Relation of Admission Blood Pressure to In-hospital and 90-Day Outcomes in Patients Presenting With Transient Ischemic Attack

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The association between admission blood pressure (BP) and outcomes in patients with transient ischemic attack (TIA) is not well defined. Patients in the United States national Get With The Guidelines-Stroke registry with a TIA were included. Admission systolic and diastolic BP was used to compute mean arterial pressure and pulse pressure (PP). A subset of this cohort was linked to Centers for Medicare and Medicaid claims data for postdischarge outcomes. The in-hospital outcomes of interest were: mortality, not discharged home, and inability to ambulate independently at discharge. Postdischarge, 30-day and 90-day outcomes of interest were mortality, readmission for stroke, and readmission for major cardiovascular event-composite of death, cerebrovascular, or cardiovascular readmission. Among the 218,803 patients with TIA, lower admission systolic blood pressure (SBP) was associated with worse in-hospital outcomes. Compared with patients with SBP of 150 mm Hg, a lower SBP of 120 mm Hg was associated with higher risk of in-hospital death (adjusted OR = 1.79; 95% CI = 1.50 to 2.12), not being discharged home (adjusted OR = 1.31; 95% CI = 1.27 to 1.36), or inability to ambulate independently at discharge (adjusted OR = 1.27; 95% CI = 1.23 to 1.31). Similarly, among the 64,352 patients in the Centers for Medicare and Medicaid-linked cohort, an inverse association between systolic BP and postdischarge mortality (p <0.0001), and major cardiovascular event (p = 0.0001) was observed at 30-days and at 90-days postdischarge. However, there was no relation between SBP and readmission for stroke either at 30-days (p = 0.35) or at 90-days (p = 0.11). Results were largely similar for diastolic BP, mean arterial pressure, PP, and outcomes. In conclusion, in patients with a transient ischemic attack, a BP paradox was observed, with higher admission BP associated with improved in-hospital, 30-day, and 90-day postdischarge outcomes. **(Am J Cardiol 2019;123:1083−1095)**

In patients presenting with an ischemic stroke, a complex association between poststroke hypertension and short-term outcomes has been described.[1−4] On one hand, poststroke hypertension is potentially beneficial due to a pressure-dependent cerebral blood flow to the ischemic regions (leading to the concept of permissive hypertension in the immediate poststroke phase),[1] but in contrast, it is also potentially deleterious due to increased incidence of recurrent stroke,[2] hemorrhagic transformation, and cerebral edema.[3,4] However, the data in patients presenting with a transient ischemic attack (TIA) are sparse. The objectives of the present study were: (1) to evaluate the association of admission blood pressure (BP) with in-hospital outcomes in patients presenting with a TIA; (2) to evaluate if mean arterial pressure (MAP) or pulse pressure (PP) is a stronger predictor of in-hospital mortality than systolic or diastolic BP; and (3) to evaluate the association of BP parameters with postdischarge outcomes.

Methods

Study cohort included patients in the GWTG-Stroke registry hospitalized with a TIA between 2004 and 2016.[5] To ensure only TIA patients with deficits due to ischemia were enrolled, only patients with symptoms that were present at the time of hospital arrival were included in this analysis. The registry collects information on patient demographics, medical history, in-hospital diagnostic work-up, treatment, discharge medications, counseling and disposition using an internet-based patient management tool, the reliability of which has been shown to be excellent.[6] The above cohort

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See page 1092 for disclosure information.

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was linked with the Centers for Medicare and Medicaid (CMS) claims data from 2004 to 2014 for postdischarge outcomes. The linkage was performed using a previously described and validated method of combining patient identifiers that are present in each system.[7] This subset included GWTG-TIA patients whose admission could be linked to CMS claims data, who survived to discharge, and who had at least 30 days of CMS data after discharge, unless they died during that time. Where a patient had more than one GWTG admission, only the first admission was used. The study was considered exempt by the institutional review boards at the participating center. As such no individual patient consent was required.[5]

TIA was defined as symptoms that were present at the time of hospital arrival, lasting <24 hours, with no alternative diagnosis. Patients with symptoms lasting <24 hours but with radiographic evidence of ischemic injury were classified as ischemic stroke.[8]

The exclusion criteria, outlined in eFigure 1, were: (1) transferred in from another facility; (2) transferred out to another acute care facility; (3) left against medical advice or if the discharge status was unknown; and (4) admission systolic or diastolic BP was missing or if the BP values were out of valid range (invalid range included patients where the diastolic BP ≥systolic BP, PP <20 mm Hg or >230 mm Hg, MAP <30 mm Hg or >220 mm Hg).

Admission systolic and diastolic BPs were recorded for each patient. MAP was calculated as MAP = [systolic BP + (2*diastolic BP)]/3. PP was calculated as PP = systolic BP-diastolic BP.

In-hospital outcomes of interest were: (1) in-hospital mortality; (2) not discharged home (including in-hospital death); and (3) inability to ambulate independently at discharge. For the outcome of not discharged home, patients where the symptoms of TIA were discovered at a chronic health care facility or while at an inpatient or outpatient healthcare setting or where the location could not be determined were excluded. Inability to ambulate independently at discharge was defined as inability to ambulate without the assistance of another person with or without device use. For this outcome only patients able to ambulate independently before the TIA, and were discharged alive, were included. Postdischarge outcomes of interest were mortality, stroke, and major adverse cardiovascular event (MACE- defined as a composite of death or cerebrovascular or cardiovascular readmission). The outcomes were identified using international classification of diseases, ninth revision, clinical modification (ICD-9-CM) primary diagnosis codes as described in a previous study.[9] Briefly, the ICD-9-CM codes 433.x1 or 434.x1 were used to identify ischemic stroke and 430 or 431 for hemorrhagic stroke, and the clinical classification software diagnosis category 96-118 were used for cardiovascular admission. These outcomes were evaluated at 30 days and 90 days postdischarge.

