

Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.

eTable 1. Process Time Goals From Select Mission: Lifeline Quality Improvement Programs

Mode of presentation	Process time goal
Directly presenting to PCI-capable hospital by emergency medical services	First evaluated by paramedics time to cardiac catheterization laboratory activation time within 20 minutes
	Emergency department wait time (hospital arrival time to cardiac catheterization arrival time) within 15 minutes
	Hospital arrival time to PCI device deployment time within 90 minutes
Directly presenting to PCI-capable hospital by walk in	Hospital arrival time to ECG time within 10 minutes
	Hospital arrival time to PCI device deployment time within 90 minutes
Transferred from another hospital	Arrival at first hospital to departure within 30 minutes
	First hospital arrival time to PCI device deployment time within 120 minutes

eTable 2. Characteristics of GWTG-CAD Registry Hospitals

Characteristics	Number of Hospitals	Percentage
Total Number	601	100
Accreditation by The Joint Commission		
Yes	466	77.5
No	96	16.0
Not available	39	6.5
Critical access hospital		
Yes	129	21.5
No	405	67.4
Not available	67	11.1
Rural referral center		
Yes	151	25.1
No	411	68.4
Not available	39	6.5
Sole community provider		
Yes	19	3.2
No	543	90.3
Not available	39	6.5
Medical school affiliation reported to American Medical Association		
Yes	366	60.9
No	196	33.6
Not available	39	6.5
Hospital location		
Rural	63	10.5
Urban	499	83.0
Not available	39	6.5
Teaching status		
Major	80	13.3
Minor	355	59.1
Non-teaching	127	21.1
Not available	39	6.5
Hospital size		
Large	153	25.4
Medium	352	58.6
Small	57	9.5
Not available	39	6.5
Bed size		
6-24 beds	4	0.7
25-49 beds	17	2.8
50-99 beds	36	6.0
100-199 beds	134	22.3

200-299 beds	138	23.0
300-399 beds	79	13.1
400-499 beds	52	8.7
500 or more beds	102	17.0
Not available	39	6.5
Adult cardiology services		
Yes	444	73.8
No	19	3.2
Not available	138	23.0
Adult diagnostic catheterization		
Yes	430	71.5
No	33	5.5
Not available	138	23.0
Cardiac rehabilitation		
Yes	383	63.7
No	80	13.3
Not available	138	23.0
Adult cardiac surgery		
Yes	294	48.9
No	169	28.1
Not available	138	23.0
Adult interventional cardiac catheterization		
Yes	418	69.5
No	45	7.5
Not available	138	23.0
STEMI receiving/referring		
Receiving	505	84.0
Referring	60	10.0
Not available	36	6.0
PCI capable center		
24 hour PCI capable	496	82.5
Non 24 hour PCI capable	12	2.0
Non PCI center	51	8.5
Not available	42	7.0

eTable 3. Selected Characteristics of Patients with STEMI or STEMI Equivalent by Year Quarter

