		
CHW Contact Intensity[b]	**Low**	**High**	**Total**
Low	2361 (65.51%)	459 (12.74%)	784 (21.75%)
High	463 (12.85%)	321 (8.91%)	2820 (78.25%)
Total	2824 (78.36%)	780 (21.64%)	3604 (100%)

eAppendix Table 1B. Categorization of J-CHiP Care Management Program Intensity Based on Intensity of Contacts by Case Managers and Community Health Workers, by contact rate percentiles

	CM Contact Intensity[a]		
CHW Contact Rate Percentiles	**Low**	**High**	**Total**
0 – 25th [0 - .2500]	834 (23.14%)	91 (2.52%)	925 (25.67%)
26 - 50th (.2500 - .5385]	748 (20.75%)	137 (3.80%)	885 (24.56%)
51 – 75th (.5385 – 1.0000]	779 (21.61%)	231 (6.41%)	1010 (28.02%)
76 – 90th (1.0000 – 1.4762]	290 (8.05%)	135 (3.75%)	425 (11.79%)
91 – 100th (1.4762 – 10.000]	173 (4.80%)	186 (5.16%)	359 (9.96%)
Total	2824 (78.36%)	780 (21.4%)	3604 (100%)

a. CM contact intensity defined as follows: low – less than 1 successful contact per three months; high – one or more successful contact(s) per three months. b. CHW contact intensity defined as follows: low – less than the 75th percentile in average number of contacts per month; high – greater than 75th percentile in average number of contacts per month.

eAppendix Table 2. Comparison of Baseline Characteristics Among Medicaid and Medicare Patients Enrolled in J-CHiP Care Management, by Case Manager program intensity.

	All			Medicaid			Medicare		
Characteristic	High CM (N=780)	Low CM (N=2824)	P-Value	High CM (N=239)	Low CM (N=1169)	P-Value	High CM (N=541)	Low CM (N=1655)	P-Value
Age at Program Enrollment (Mean, SD)	63.3 (16.4)	61.3 (18.0)	.0034	49.8 (10.3)	46.7 (11.2)	.0001	69.2 (14.9)	71.5 (14.5)	.0013
Gender (%)			.0074			.0553			.8256
Female	479 (61)	1831 (65)		155 (65)	831 (71)		324 (60)	1000 (60)	
Male	301 (39)	993 (35)		84 (35)	338 (29)		217 (40)	655 (40)	
Race (%)			.8834			.7420			.6122
African American	391 (50)	1424 (50)		143 (60)	686 (59)		248 (46)	738 (45)	
Other	389 (50)	1400 (50)		96 (40)	483 (41)		293 (54)	917 (55)	
Patient Identification for Program (%)			.0043			.1256			<.0001
ACG Risk Prediction	417 (53)	1599 (57)		107 (45)	597 (51)		310 (57)	1002 (61)	
Direct Provider Referral	310 (40)	963 (34)		132 (55)	566 (48)		178 (33)	397 (24)	
Both	53 (7)	262 (9)		0 (0)	6 (1)		53 (10)	256 (15)	
Comorbidities (%)									
CHF	178 (23)	564 (20)	.0815	50 (21)	187 (16)	.0638	128 (24)	377 (23)	.6727
COPD	187 (24)	561 (20)	.0123	40 (17)	177 (15)	.5337	147 (27)	384 (23)	.0612
Diabetes	262 (34)	893 (32)	.2972	72 (30)	293 (25)	.1037	190 (35)	600 (36)	.6334
Hypertension	424 (54)	1698 (60)	.0038	95 (40)	519 (44)	.1867	329 (61)	1179 (71)	<.0001
Lipid Disorder	298 (38)	1184 (42)	.0615	70 (29)	318 (27)	.5108	228 (42)	866 (52)	<.0001
Obesity	351 (45)	1173 (42)	.0831	84 (35)	419 (36)	.8378	267 (49)	754 (46)	.1245

eAppendix Table 3. Comparison of Baseline Characteristics Among Medicaid and Medicare Patients Enrolled in J-CHiP Care Management, by Community Health Worker program intensity

	All			Medicaid			Medicare		
Characteristic	High CHW (N=784)	Low CHW (N=2820)	P-Value	High CHW (N=309)	Low CHW (N=1099)	P-Value	High CHW (N=475)	Low CHW (N=1721)	P-Value
Age at Program Enrollment (Mean, SD)	60.0 (16.1)	62.2 (18.1)	.0013	48.5 (10.3)	46.9 (11.3)	.0163	67.5 (14.7)	71.9 (14.5)	<.0001
Gender (%)			.4244			.4489			.1216
Female	512 (65)	1798 (64)		211 (68)	775 (71)		301 (63)	1023 (59)	
Male	272 (35)	1022 (36)		98 (32)	324 (29)		174 (37)	698 (41)	
Race (%)			.0045			.6881			.0009
African American	430 (55)	1385 (49)		185 (60)	644 (59)		245 (52)	741 (43)	
Other	354 (45)	1435 (51)		124 (40)	455 (41)		230 (48)	980 (57)	
Patient Identification for Program (%)			<.0001			.0025			<.0001
ACG Risk Prediction	333 (42)	1683 (60)		129 (42)	575 (52)		204 (43)	1108 (64)	
Direct Provider Referral	373 (48)	900 (32)		178 (58)	520 (47)		195 (41)	380 (22)	
Both	78 (10)	237 (8)		2 (1)	4 (<1)		76 (16)	233 (14)	
Comorbidities (%)									
CHF	159 (20)	583 (21)	.8097	48 (16)	189 (17)	.4899	111 (23)	394 (23)	.8277
COPD	156 (20)	592 (21)	.5037	43 (14)	174 (16)	.4097	113 (24)	418 (24)	.8222
Diabetes	220 (28)	935 (33)	.0068	73 (24)	292 (27)	.2966	147 (31)	643 (37)	.0099
Hypertension	381 (49)	1741 (62)	<.0001	123 (40)	491 (45)	.1271	258 (54)	1250 (73)	<.0001
Lipid Disorder	266 (34)	1216 (43)	<.0001	76 (25)	312 (28)	.1873	190 (40)	904 (53)	<.0001
Obesity	382 (49)	1142 (41)	<.0001	121 (39)	382 (35)	.1539	261 (55)	760 (44)	<.0001