Patients were grouped by quintile of their admission systolic BP (≤129, 130 to 144, 145 to 158, 159 to 177, ≥178 mm Hg), and baseline covariates were compared across groups using Pearson chi-square tests for categorical variables and Kruskal−Wallis tests for continuous variables. Multivariable logistic regression models with a Generalized Estimating Equations approach to account for within-hospital clustering was used to evaluate the relation between continuous BP variables and outcomes. First, each admission BP variable was assessed for the linearity of its relation with each outcome, using restricted cubic splines, simplified (piecewise linear) splines, and polynomials. These assessments were adjusted for other covariates (listed below). The form of the model that best captured the shape of the relation for all BP variables and outcomes was a 5th order polynomial, i.e., including terms up to x^5. For each BP variable, a reference value was set at systolic BP of 150 mm Hg, diastolic BP of 70 mm Hg, MAP of 100 mm Hg and a PP of 80 mm Hg. Odd ratios for each 10 mm Hg change away from the reference value were generated using adjusted models. The covariates included were age, gender, race, body mass index (BMI), arrival time (on vs off hours), arrival mode, medical history (atrial fibrillation/flutter, coronary artery disease, prior stroke/TIA, carotid stenosis, diabetes, peripheral vascular disease, hypertension, dyslipidemia, smoking), and site characteristics (region, teaching hospital, number of beds, rural vs urban hospital). Missing values of covariates were imputed using multiple imputations (25 imputations). Observed event rates were generated for each BP variable in 10 mm Hg increments.

To evaluate the relative contribution of BP variable to in-hospital mortality models we used the F statistics from the above models. The F test assesses whether the measure is associated with the outcome, conditional on all other covariates, with the largest F statistic demonstrating the closest association with in-hospital mortality risk. In addition, the C-index was calculated for each BP variable. All statistical analyses were performed using SAS version 9.2 or higher (SAS Institute, Cary, North Carolina). All p values were two-sided, with $p < 0.05$ considered statistically significant.

Results

A total of 218,803 patients with a TIA fulfilled our inclusion/exclusion criteria (eFigure 1) for in-hospital outcomes assessment. The CMS-linked cohort for postdischarge outcomes included 64,352 patients. Among patients with a TIA, systolic BP ≥140 mm was observed in 67% and diastolic BP ≥90 mm Hg in 28%. Patients with lower admission systolic BP were more likely to be younger, have atrial fibrillation/flutter, prior stroke/ TIA, coronary artery disease/prior MI, history of heart failure or be a smoker than those who presented with higher systolic BP. Patients who presented with higher admission systolic BP were more likely to be older, female, have a history of hypertension, or have diabetes than those who presented with lower systolic BP (Table 1). The baseline characteristics of the CMS-linked cohort are outlined in eTable 1.

Among the patients included in the study, 174,293 (80%) were able to ambulate independently before the current event, of which 25,106 (14.4%) were unable to ambulate independently at discharge. Among the 198,418 (91%) patients who had the TIA episode while not in a healthcare setting, 20,755 (10.5%) were not discharged to home.

Given a TIA cohort, the overall rate of in-hospital death was low (0.2%). There was an inverse association between systolic BP and in-hospital death, not discharged home and inability to ambulate independently at discharge such that

Table 1
Baseline characteristics by quintile of admission systolic blood pressure (mm Hg) in patients presenting with transient ischemic attack

Variable	Overall (N = 218,803)	50-129 (N = 44,270)	130-144 (N = 44,013)	145-158 (N = 44,271)	159-177 (N = 41,821)	178-250 (N = 44,428)
Age (years)	72 (59-82)	70 (57-81)	70 (57-81)	71 (59-82)	73 (61-83)	75 (63-84)
Women	58.0%	55.7%	55.4%	56.3%	58.3%	64.4%
White	72.6%	72.3%	72.3%	72.9%	73.2%	72.3%
Black	15.6%	15.1%	15%	15.1%	15.3%	17.3%
Hispanic	7.0%	7.5%	7.7%	7.0%	6.7%	6.0%
Asian	1.7%	1.7%	1.7%	1.6%	1.8%	1.6%
Other	3.2%	3.4%	3.3%	3.4%	3.1%	2.9%
On-hour arrival (M-F 7a-6p)	56.7%	58.9%	57.7%	57.1%	55.9%	54.2%
National Institute of Health Stroke Scale	2 (1-4)	2 (1-4)	2 (0-4)	2 (0-4)	2 (0-3)	2 (0-4)
Serum creatinine (mg/dL)	1.00 (0.80-1.20)	1.00 (0.80-1.30)	1.00 (0.80-1.20)	1.00 (0.80-1.20)	1.00 (0.80-1.20)	1.00 (0.80-1.20)
Low Density Lipoprotein cholesterol (mg/dL)	91 (69-118)	85 (64-110)	89 (68-115)	92 (70-118)	93 (71-120)	97 (74-125)
Atrial fib/flutter	14.2%	16.7%	14.5%	14.1%	13.5%	12.0%
Prior stroke or transient ischemic attack	38.9%	40.3%	39.1%	38.3%	38.5%	38.4%
Coronary artery disease/prior myocardial infarction	26.5%	29.5%	26.2%	25.4%	25.6%	25.6%
Hypertension	74.8%	66.9%	69.3%	73.9%	79.0%	85.2%
Diabetes mellitus	31.8%	31.2%	30.0%	30.8%	31.9%	35.0%
Smoker	14.2%	17.3%	15.6%	13.9%	12.3%	11.8%
Dyslipidemia	47.2%	45.4%	46.7%	47.6%	48.3%	48.1%
Chronic heart failure	7.7%	10.8%	7.9%	6.7%	6.6%	6.5%
Peripheral vascular disease	4.2%	4.8%	4.1%	3.9%	4.0%	4.3%
Carotid stenosis	3.9%	3.9%	3.5%	3.7%	3.9%	4.4%
Antithrombotic	59.7%	61.7%	59.6%	59.3%	59.5%	58.5%
Antiplatelet	51.8%	51.8%	51.2%	51.4%	52.2%	52.3%
Anticoagulant	12.6%	15.8%	13.5%	12.4%	11.5%	9.7%
Antihypertensive	71.7%	68.1%	68.1%	70.6%	74.1%	77.6%

$p < 0.05$ for all comparisons. Dyslipidemia was coded if high cholesterol, hyperlipidemia or hypercholesterolemia was present based on physician diagnosis, treatment with a lipid lowering agent, total cholesterol greater than 200, LDL greater than 130, HDL less than 40, or elevated triglycerides greater than 200. Patients on lipid lowering therapy were included in this category even if their LDL levels were in range.