Characteristics	Categorical descriptors N (%), Continuous descriptors Median (Interquartile range)													
	Q2 2018 N=8858	Q3 2018 N=8429	Q4 2018 N=8717	Q1 2019 N=8560	Q2 2019 N=8675	Q3 2019 N=8521	Q4 2019 N=8542	Q1 2020 N=8622	Q2 2020 N=7574	Q3 2020 N=7864	Q4 2020 N=7943	Q1 2021 N=7873	Q2 2021 N=7926	Q3 2021 N=6767
Age	62 (54, 71)	62 (53, 71)	62 (54, 71)	63 (54, 72)	63 (54, 72)	63 (55, 71)	63 (55, 72)	63 (54, 72)	62 (54, 71)	63 (54, 71)	63 (54, 72)	63 (55, 72)	63 (54, 72)	63 (54, 72)
Male	6349 (71.7)	6050 (71.8)	6135 (70.4)	6071 (70.9)	6167 (71.1)	6064 (71.2)	5986 (70.1)	6106 (70.8)	5417 (71.5)	5667 (72.1)	5562 (70.0)	5620 (71.4)	5626 (71.0)	4828 (71.3)
Female	2509 (28.3)	2379 (28.2)	2582 (29.6)	2489 (29.1)	2508 (28.9)	2457 (28.8)	2556 (29.9)	2516 (29.2)	2157 (28.5)	2197 (27.9)	2381 (30.0)	2253 (28.6)	2300 (29.0)	1939 (28.7)
Race and ethnicity														
American Indian/Alaskan Native	46 (0.5)	39 (0.5)	45 (0.5)	36 (0.4)	45 (0.5)	47 (0.6)	56 (0.7)	48 (0.6)	46 (0.6)	45 (0.6)	49 (0.6)	49 (0.6)	44 (0.6)	25 (0.4)
Asian	308 (3.5)	262 (3.1)	272 (3.1)	300 (3.5)	318 (3.7)	311 (3.6)	308 (3.6)	365 (4.2)	264 (3.5)	283 (3.6)	312 (3.9)	328 (4.2)	340 (4.3)	308 (4.6)
Black	1002 (11.3)	901 (10.7)	857 (9.8)	922 (10.8)	899 (10.4)	951 (11.2)	929 (10.9)	962 (11.2)	806 (10.6)	846 (10.8)	827 (10.4)	878 (11.2)	928 (11.7)	789 (11.7)
Hispanic	646 (7.3)	645 (7.7)	714 (8.2)	731 (8.5)	772 (8.9)	758 (8.9)	679 (7.9)	677 (7.9)	559 (7.4)	549 (7.0)	600 (7.6)	671 (8.5)	655 (8.3)	574 (8.5)
Native Hawaiian/Pacific Islander	25 (0.3)	11 (0.1)	26 (0.3)	24 (0.3)	20 (0.2)	20 (0.2)	25 (0.3)	9 (0.1)	23 (0.3)	19 (0.2)	27 (0.3)	20 (0.3)	35 (0.4)	22 (0.3)
Non-Hispanic White	6637 (74.9)	6346 (75.3)	6581 (75.5)	6309 (73.7)	6387 (73.6)	6206 (72.8)	6299 (73.7)	6279 (72.8)	5653 (74.6)	5914 (75.2)	5894 (74.2)	5622 (71.4)	5666 (71.5)	4732 (69.9)
Not specified	194 (2.2)	225 (2.7)	222 (2.5)	238 (2.8)	234 (2.7)	228 (2.7)	246 (2.9)	282 (3.3)	223 (2.9)	208 (2.6)	234 (2.9)	305 (3.9)	258 (3.3)	317 (4.7)
Heart rate documented on first medical contact, median (IQR)	79 (66, 94)	78 (64, 93)	79 (65, 94)	80 (66, 94)	80 (66, 94)	78 (65, 94)	79 (65, 95)	80 (66, 95)	80 (66, 95)	80 (66, 95)	80 (66, 95)	81 (66, 96)	80 (66, 95)	80 (66, 95)
Systolic blood pressure on first medical contact, median (IQR)	145 (125, 168)	149 (126, 171)	143 (122, 165)	144 (122, 167)	143 (120, 166)	142 (120, 164)	144 (120, 167)	144 (120, 167)	145 (122, 168)	144 (121, 166)	144 (121, 166)	145 (121, 168)	145 (122, 167)	143 (120, 166)

Cardiac arrest prior to arrival														
Yes	427/323 0 (13.2)	422/322 5 (13.1)	437/355 8 (5.0)	465/453 5 (10.3)	475/461 0 (10.3)	481/440 5 (10.9)	476/453 8 (10.5)	460/458 2 (10.0)	436/421 7 (10.3)	433/426 5 (10.2)	449/431 3 (10.4)	458/431 4 (10.6)	461/425 3 (10.8)	392/372 5 (10.5)
Missing or not applicable to walk in patients	5628 (63.5)	5204 (61.7)	5159 (59.2)	4025 (47.0)	4065 (46.9)	4116 (48.3)	4004 (46.9)	4040 (46.9)	3357 (44.3)	3599 (45.8)	3630 (45.7)	3559 (45.2)	3673 (46.3)	3042 (45.0)
Heart failure documented on first medical contact														
Yes	406/582 6 (7.0)	432/596 0 (7.2)	486/628 4 (7.7)	599/833 0 (7.2)	679/851 2 (8.0)	621/830 2 (7.5)	608/833 3 (7.3)	650/842 5 (7.7)	562/734 6 (7.7)	586/762 6 (7.7)	608/768 3 (7.9)	667/760 5 (8.8)	667/765 6 (8.7)	521/650 6 (8.0)
Missing	3032 (34.2)	2469 (29.3)	2433 (27.9)	230 (2.7)	163 (1.9)	219 (2.6)	209 (2.4)	197 (2.3)	228 (3.0)	238 (3.0)	260 (3.3)	268 (3.4)	270 (3.4)	261 (3.9)
Cardiogenic shock documented on first medical contact														
Yes	427/583 2 (7.3)	423/593 8 (7.1)	447/625 8 (7.1)	574/832 6 (6.9)	622/850 1 (7.3)	596/829 9 (7.2)	608/833 0 (7.3)	621/841 7 (7.4)	527/734 6 (7.2)	540/763 6 (7.1)	582/768 6 (7.6)	585/761 2 (7.7)	594/765 2 (7.8)	484/649 9 (7.4)
Missing	3026 (34.2)	2491 (29.6)	2459 (28.2)	234 (2.7)	174 (2.0)	222 (2.6)	212 (2.5)	205 (2.4)	228 (3.0)	228 (2.9)	257 (3.2)	261 (3.3)	274 (3.5)	268 (4.0)
Covid-19 infection ^a	NA	NA	NA	NA	NA	NA	NA	NA	17 (0.2)	18 (0.2)	48 (0.6)	58 (0.7)	54 (0.7)	37 (0.5)
History of smoking														
Yes	3527/88 47 (39.9)	3233/84 21 (38.4)	3174/87 08 (36.4)	3294/81 55 (40.4)	3287/82 45 (39.9)	3218/81 13 (39.7)	3284/81 70 (40.2)	3318/80 32 (41.3)	2872/69 84 (41.1)	3088/73 42 (42.1)	2906/74 26 (39.1)	2890/75 48 (38.3)	2908/75 67 (38.4)	2463/65 82 (34.4)
Missing	11 (0.1)	8 (0.1)	9 (0.1)	405 (4.7)	430 (5.0)	408 (4.8)	372 (4.4)	590 (6.8)	590 (7.8)	522 (6.6)	517 (6.6)	325 (4.1)	359 (4.5)	185 (2.7)
Direct presenting to PCI hospital via EMS	4304 (48.6)	4121 (48.9)	4296 (49.3)	4284 (50.0)	4386 (50.6)	4165 (48.9)	4267 (50.0)	4253 (49.3)	3917 (51.7)	3980 (50.6)	4008 (50.5)	3967 (50.4)	3931 (49.6)	3424 (50.6)
Direct presenting to PCI-capable hospital - via walk in	2574 (29.1)	2390 (28.4)	2456 (28.2)	2572 (30.0)	2635 (30.4)	2603 (30.5)	2485 (29.1)	2449 (28.4)	1992 (26.3)	2112 (26.9)	2110 (26.6)	2099 (26.7)	2208 (27.9)	1798 (26.6)