eAppendix Table 4. Distribution of Case Manager and Community Health Worker Contacts, per months enrolled, and stratified by payer

	Total				**Medicaid**				**Medicare**			
	Mean (SD)	Median (IQR)	Min	Max	Mean (SD)	Median (IQR)	Min	Max	Mean (SD)	Median (IQR)	Min	Max
Successful **CM In-Person Contacts**	0.21 (0.26)	0.13 (0.00 -0.29)	0	2.40	0.22 (0.25)	0.15 (0.05-0.32)	0	2.00	0.19 (0.27)	0.11 (0.00-0.28)	0	2.40
Successful **CM Telephone Contacts**	0.51 (0.73)	0.29 (0.11-0.62)	0	11.69	0.44 (0.58)	0.29 (0.11-0.56)	0	7.42	0.55 (0.81)	0.29 (0.12-0.64)	0	11.69
Successful **CM Contacts**	0.71 (0.88)	0.45 (0.17-0.89)	0	12.88	0.67 (0.73)	0.48 (0.21-0.87)	0	9.00	0.74 (0.96)	0.43 (0.14-0.91)	0	12.88
Successful **CHW In-Person Contacts**	0.25 (0.30)	0.15 (0.05-0.33)	0	3.00	0.26 (0.30)	0.17 (0.06-0.35)	0	2.31	0.24 (0.30)	0.14 (0.04-0.32)	0	3.00
Successful **CHW Telephone Contacts**	0.49 (0.53)	0.33 (0.14-0.64)	0	7.87	0.48 (0.52)	0.35 (0.17-0.63)	0	6.27	0.48 (0.54)	0.33 (0.14-0.67)	0	7.87
Successful **CHW Contacts**	0.72 (0.73)	0.54 (0.25-1.00)	0	10.00	0.73 (0.72)	0.56 (0.28-0.97)	0	7.64	0.72 (0.74)	0.52 (0.22-1.00)	0	10.00

eAppendix Table 5A. Crude Emergency Department Visits Rates, per month enrolled, Before and After J-CHiP Implementation.

	Mediciad			Medicare		
	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change
All	0.255	0.235	-5.7% (-12.9,2.2)	0.179	0.198	4.7% (-3.1,13.1)
Low CM Low CHW	0.226	0.236	-2.6% (-11.9 ,7.7)	0.167	0.183	3.1% (-7.5,15.0)
Low CM High CHW	0.273	0.238	-13.5% (-26.9, 2.2)	0.207	0.215	5.1% (-13.9,28.5)
High CM Low CHW	0.314	0.223	-25.1% (-40.6,-5.6)	0.161	0.228	20.2% (2.8,40.7)
High CM High CHW	0.328	0.389	21.7% (-3.0, 52.5)	0.249	0.255	-2.8% (-18.6,16.0)

eAppendix Table 5B. Crude Hospital Admission Rates per month Before and After J-CHiP Implementation

	Medicaid			Medicare		
	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change
All	.0783	.0689	-10.9% (-18.7,-2.3)	.0646	.0732	12.6% (4.2,21.7)
Low CM Low CHW	.0748	.0606	-17.6% (-26.5,-7.6)	.0590	.0657	9.1% (-1.5,20.8)
Low CM High CHW	.0616	.0615	-4.1% (-24.6,22.0)	.0716	.0725	0.81% (-19.7,26.6)
High CM Low CHW	.1105	.1015	-6.3% (-28.9,23.4)	.0668	.0915	39.1% (14.2,69.5)
High CM High CHW	.1056	.1790	54.5% (21.1,97.1)	.0891	.1129	25.2% (4.0,50.8)

eAppendix Table 5C. Crude 30-Day Hospital Readmission Rates per month Before and After J-CHiP Implementation

	Medicaid			Medicare		
	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change	Pre J-CHiP rate	Post J-CHiP Rate	Percent Change
All	.0201	.0223	14.8% (-6.3,40.6)	.0148	.0160	7.1% (-10.6,28.5)
Low CM Low CHW	.0187	.0190	6.8% (-18.8,40.6)	.0137	.0140	0% (-20.7,26.1)
Low CM High CHW	.0103	.0153	40.9% (-25.3,165.8)	.0181	.0151	-16.3% (-51.2,43.3)
High CM Low CHW	.0297	.0274	0.3% (-45.1,83.5)	.0151	.0210	38.6% (-11.4,117)
High CM High CHW	.0426	.0895	81.7% (27.2,159.6)	.0176	.0279	53.7% (-3.0,143.5)

eAppendix Table 6. Crude and Adjusted Relative Risk of 30-day Hospital Readmission based on program intensity, stratified by payer, using zero-inflated model