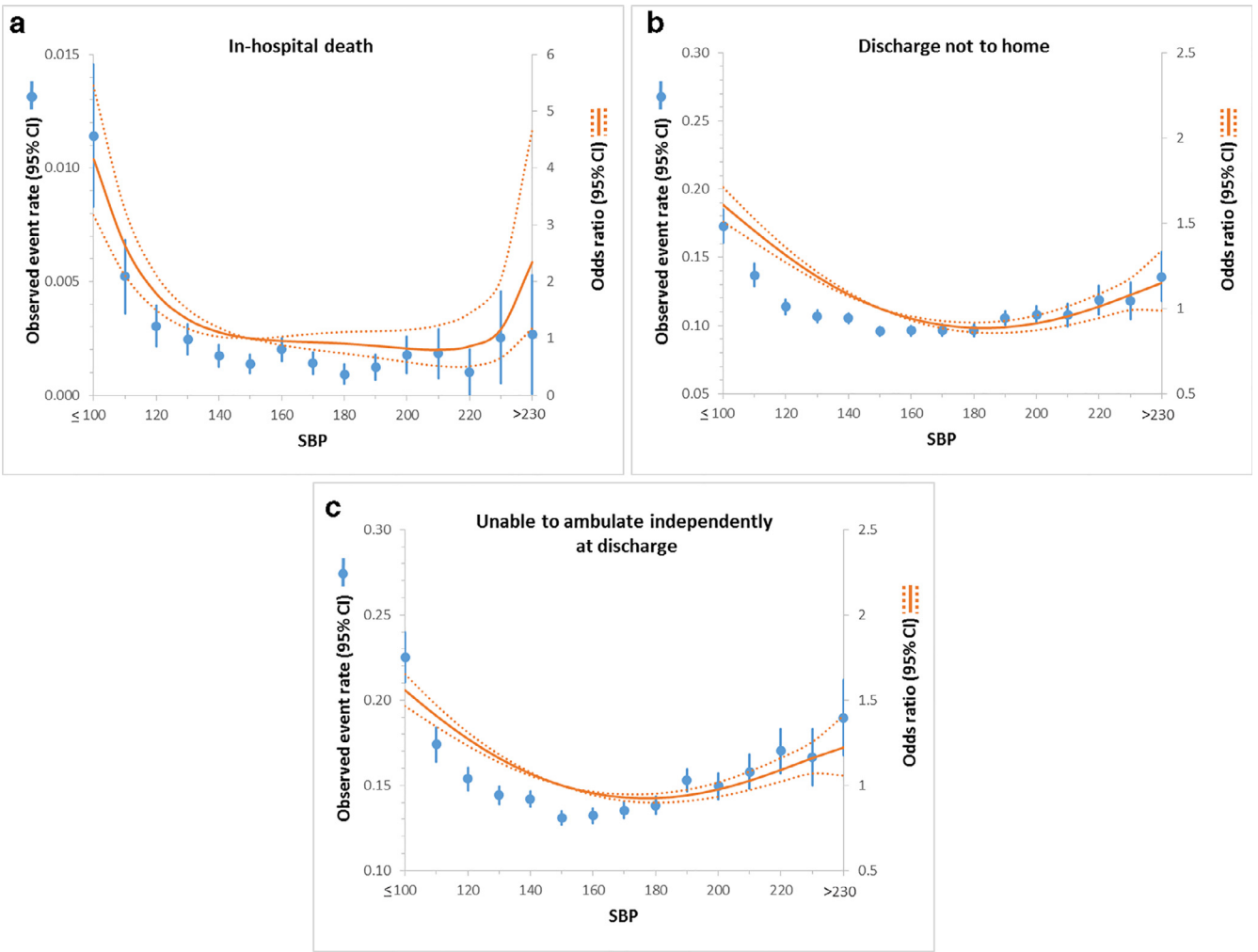

Figure 1. Relation between systolic blood pressure and in-hospital outcomes. Adjusted odds ratio (OR) and 95% confidence interval (CI) are shown for each 10 mm Hg change away from the reference value (150 mm Hg).

at lower systolic BP below 150 mm Hg, the adjusted odds of these outcomes increased (Figure 1, Table 2). For example, when compared with patients with systolic BP 150 mm Hg (reference) a lower BP (120 mm Hg) was associated with a higher risk of in-hospital death (adjusted OR = 1.79; 95% CI = 1.50 to 2.12), not being discharged home (adjusted OR = 1.31; 95% CI = 1.27 to 1.36), or inability to ambulate independently at discharge (adjusted OR = 1.27; 95% CI = 1.23 to 1.31) (Figure 1, Table 2). At higher systolic BP values, greater risk was observed only at the extreme tail of the BP range (above 200 mm Hg), with a higher risk of in-hospital death (240 vs 150 adjusted OR = 2.34; 95% CI = 1.18 to 4.65), inability to ambulate independently at discharge (240 vs 150 mm Hg adjusted OR = 1.22; 95% CI = 1.06 to 1.41), and numerically higher risk of not being discharged home (240 vs 150 adjusted OR = 1.15; 95% CI = 0.99 to 1.34) (Figure 1, Table 2).

Similar to the findings above, there was an inverse association between other BP parameters (diastolic BP, MAP and PP) and in-hospital death, not discharged home and inability to ambulate independently at discharge such that at lower BP below the reference range, the adjusted odds of these outcomes increased (Figure 2, eFigures 2 and 3, eTables 2 to 4). Only at the tail end of distribution of higher BP range, there was a higher incidence of not discharged home or inability to ambulate independently at discharge.

All 4 BP variables were significant predictors of in-hospital mortality, after all other covariates were accounted for, with F statistic being highest for systolic BP (34.55) followed by MAP (31.39), diastolic BP (17.69) and pulse pressure (13.93). However, the C-statistics of the models were largely similar (0.7973, 0.7908, 0.7897 and 0.7887 respectively).