Transferred from other facility to PCI hospital via air/ground	1980 (22.4)	1918 (22.8)	1965 (22.5)	1704 (19.9)	1654 (19.1)	1753 (20.6)	1790 (21.0)	1920 (22.3)	1665 (22.0)	1772 (22.5)	1825 (23.0)	1807 (23.0)	1787 (22.5)	1545 (22.8)
Destination pre-arrival alert or notification	3588 (40.5)	3425 (40.6)	3602 (41.3)	2983 (34.8)	3017 (34.8)	2997 (35.2)	3079 (36.0)	3250 (37.7)	2952 (39.0)	3043 (38.7)	3042 (38.3)	3262 (41.4)	3215 (40.6)	2961 (43.8)
Treatment														
PCI	7459/86 49 (86.2)	7197/83 41 (86.3)	7389/86 12 (85.8)	7151/84 41 (84.7)	7214/84 86 (85.0)	7242/83 21 (87.0)	7260/83 86 (86.6)	7459/86 04 (86.7)	6495/75 05 (86.5)	6629/76 83 (86.3)	6708/78 04 (86.0)	6598/77 21 (85.5)	6650/77 69 (85.6)	5716/66 61 (85.8)
Thrombolytics	383/864 9 (4.4)	382/834 1 (4.6)	402/861 2 (4.7)	383/844 1 (4.5)	347/848 6 (4.1)	346/832 1 (4.2)	366/838 6 (4.4)	386/860 4 (4.5)	364/750 5 (4.9)	349/768 3 (4.5)	367/780 4 (4.7)	384/772 1 (5.0)	345/776 9 (4.4)	311/666 1 (4.7)
No treatment	1016/86 49 (11.7)	850/834 1 (10.2)	926/861 2 (10.8)	1026/84 41 (12.2)	1114/84 86 (11.8)	933/832 1 (11.2)	916/838 6 (10.9)	777/860 4 (9.0)	715/750 5 (9.5)	886/768 3 (11.5)	868/780 4 (11.1)	891/772 1 (11.5)	931/776 9 (12.0)	740/666 1 (11.1)
Missing	209 (2.4)	88 (1.0)	105 (1.2)	119 (1.4)	189 (2.2)	200 (2.3)	156 (1.8)	18 (0.2)	69 (0.9)	181 (2.3)	139 (1.8)	152 (1.9)	157 (2.0)	106 (1.6)
In-hospital mortality	496 (5.6)	489 (5.8)	613 (7)	575 (6.7)	573 (6.6)	551 (6.5)	617 (7.2)	571 (6.6)	544 (7.2)	546 (6.9)	627 (7.9)	683 (8.7)	611 (7.7)	485 (7.2)
In-hospital mortality adjusted odds ratio (95% odds ratio)	Reference	0.88(0.71-1.08)	1.18 (0.97-1.43)	1.11 (0.92-1.33)	1.09 (0.91-1.32)	1.06 (0.88-1.28)	1.16(0.97-1.40)	1.08(0.90-1.30)	1.22 (1.01-1.47)	1.15(0.95-1.38)	1.29(1.08-1.55)	1.38 (1.15-1.65)	1.26 (1.05-1.51)	1.17 (0.97-1.41)