	Medicaid				Medicare			
	Crude RR	P-value	Adjusted RR	P-value	Crude RR	P-Value	Adjusted RR	P-value
High CHW High CM	2.24	0.04	2.19	0.01	1.30	0.42	1.22	0.48
High CHW Low CM	0.50	0.08	1.24	0.52	0.86	0.66	0.94	0.82
Low CHW High CM	1.30	0.51	1.38	0.29	1.80	0.10	2.20	0.01
Low CHW Low CM	Reference		1					
Age at Enrollment			0.98	0.02			0.96	0.03
Gender (Male)			0.94	0.76			0.97	0.89
Enrollment Risk Score			5.05	<.001			4.22	0.004
African American			0.71	0.11			0.85	0.41
Baseline Rate			5.95	<.001			12.36	0.001

eAppendix Table 7. Adjusted Relative Risk for Hospital Readmissions per program intensity with and without baseline rate.

	Medicaid				Medicare			
	Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate		Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW Low CM	2.61	(1.33-5.11)	2.39	(1.35-4.24)	1.08	(0.65-1.79)	1.26	(0.77-2.06)
High CHW High CM	1.43	(0.68-3.02)	1.6	(0.86-2.97)	1.09	(0.61-1.94)	1.17	(0.67-2.02)
Low CHW High CM	1.5	(0.75-2.99)	1.43	(0.8-2.55)	2.14	(1.16-3.95)	2.38	(1.31-4.34)
Low CHW Low CM	Ref							
Age at Enrollment	0.98	(0.96-1)	0.98	(0.97-1)	0.98	(0.97-0.99)	0.99	(0.97-1)
Male	0.87	(0.51-1.46)	0.92	(0.6-1.4)	1	(0.68-1.47)	1.06	(0.73-1.53)
Female	Ref							
Enrollment Risk Score	17.01	(6.75-42.83)	3.41	(1.42-8.2)	12.13	(4.68-31.44)	4.73	(1.82-12.27)
African American	0.82	(0.48-1.39)	1.02	(0.65-1.58)	0.73	(0.46-1.14)	0.79	(0.51-1.23)
Not African American	Ref							
BMS Highlandtown	0.77	(0.11-5.55)	0.92	(0.2-4.33)	1.58	(0.35-7.06)	1.45	(0.35-5.94)
JHBMC Comprehensive Care Clinic	0.35	(0.06-2.14)	0.39	(0.1-1.57)	2.19	(0.45-10.6)	2.1	(0.48-9.18)
JHCP @ EBMC	0.33	(0.06-1.92)	0.37	(0.1-1.45)	2.93	(0.7-12.32)	2.58	(0.66-10.09)
Missing Clinic	0.54	(0.09-3.25)	0.66	(0.17-2.61)	0.92	(0.25-3.42)	0.65	(0.18-2.32)
JHBMC General Medical Clinic	0.31	(0.04-2.59)	0.21	(0.04-1.09)	1.24	(0.33-4.64)	1.08	(0.31-3.81)
JHCP @ Dundalk	0.04	(0.01-0.27)	0.04	(0.01-0.18)	2.02	(0.42-9.63)	2.01	(0.46-8.75)
JHOC	0.36	(0.06-2.28)	0.2	(0.05-0.84)	1.88	(0.49-7.18)	1.48	(0.41-5.36)
JHBMC Beacham	----	----	----	----	0.99	(0.21-4.72)	0.93	(0.21-4.07)
JHCP @ Wyman Park	Ref							
Comorbidities	0.84	(0.44-1.61)	0.9	(0.53-1.54)	0.42	(0.24-0.73)	0.41	(0.24-0.69)
No Comorbidities	Ref							
Pre-baseline Rate	----	----	9.52	(4.36-20.81)	----	----	18.67	(4.51-77.23)

eAppendix Table 8. Adjusted Relative Risk for ED Visits per program intensity with and without baseline rate.