Among the 64,352 patients in the CMS-linked cohort, 1219 (1.9%) died, 1097 (1.7%) were readmitted for a stroke and 6580 (10.3%) had a MACE at 30 days postdischarge. Moreover, at 90-days postdischarge, 3197 (5.1%) died, 1709 (2.9%) were readmitted for a stroke and 11,086 (17.6%) had a MACE. There was an inverse association between systolic BP and postdischarge mortality ($p < 0.0001$), and MACE ($p = 0.0001$) such that at lower systolic BP below 150 mm Hg, the adjusted odds

Table 2
Systolic blood pressure and in-hospital outcomes

	In-hospital death		Discharge not to home		Unable to ambulate independently at discharge	
p value	<0.0001		<0.0001		<0.0001	
mm Hg	Event rate % (CI) [n/N]	Odds ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds ratio (CI) vs reference*
≤100	1.1% (0.8, 1.5) [50/4,380]	4.15 (3.17,5.45)	17.3% (16.1, 18.5) [627/3,628]	1.61 (1.51,1.71)	22.5% (21.0, 24.0) [702/3,119]	1.56 (1.47,1.65)
101-110	0.5% (0.4, 0.7) [39/7,474]	2.63 (2.12,3.28)	13.7% (12.9, 14.5) [873/6,373]	1.45 (1.39,1.53)	17.4% (16.4, 18.4) [965/5,547]	1.41 (1.35,1.47)
111-120	0.3% (0.2, 0.4) [43/14,107]	1.79 (1.50,2.12)	11.4% (10.8, 11.9) [1,393/12,260]	1.31 (1.27,1.36)	15.4% (14.7, 16.1) [1,665/10,824]	1.27 (1.23,1.31)
121-130	0.2% (0.2, 0.3) [52/21,083]	1.34 (1.18,1.52)	10.7% (10.2, 11.1) [1,994/18,673]	1.19 (1.16,1.21)	14.4% (13.9, 15.0) [2,361/16,377]	1.16 (1.14,1.18)
131-140	0.2% (0.1, 0.2) [50/28,639]	1.11 (1.03,1.19)	10.5% (10.1, 10.9) [2,714/25,805]	1.08 (1.07,1.09)	14.2% (13.8, 14.7) [3,244/22,824]	1.07 (1.06,1.08)
141-150	0.1% (0.1, 0.2) [44/32,096]	reference	9.6% (9.2, 9.9) [2,802/29,278]	reference	13.1% (12.7, 13.5) [3,369/25,779]	reference
151-160	0.2% (0.2, 0.3) [62/30,742]	0.95 (0.88,1.03)	9.6% (9.3, 10.0) [2,716/28,215]	0.94 (0.93,0.95)	13.2% (12.8, 13.6) [3,263/24,698]	0.95 (0.94,0.96)
161-170	0.1% (0.1, 0.2) [32/22,825]	0.93 (0.81,1.08)	9.7% (9.3, 10.1) [2,034/21,027]	0.90 (0.88,0.92)	13.5% (13.0, 14.0) [2,502/18,478]	0.93 (0.91,0.95)
171-180	0.1% (0.0, 0.1) [17/18,677]	0.91 (0.74,1.11)	9.6% (9.2, 10.1) [1,664/17,252]	0.89 (0.86,0.92)	13.8% (13.3, 14.4) [2,101/15,189]	0.93 (0.90,0.95)
181-190	0.1% (0.1, 0.2) [18/14,776]	0.87 (0.67,1.12)	10.5% (10.0, 11.0) [1,436/13,634]	0.89 (0.86,0.93)	15.3% (14.7, 15.9) [1,827/11,940]	0.94 (0.91,0.98)
191-200	0.2% (0.1, 0.3) [18/10,183]	0.82 (0.59,1.15)	10.8% (10.2, 11.4) [1,020/9,463]	0.91 (0.87,0.96)	15.0% (14.2, 15.7) [1,241/8,300]	0.98 (0.93,1.02)
201-210	0.2% (0.1, 0.3) [11/5,993]	0.80 (0.52,1.23)	10.8% (9.9, 11.6) [596/5,540]	0.95 (0.90,1.01)	15.8% (14.8, 16.8) [773/4,892]	1.03 (0.97,1.08)
211-220	0.1% (0.0, 0.2) [4/3,970]	0.86 (0.51,1.44)	11.9% (10.8, 12.9) [437/3,680]	1.01 (0.94,1.08)	17.0% (15.7, 18.3) [544/3,198]	1.09 (1.02,1.16)
221-230	0.3% (0.1, 0.5) [6/2,362]	1.16 (0.66,2.04)	11.8% (10.5, 13.2) [259/2,189]	1.08 (0.99,1.18)	16.7% (15.0, 18.3) [320/1,921]	1.16 (1.07,1.26)
>230	0.3% (0.0, 0.5) [4/1,496]	2.34 (1.18,4.65)	13.6% (11.8, 15.4) [190/1,401]	1.15 (0.99,1.34)	19.0% (16.8, 21.2) [229/1,207]	1.22 (1.06,1.41)

* OR is for the *upper* end of the category range shown vs the reference value (150). For example, for the category 171-180, the OR shown is for 180 vs 150. For the topmost category (>230), the OR shown is for 240 vs 150. Confidence intervals (CI) are 95%.