^a Covid-19 infection recorded when a confirmed diagnosis was documented by the provider or when a positive test result was documented in the patient medical record.

eTable 4. Hospital-Specified Reasons for Delay by Year Quarter

Reasons	Patients, Number (%)														Total
	Q2 2018 N=8858	Q3 2018 N=8429	Q4 2018 N=8717	Q1 2019 N=8560	Q2 2019 N=8675	Q3 2019 N=8521	Q4 2019 N=8542	Q1 2020 N=8622	Q2 2020 N=7574	Q3 2020 N=7864	Q4 2020 N=7943	Q1 2021 N=7873	Q2 2021 N=7926	Q3 2021 N=6767	
Cardiac arrest and/or need for intubation	540 (6.1)	537 (6.4)	544 (6.2)	516 (6.0)	550 (6.3)	561 (6.6)	568 (6.6)	584 (6.8)	533 (7.0)	584 (7.4)	595 (7.5)	599 (7.6)	583 (7.4)	502 (7.4)	7796 (6.8)
Other reasons	460 (5.2)	428 (5.1)	475 (5.4)	434 (5.1)	438 (5.0)	409 (4.8)	457 (5.4)	485 (5.6)	634 (8.4)	476 (6.1)	555 (7.0)	543 (6.9)	493 (6.2)	388 (5.7)	6675 (5.8)
Difficulty crossing the culprit lesion	281 (3.2)	279 (3.3)	290 (3.3)	287 (3.4)	290 (3.3)	314 (3.7)	307 (3.6)	364 (4.2)	337 (4.4)	349 (4.4)	366 (4.6)	338 (4.3)	326 (4.1)	275 (4.1)	4403 (3.8)
Difficult vascular access	242(2.7)	206(2.4)	250(2.9)	194 (2.3)	146 (1.7)	179 (2.1)	206 (2.4)	182 (2.1)	184 (2.4)	186 (2.4)	225 (2.8)	260 (3.3)	213 (2.7)	189 (2.8)	2862 (2.5)
Need for additional PPE for suspected/confirmed infectious disease	NA	NA	NA	NA	NA	NA	NA	29 (0.3)	407 (5.4)	299 (3.8)	300 (3.8)	215 (2.7)	89 (1.1)	85 (1.3)	1424 (1.2)
Patient delays in providing consent	48 (0.5)	63 (0.7)	66 (0.8)	75 (0.9)	64 (0.7)	56 (0.7)	60 (0.7)	72 (0.8)	104 (1.4)	74 (0.9)	67 (0.8)	74 (0.9)	80 (1.0)	58 (0.9)	961 (0.8)
Emergent placement of LV support device	NA	NA	NA	10 (0.1)	11 (0.1)	12 (0.1)	53 (0.6)	118 (1.4)	87 (1.1)	120 (1.5)	132 (1.7)	151 (1.9)	147 (1.9)	118 (1.7)	959 (0.8)
One or more reasons for delay	1515 (17.1)	1452 (17.2)	1549 (17.8)	1419 (16.6)	1416 (16.3)	1426 (16.7)	1520 (17.8)	1693 (19.6)	1933 (25.5)	1801 (22.9)	1934 (24.3)	1848 (23.5)	1659 (20.9)	1415 (20.9)	22580 (19.7)

eTable 5. Model Diagnostics for Multivariate Logistic Regression

Subgroup	Adjusted multivariate model	AUROC	Deviance residuals median (IQR)
EMS	First medical contact to catheterization laboratory activation (20 min.)	0.85	-0.23 (-0.32, -0.17)
	Emergency department time (15 min.)	0.85	-0.27 (-0.38, -0.19)
	First medical contact to device (90 min.)	0.85	-0.22 (-0.33, -0.16)
Walk in	First medical contact /hospital arrival to ECG (10 min.)	0.80	-0.18 (-0.24, -0.14)
	First medical contact /hospital arrival to device contact to device (90 min.)	0.80	-0.16 (-0.22, -0.13)
Transfer patients	Door in door out (30 min.)	0.83	-0.35 (-0.49, -0.26)
	First medical contact / first hospital arrival to device (120 min.)	0.84	-0.32 (-0.44, -0.23)

Abbreviation: AUROC = Area under receiver operating characteristic curve, IQR = Inter-quartile range