	Medicaid				Medicare			
	Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate		Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW High CM	1.56	(1.21-2)	1.31	(1.04-1.66)	1.13	(0.91-1.41)	1.13	(0.92-1.39)
High CHW Low CM	1.21	(1.01-1.44)	1.09	(0.93-1.29)	1.25	(1.03-1.51)	1.33	(1.12-1.59)
Low CHW High CM	1.17	(0.93-1.47)	1.1	(0.89-1.36)	1.12	(0.93-1.36)	1.18	(0.98-1.41)
Low CHW Low CM	Ref							
Age at Enrollment	0.98	(0.97-0.98)	0.99	(0.98-0.99)	0.97	(0.96-0.97)	0.98	(0.98-0.98)
Male	0.98	(0.85-1.12)	1.06	(0.94-1.21)	0.99	(0.87-1.12)	0.95	(0.84-1.07)
Female	Ref							
Enrollment Risk Score	12.54	(9.48-16.6)	3.1	(2.28-4.22)	12.8	(9.31-17.58)	3.42	(2.45-4.77)
African American	0.97	(0.84-1.11)	0.93	(0.82-1.06)	0.94	(0.81-1.09)	1	(0.87-1.15)
Not African American	Ref							
BMS Highlandtown	0.8	(0.47-1.34)	0.84	(0.52-1.36)	1.03	(0.65-1.64)	1.04	(0.68-1.58)
JHBMC Comprehensive Care Clinic	0.88	(0.55-1.41)	0.93	(0.6-1.45)	1.14	(0.73-1.77)	1.07	(0.71-1.6)
JHCP @ EBMC	1.06	(0.67-1.67)	1.02	(0.67-1.55)	1.3	(0.86-1.97)	1.13	(0.77-1.65)
Missing Clinic	0.8	(0.52-1.25)	0.84	(0.55-1.27)	1.21	(0.82-1.79)	0.87	(0.61-1.25)
JHBMC General Medical Clinic	0.84	(0.5-1.39)	0.94	(0.59-1.51)	1.2	(0.81-1.78)	1.08	(0.75-1.55)
JHCP @ Dundalk	0.68	(0.39-1.18)	0.88	(0.53-1.47)	0.97	(0.63-1.49)	1	(0.67-1.49)
JHOC	0.81	(0.51-1.28)	0.85	(0.56-1.31)	1.35	(0.92-1.97)	1.17	(0.82-1.66)
JHBMC Beacham	----	----	----	----	0.86	(0.57-1.31)	0.8	(0.55-1.16)
JHCP @ Wyman Park	Ref							
Comorbidities	0.97	(0.83-1.14)	1.03	(0.88-1.19)	0.73	(0.59-0.91)	0.72	(0.59-0.88)
No Comorbidities	Ref							
Pre-Baseline Rate	----	----	3.35	(2.79-4.03)	----	----	2.86	(2.38-3.44)

eAppendix Table 9. Adjusted Relative Risk for Hospital Admissions per program intensity with and without baseline rate.

	Medicaid				Medicare			
	Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate		Adjusted Model without pre-baseline rate		Adjusted Model including pre-baseline rate	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW High CM	2.21	(1.63-3)	2.15	(1.59-2.9)	1.41	(1.15-1.72)	1.44	(1.18-1.76)
High CHW Low CM	1.3	(1.03-1.65)	1.24	(0.99-1.56)	1.11	(0.92-1.33)	1.12	(0.93-1.34)
Low CHW High CM	1.79	(1.35-2.39)	1.73	(1.31-2.29)	1.49	(1.24-1.79)	1.49	(1.24-1.79)
Low CHW Low CM	Ref							
Age at Enrollment	1	(0.99-1.01)	1.01	(1-1.01)	1	(0.99-1)	1	(1-1.01)
Male	1.33	(1.11-1.59)	1.28	(1.07-1.52)	0.97	(0.86-1.1)	0.99	(0.88-1.12)
Female	Ref	(1-1)	1	(1-1)	1	(1-1)	1	(1-1)
Enrollment Risk Score	37.85	(26.64-53.76)	16.38	(10.46-25.64)	22.48	(16.57-30.49)	11.34	(7.38-17.42)
African American	0.71	(0.59-0.86)	0.75	(0.63-0.91)	0.93	(0.81-1.08)	0.93	(0.81-1.08)
Not African American	Ref							
BMS Highlandtown	0.75	(0.38-1.5)	0.73	(0.37-1.41)	1.38	(0.88-2.17)	1.33	(0.85-2.07)
JHBMC Comprehensive Care Clinic	0.79	(0.43-1.48)	0.79	(0.43-1.43)	1.03	(0.66-1.6)	1.02	(0.66-1.58)
JHCP @ EBMC	0.95	(0.52-1.73)	0.91	(0.51-1.62)	1.34	(0.89-2.01)	1.32	(0.88-1.99)
Missing Clinic	0.81	(0.44-1.46)	0.8	(0.45-1.42)	0.97	(0.66-1.44)	0.94	(0.64-1.38)
JHBMC General Medical Clinic	0.73	(0.37-1.45)	0.69	(0.36-1.34)	1.23	(0.83-1.82)	1.21	(0.82-1.78)
JHCP @ Dundalk	0.66	(0.32-1.37)	0.67	(0.33-1.35)	1.1	(0.72-1.68)	1.1	(0.72-1.67)
JHOC	0.78	(0.42-1.44)	0.72	(0.4-1.31)	1.23	(0.84-1.81)	1.19	(0.81-1.73)
JHBMC Beacham	----	----	----	----	0.81	(0.54-1.22)	0.79	(0.53-1.19)
JHCP @ Wyman Park	Ref							
Comorbidities	0.82	(0.66-1.02)	0.84	(0.68-1.04)	0.72	(0.58-0.88)	0.74	(0.6-0.91)
No Comorbidities	Ref							
Pre-baseline Rate	----	----	3.68	(2.23-6.08)	----	----	3.54	(1.97-6.36)

eAppendix Table 10. Adjusted Relative Risk for ED visits by program intensity with higher categorical threshold for CM program intensity