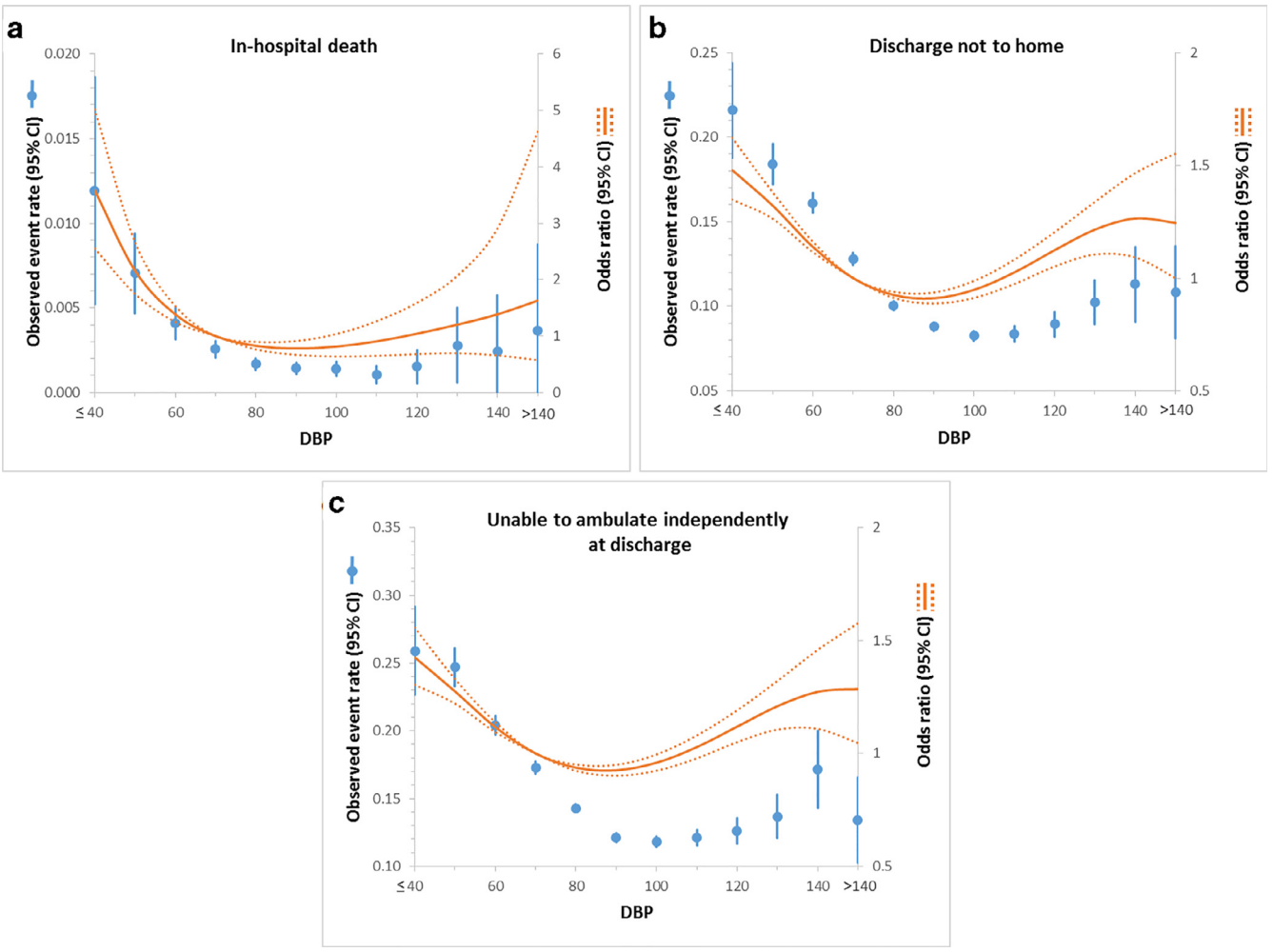

Figure 2. Relation between diastolic blood pressure and in-hospital outcomes. Adjusted odds ratio (OR) and 95% confidence interval (CI) are shown for each 10 mm Hg change away from the reference value (70 mm Hg).

of these outcomes increased at 30-days (Figure 3, Table 3) and at 90-days postdischarge (Figure 4, eTable 5). However, there was no relation between systolic BP and readmission for stroke either at 30-days ($p = 0.35$) (Figure 3, Table 3) or at 90-days ($p = 0.11$) (Figure 4, eTable 5). Similar inverse association of higher adjusted odds of outcomes at lower pressures for mortality and MACE but not readmission for stroke was seen for diastolic BP (Figures 5 and 6, Table 4, eTable 6), MAP (eFigures 4 and 5, eTables 7 and 8) and for PP (eFigures 6 and 7, eTables 9 and 10).

Discussion

The present study of 218,803 patients with a TIA, the largest study to date, showed that, over broad ranges of BP, higher admission BP (systolic, diastolic, MAP or PP) were associated with better in-hospital outcomes, including reduced in-hospital death, increased discharge to home, and increased independent ambulation at discharge. At the upper extremes of BP parameter values, this relation attenuated or reversed. Similarly, over broad ranges, higher values for all four BP variables were associated with lower death and lower readmission for MACE events, though not stroke alone, through 30-days and 90-days postdischarge.

Prior studies have studied smaller TIA cohorts and provided mixed findings, some showing a beneficial,[10–12] others a neutral and others a deleterious association of elevated BP with TIA outcomes.[2] In the related ischemic stroke population, a prior GWTG-Stroke analysis showed a J-shaped/U-shaped association between admission BP variables and in-hospital outcomes, but the TIA population has not previously investigated.[13] Patients with a TIA are at high risk for ischemic stroke, greatest in the first hours to days after a TIA, with a 90-day stroke rate of 4% to 20%.[14–16] Our data with over 218,000 patients with TIA show a complex relation between BP and in-hospital outcomes. In our analyses we showed an inverse association of BP variables and outcomes such that low BP but not high BP was associated with worse outcomes. Unlike the relation for stroke, only at the tail end of distribution of higher BP range, there was a higher incidence of not