	Medicaid				Medicare			
	NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)		NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW High CM	1.56	(1.21-2)	1.82	(1.34-2.47)	1.13	(0.91-1.41)	1.44	(1.12-1.85)
High CHW Low CM	1.21	(1.01-1.44)	1.17	(0.99-1.39)	1.25	(1.03-1.51)	1.11	(0.94-1.33)
Low CHW High CM	1.17	(0.93-1.47)	1.24	(0.87-1.76)	1.12	(0.93-1.36)	1.39	(1.05-1.84)
Low CHW Low CM	Ref							
Age at Enrollment	0.98	(0.97-0.98)	0.98	(0.97-0.98)	0.97	(0.96-0.97)	0.97	(0.96-0.97)
Male	0.98	(0.85-1.12)	0.98	(0.85-1.13)	0.99	(0.87-1.12)	0.98	(0.86-1.12)
Female	Ref							
Enrollment Risk Score	12.54	(9.48-16.6)	11.9	(8.95-15.82)	12.8	(9.31-17.58)	12.45	(9.06-17.1)
African American	0.97	(0.84-1.11)	0.97	(0.85-1.12)	0.94	(0.81-1.09)	0.97	(0.83-1.12)
Not African American	Ref							
BMS Highlandtown	0.8	(0.47-1.34)	0.76	(0.45-1.28)	1.03	(0.65-1.64)	1.04	(0.66-1.65)
JHBMC Comprehensive Care Clinic	0.88	(0.55-1.41)	0.85	(0.53-1.36)	1.14	(0.73-1.77)	1.12	(0.72-1.74)
JHCP @ EBMC	1.06	(0.67-1.67)	1.02	(0.65-1.61)	1.3	(0.86-1.97)	1.31	(0.87-1.97)
Missing Clinic	0.8	(0.52-1.25)	0.78	(0.5-1.21)	1.21	(0.82-1.79)	1.18	(0.8-1.74)
JHBMC General Medical Clinic	0.84	(0.5-1.39)	0.76	(0.46-1.27)	1.2	(0.81-1.78)	1.16	(0.78-1.72)
JHCP @ Dundalk	0.68	(0.39-1.18)	0.66	(0.38-1.15)	0.97	(0.63-1.49)	0.96	(0.62-1.48)
JHOC	0.81	(0.51-1.28)	0.79	(0.5-1.26)	1.35	(0.92-1.97)	1.34	(0.92-1.96)
JHBMC Beacham	----	----	----	----	0.86	(0.57-1.31)	0.86	(0.57-1.3)
JHCP @ Wyman Park	Ref							
Comorbidities	0.97	(0.83-1.14)	0.96	(0.82-1.13)	0.73	(0.59-0.91)	0.74	(0.6-0.92)
No Comorbidities	Ref							

eAppendix Table 11. Adjusted Relative Risk for Hospital Admissions by program intensity with higher categorical threshold for CM program intensity.

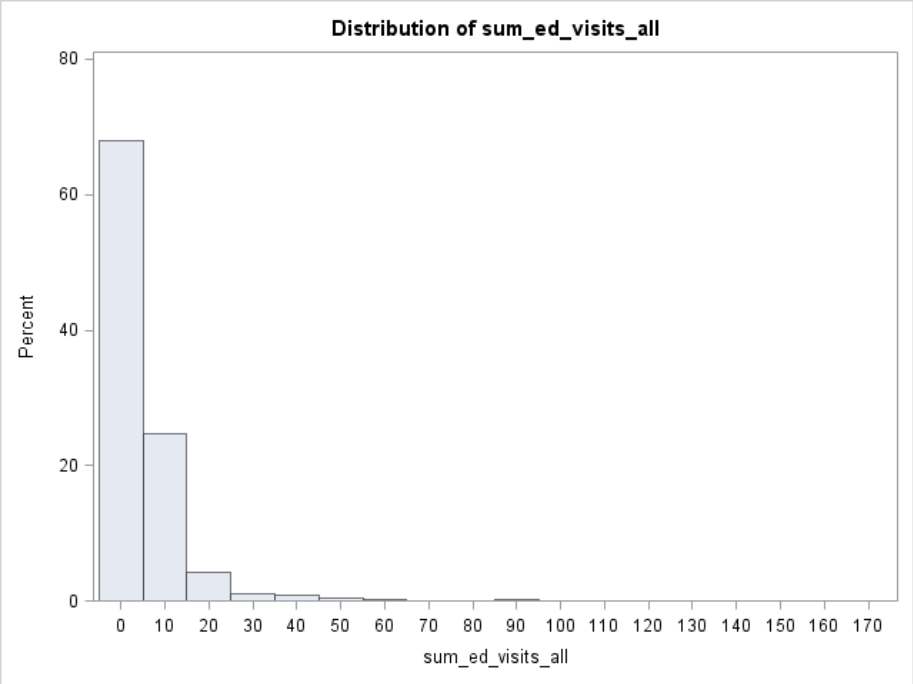
	Medicaid				Medicare			
	NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)		NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW High CM	2.21	(1.63-3)	2.8	(1.96-3.99)	1.41	(1.15-1.72)	1.5	(1.2-1.89)
High CHW Low CM	1.3	(1.03-1.65)	1.18	(0.95-1.48)	1.11	(0.92-1.33)	1.08	(0.91-1.28)
Low CHW High CM	1.79	(1.35-2.39)	1.84	(1.22-2.78)	1.49	(1.24-1.79)	1.72	(1.33-2.22)
Low CHW Low CM	Ref							
Age at Enrollment	1	(0.99-1.01)	1	(1-1.01)	1	(0.99-1)	1	(0.99-1)
Male	1.33	(1.11-1.59)	1.32	(1.1-1.58)	0.97	(0.86-1.1)	0.98	(0.86-1.11)
Female	Ref							
Enrollment Risk Score	37.85	(26.64-53.76)	37.19	(26.15-52.9)	22.48	(16.57-30.49)	22.1	(16.28-30.02)
African American	0.71	(0.59-0.86)	0.74	(0.62-0.9)	0.93	(0.81-1.08)	0.95	(0.83-1.1)
Not African American	Ref							
BMS Highlandtown	0.75	(0.38-1.5)	0.71	(0.36-1.41)	1.38	(0.88-2.17)	1.29	(0.83-2.02)
JHBMC Comprehensive Care Clinic	0.79	(0.43-1.48)	0.74	(0.4-1.37)	1.03	(0.66-1.6)	0.94	(0.6-1.46)
JHCP @ EBMC	0.95	(0.52-1.73)	0.91	(0.5-1.66)	1.34	(0.89-2.01)	1.24	(0.83-1.87)
Missing Clinic	0.81	(0.44-1.46)	0.79	(0.44-1.42)	0.97	(0.66-1.44)	0.89	(0.6-1.32)
JHBMC General Medical Clinic	0.73	(0.37-1.45)	0.6	(0.31-1.2)	1.23	(0.83-1.82)	1.14	(0.77-1.68)
JHCP @ Dundalk	0.66	(0.32-1.37)	0.68	(0.33-1.41)	1.1	(0.72-1.68)	1.03	(0.68-1.58)
JHOC	0.78	(0.42-1.44)	0.78	(0.42-1.42)	1.23	(0.84-1.81)	1.15	(0.79-1.68)
JHBMC Beacham	----	----	----	----	0.81	(0.54-1.22)	0.77	(0.51-1.16)
JHCP @ Wyman Park	Ref							
Comorbidities	0.82	(0.66-1.02)	0.8	(0.64-1)	0.72	(0.58-0.88)	0.72	(0.59-0.89)
No Comorbidities	Ref							

eAppendix Table 12. Adjusted Relative Risk for Hospital Readmissions by program intensity with higher categorical threshold for CM program intensity.

	Medicaid				Medicare			
	NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)		NCQA Standard		CM Sensitivity Analysis (90th percentile cutoff)	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
High CHW Low CM	2.61	(1.33-5.11)	3.19	(1.54-6.6)	1.08	(0.65-1.79)	1.29	(0.75-2.21)
High CHW High CM	1.43	(0.68-3.02)	0.96	(0.48-1.93)	1.09	(0.61-1.94)	0.82	(0.48-1.42)
Low CHW High CM	1.5	(0.75-2.99)	0.99	(0.46-2.11)	2.14	(1.16-3.95)	1.98	(0.96-4.07)
Low CHW Low CM	Ref							
Age at Enrollment	0.98	(0.96-1)	0.98	(0.96-1)	0.98	(0.97-0.99)	0.98	(0.97-0.99)
Male	0.87	(0.51-1.46)	1.02	(0.58-1.8)	1	(0.68-1.47)	0.97	(0.66-1.43)
Female	Ref							
Enrollment Risk Score	17.01	(6.75-42.83)	15.84	(6.38-39.34)	12.13	(4.68-31.44)	10.82	(4.29-27.29)
African American	0.82	(0.48-1.39)	0.89	(0.53-1.52)	0.73	(0.46-1.14)	0.73	(0.47-1.13)
Not African American	Ref							
BMS Highlandtown	0.77	(0.11-5.55)	0.96	(0.13-6.98)	1.58	(0.35-7.06)	0.92	(0.24-3.47)
JHBMC Comprehensive Care Clinic	0.35	(0.06-2.14)	0.48	(0.08-2.99)	2.19	(0.45-10.6)	1.37	(0.31-6.06)
JHCP @ EBMC	0.33	(0.06-1.92)	0.4	(0.07-2.32)	2.93	(0.7-12.32)	1.78	(0.49-6.47)
Missing Clinic	0.54	(0.09-3.25)	0.6	(0.1-3.61)	0.92	(0.25-3.42)	0.59	(0.18-1.99)
JHBMC General Medical Clinic	0.31	(0.04-2.59)	0.18	(0.02-1.5)	1.24	(0.33-4.64)	0.77	(0.23-2.58)
JHCP @ Dundalk	0.04	(0.01-0.27)	0.05	(0.01-0.33)	2.02	(0.42-9.63)	1.29	(0.3-5.55)
JHOC	0.36	(0.06-2.28)	0.49	(0.08-3.12)	1.88	(0.49-7.18)	1.24	(0.36-4.22)
JHBMC Beacham	----	----	----	----	0.99	(0.21-4.72)	0.66	(0.15-2.86)
JHCP @ Wyman Park	Ref							
Comorbidities	0.84	(0.44-1.61)	0.78	(0.4-1.5)	0.42	(0.24-0.73)	0.43	(0.25-0.74)
No Comorbidities	Ref							