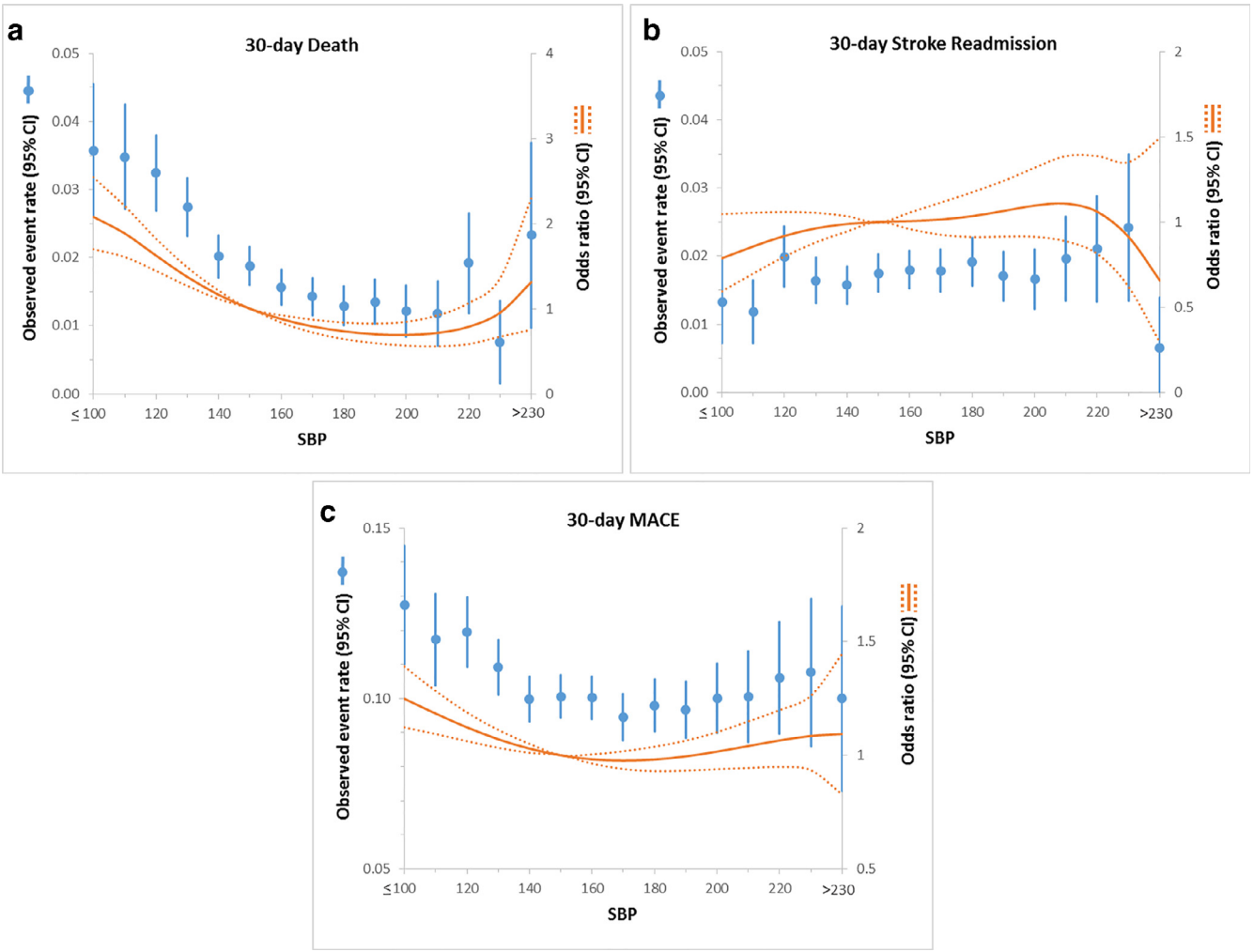

Figure 3. Relation between systolic blood pressure and 30-day postdischarge outcomes. ORs are shown for each 10 mm Hg change away from the reference value (150).

discharged home or inability to ambulate independently at discharge.

Similarly, there was an inverse relation between BP parameters and postdischarge death and MACE such that the adjusted odds of these outcomes were higher at lower BP values. However, there was no relation between BP parameters and the outcome of postdischarge readmission for stroke. Of note, the ABCD[2] score in patients with a TIA includes BP ≥140/90 mm Hg on first evaluation as a predictor of short term-risk of subsequent stroke. However, other scores such as the California score do not consider hypertension or a certain BP cut point as a predictor of recurrent stroke.[14] The California score was derived using a cohort of 1707 patients with a TIA whereas the ABCD score was derived using a cohort of 209 patients. In the GWTG Stroke after TIA score, derived and validated using a sample of 67,892 patients with TIA, neither a history of hypertension nor systolic BP on admission were predictors of ischemic stroke within 1 year, consistent with the findings from our analysis. [17] Although the relation between BP and readmission for stroke was directionally similar to that for other outcomes, it was much weaker and did not reach statistical significance.

The poorer prognosis of patients within the lower BP range in our study could be attributable to a number of reasons: (1) low BP can potentially impair pressure-dependent cerebral blood flow to ischemic regions in patients with extra or intracranial artery stenosis leading to worse outcomes; (2) low BP (especially diastolic) can increase the risk of coronary events due to coronary hypoperfusion perhaps explaining the higher mortality and MACE with lower pressures;[18–22] (3) low BP can be a marker for increased co-morbidities and frailty,[23,24] and the worse outcomes may in part be an epiphenomenon; (4) acutely elevated BP is a physiological response to stroke/TIA and inability to mount this response is perhaps an ominous sign with poor prognosis; and (5) alternative etiologies such as atrial fibrillation, which was more common at baseline in the lower blood pressure patients, may carry a worse prognosis than TIA due to hypertension. Although not a TIA study, in the Prevention Regimen For Effectively avoiding Second Strokes (PRoFESS) trial a

Table 3
Systolic blood pressure and 30-day postdischarge outcomes

	Death within 30 days after discharge		Stroke readmission within 30 days after discharge		Major Adverse Cardiovascular Event within 30 days after discharge	
p value	<0.0001		0.35		0.0001	
mm Hg	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*
≤ 100	3.6% (2.6, 4.5) [50/1,399]	2.08 (1.70,2.55)	1.3% (0.7, 1.9) [18/1,352]	0.79 (0.59,1.05)	12.7% (11.0, 14.5) [178/1,397]	1.25 (1.12,1.39)
101-110	3.5% (2.7, 4.2) [76/2,185]	1.88 (1.61,2.21)	1.2% (0.7, 1.6) [25/2,113]	0.86 (0.70,1.06)	11.7% (10.4, 13.1) [256/2,183]	1.18 (1.09,1.28)
111-120	3.2% (2.7, 3.8) [126/3,885]	1.62 (1.44,1.83)	2.0% (1.5, 2.4) [75/3,765]	0.92 (0.80,1.06)	12.0% (10.9, 13.0) [464/3,880]	1.12 (1.06,1.19)
121-130	2.7% (2.3, 3.2) [156/5,694]	1.37 (1.27,1.49)	1.6% (1.3, 2.0) [91/5,540]	0.96 (0.88,1.06)	10.9% (10.1, 11.7) [620/5,681]	1.07 (1.03,1.11)
131-140	2.0% (1.7, 2.3) [158/7,828]	1.16 (1.11,1.21)	1.6% (1.3, 1.9) [121/7,679]	0.99 (0.94,1.04)	10.0% (9.3, 10.6) [780/7,815]	1.03 (1.01,1.05)
141-150	1.9% (1.6, 2.2) [167/8,920]	reference	1.7% (1.5, 2.0) [153/8,745]	reference	10.1% (9.4, 10.7) [895/8,897]	reference
151-160	1.6% (1.3, 1.8) [140/8,943]	0.88 (0.84,0.92)	1.8% (1.5, 2.1) [158/8,796]	1.01 (0.96,1.06)	10.0% (9.4, 10.6) [894/8,920]	0.98 (0.96,1.00)
161-170	1.4% (1.1, 1.7) [99/6,939]	0.79 (0.72,0.87)	1.8% (1.5, 2.1) [122/6,836]	1.02 (0.92,1.12)	9.4% (8.8, 10.1) [654/6,924]	0.98 (0.94,1.02)
171-180	1.3% (1.0, 1.6) [75/5,816]	0.73 (0.64,0.84)	1.9% (1.6, 2.3) [110/5,734]	1.03 (0.91,1.18)	9.8% (9.0, 10.6) [568/5,796]	0.98 (0.93,1.04)
181-190	1.4% (1.0, 1.7) [66/4,880]	0.70 (0.60,0.82)	1.7% (1.3, 2.1) [82/4,811]	1.06 (0.91,1.24)	9.7% (8.8, 10.5) [471/4,870]	1.00 (0.93,1.06)
191-200	1.2% (0.8, 1.6) [40/3,293]	0.69 (0.57,0.84)	1.7% (1.2, 2.1) [54/3,253]	1.10 (0.91,1.32)	10.0% (9.0, 11.0) [329/3,286]	1.02 (0.94,1.10)
201-210	1.2% (0.7, 1.7) [23/1,954]	0.72 (0.56,0.92)	2.0% (1.3, 2.6) [38/1,933]	1.11 (0.89,1.39)	10.0% (8.7, 11.4) [196/1,951]	1.04 (0.94,1.15)
211-220	1.9% (1.2, 2.7) [26/1,352]	0.79 (0.59,1.06)	2.1% (1.3, 2.9) [28/1,327]	1.06 (0.81,1.39)	10.6% (9.0, 12.2) [143/1,349]	1.07 (0.95,1.20)
221-230	0.8% (0.2, 1.4) [6/792]	0.95 (0.67,1.35)	2.4% (1.3, 3.5) [19/784]	0.91 (0.62,1.35)	10.8% (8.6, 12.9) [85/789]	1.09 (0.93,1.26)
> 230	2.3% (1.0, 3.7) [11/472]	1.31 (0.75,2.30)	0.7% (0.0, 1.4) [3/460]	0.66 (0.29,1.49)	10.0% (7.3, 12.7) [47/470]	1.09 (0.83,1.45)