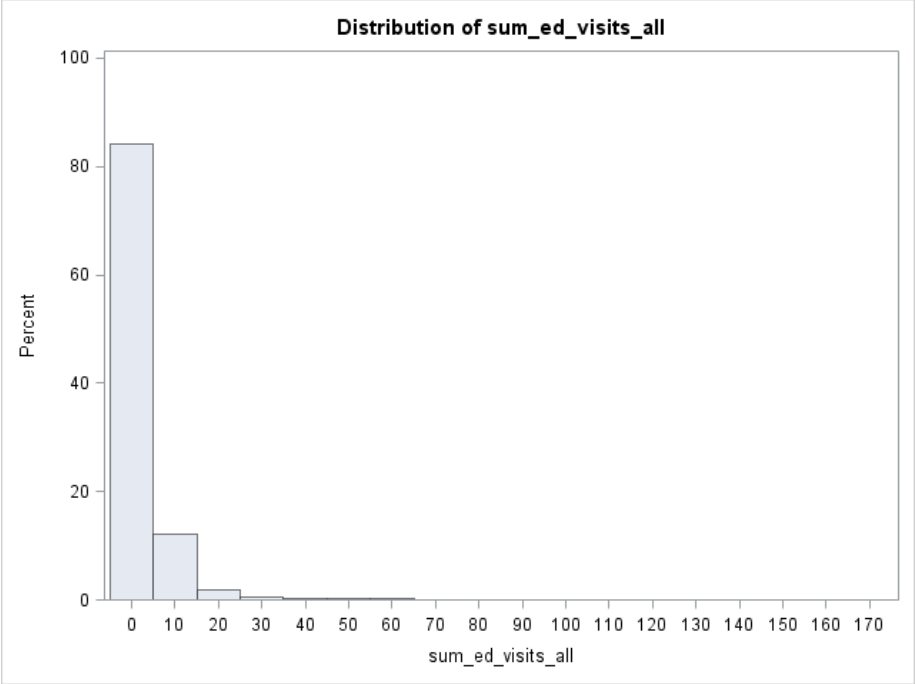
eAppendix Figure 1. Distribution of all ED visits post-intervention among Medicaid beneficiaries with percentiles. *Quantile column lists the sum of ED visits at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	172
99%	49
95%	18
90%	12
75% Q3	6
50% Median	2
25% Q1	1
10%	0
5%	0
1%	0
0% Min	0



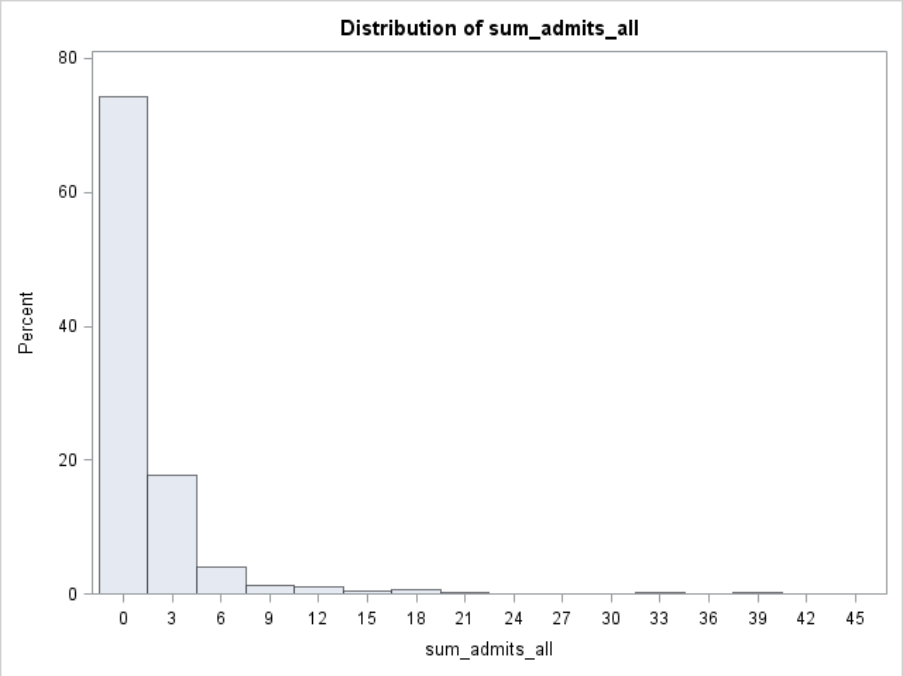
eAppendix Figure 2. Distribution of all ED visits post-intervention among Medicare beneficiaries with percentiles. *Quantile column lists the sum of ED visits at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	174
99%	37
95%	11
90%	7
75% Q3	3
50% Median	1
25% Q1	0
10%	0
5%	0
1%	0
0% Min	0