* OR is for the *upper* end of the category range shown vs the reference value (150). For example, for the category 171-180, the OR shown is for 180 vs 150. For the topmost category (>230), the OR shown is for 240 vs 150. Confidence intervals (CI) are 95%.

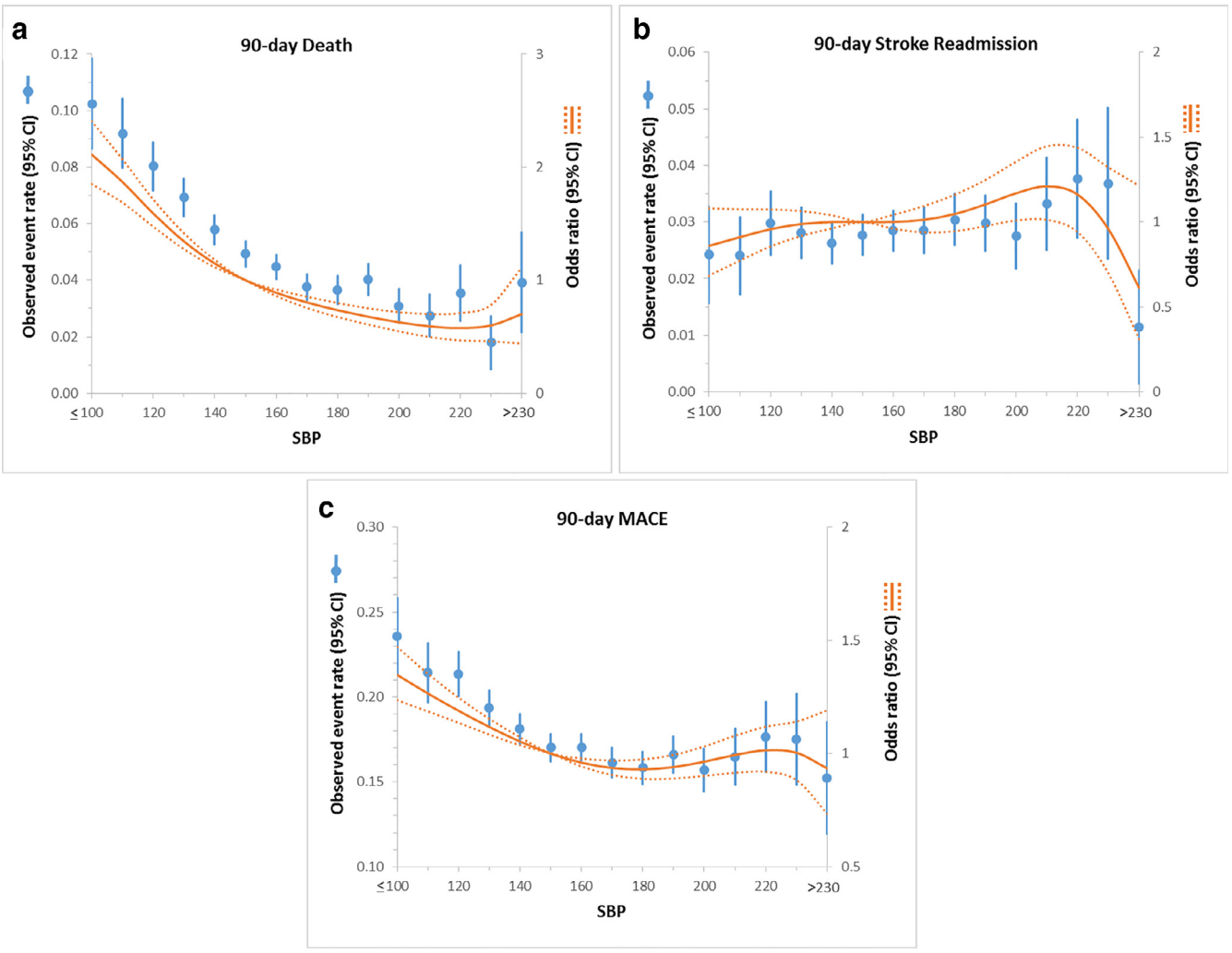

Figure 4. Relation between systolic blood pressure and 90-day postdischarge outcomes. ORs are shown for each 10 mm Hg change away from the reference value (150).

J-shaped relation was seen between on-treatment systolic BP and the risk of cardiovascular events or risk of recurrent stroke, such that at both low and high BP, the risk increased.[25] However, other studies evaluating on-treatment BP and largely primary prevention of stroke have shown lower stroke incidence with lower systolic BP.[18,21]

Our study showed that although the in-hospital mortality in patients with TIA was low (0.2%), the mortality at 30-days was 1.9% and at 90-days was 5.1%, attesting to the high-risk nature of these patients. Similarly, the 90-day rate of readmission for stroke (2.9%) and MACE (17.6%) was high emphasizing the need for comprehensive secondary prevention measures.