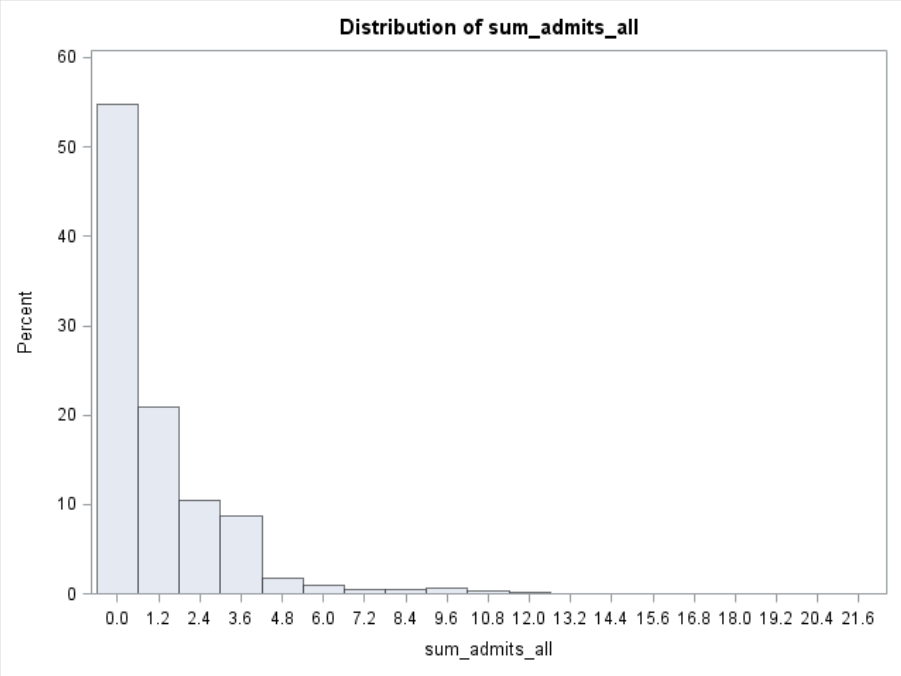
eAppendix Figure 3. Distribution of all Hospital Admissions post-intervention among Medicaid beneficiaries with percentiles. *Quantile column lists the sum of hospital admissions at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	45
99%	18
95%	6
90%	4
75% Q3	2
50% Median	0
25% Q1	0
10%	0
5%	0
1%	0
0% Min	0



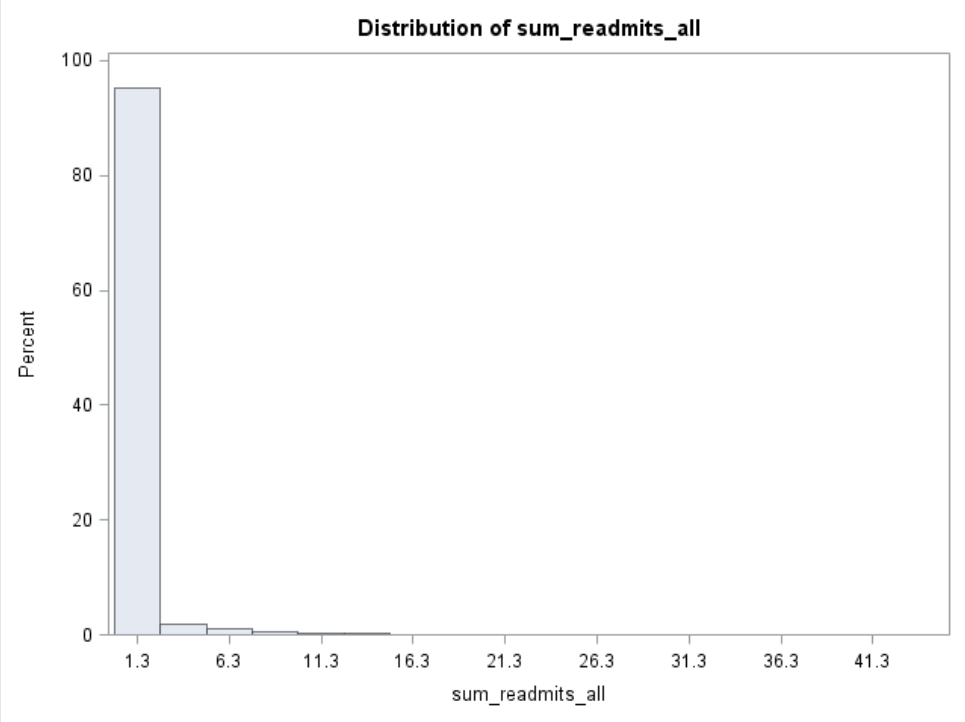
eAppendix Figure 4. Distribution of all Hospital Admissions post-intervention among Medicare beneficiaries with percentiles. *Quantile column lists the sum of hospital admissions at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	22
99%	10
95%	5
90%	3
75% Q3	1
50% Median	0
25% Q1	0
10%	0
5%	0
1%	0
0% Min	0



eAppendix Figure 5. Distribution of all Hospital Readmissions post-intervention among Medicaid beneficiaries with percentiles. *Quantile column lists the sum of readmissions at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	44
99%	10
95%	2
90%	1
75% Q3	0
50% Median	0
25% Q1	0
10%	0
5%	0
1%	0
0% Min	0



eAppendix Figure 6. Distribution of all Hospital Readmissions post-intervention among Medicare beneficiaries with percentiles. *Quantile column lists the sum of readmissions at the indicated percentile.

Quantiles (Definition 5)	
Level	**Quantile**
100% Max	15
99%	4
95%	1
90%	1
75% Q3	0
50% Median	0
25% Q1	0
10%	0
5%	0
1%	0
0% Min	0