In addition to systolic and diastolic BP, BP is also characterized by its pulsatile and steady components. The PP estimates the pulsatile component and is affected by stroke volume, arterial stiffness and heart rate. MAP represents the average pressure during a cardiac cycle and is believed to be a better indicator of perfusion to vital organs than systolic BP with the advantage of incorporating both the systolic and diastolic BP. Whether these additional components better predict in-hospital outcomes in patients with TIA is not known. Our study showed that systolic BP had the best predictive value to predict in-hospital death. However, the C-statistics of the models were largely similar for other components of BP as well.

The study assessed the outcomes associated with admission BP variables in patients with a TIA with symptoms that were present at the time of hospital arrival. Moreover, we did not have BP measurements beyond the admission phase. In addition, we did not have data on time to initiation of symptoms and BP measurements nor on antihypertensive medications administered before or immediately after BP measurement. Although the multivariable model adjusted for many baseline confounders, it does not account for unmeasured confounders such as frailty. Moreover, the multivariable model do not consider the random variation in blood pressure measurement between and within hospital, although a Generalized Estimating Equations approach to account for within-hospital clustering was used. Postdischarge outcomes were confined to those who were Medicare beneficiaries age 65 and older. This study evaluated

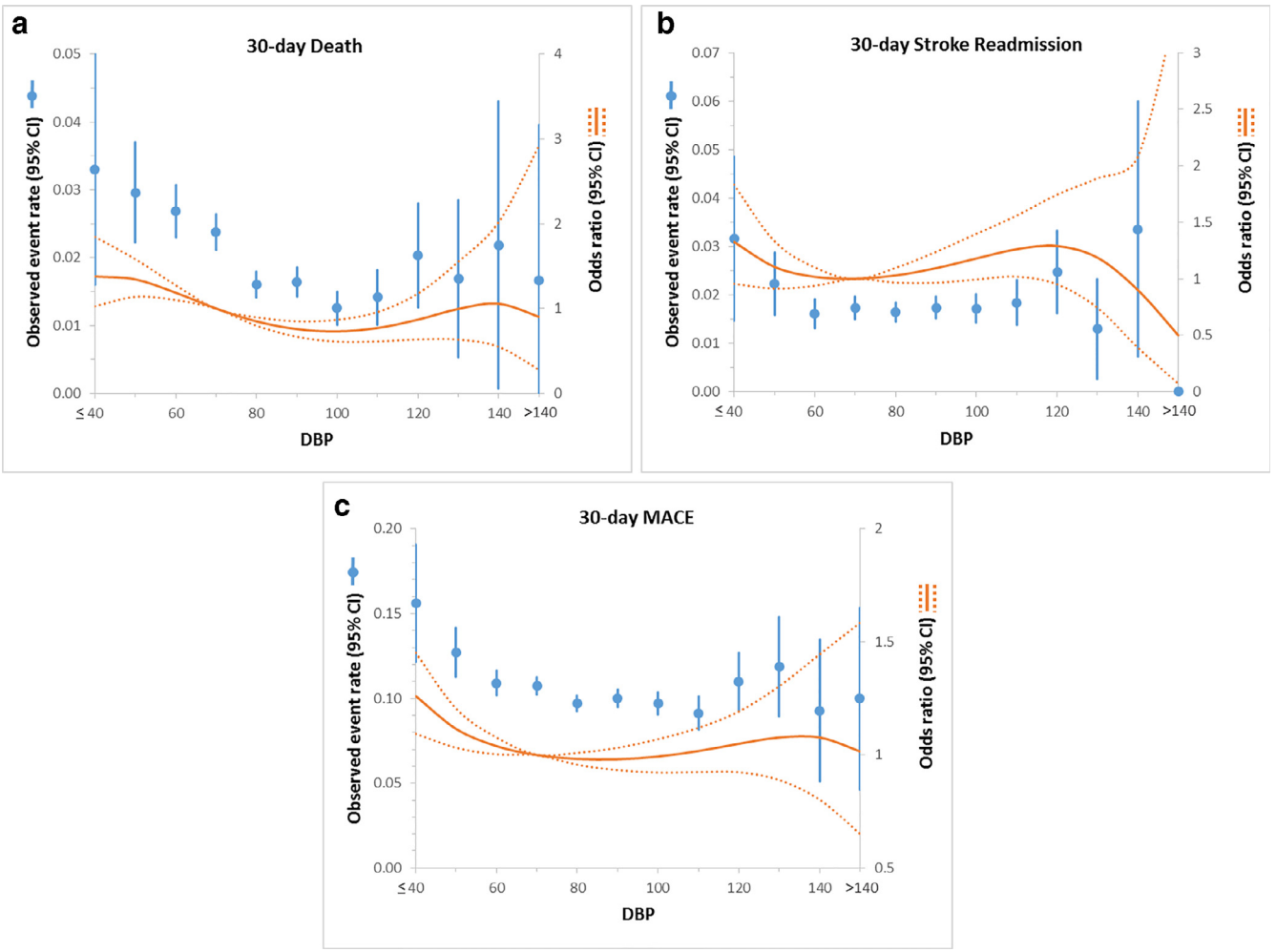

Figure 5. Relation between diastolic blood pressure and 30-day postdischarge outcomes. ORs are shown for each 10 mm Hg change away from the reference value (70).

associations and cannot further assess whether a high/low BP is a marker or mediator of worse outcomes.

In patients with a TIA, higher admission BP parameter values over a broad range were associated with decreased in-hospital mortality and improved functional outcomes at discharge and reduced 30- and 90-day mortality and readmission for MACE, though not readmission for stroke. In addition, at the upper extremes of BP parameter values, adverse outcomes plateaued or increased again mildly. Among all BP parameters, increasing SBP was most strongly related to reduced in-hospital mortality.

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Dr. Gregg C. Fonarow reports the following: Employment – UCLA Employee, which holds a patent on stroke retriever devices, NIH and PCORI – Grants and grants pending.

Dr. Deepak L. Bhatt discloses the following relations – Advisory Board: Cardax, Elsevier Practice Update Cardiology, Medscape Cardiology, Regado Biosciences; Board of Directors: Boston VA Research Institute, Society of Cardiovascular Patient Care, TobeSoft; Chair: American Heart Association Quality Oversight Committee; Data Monitoring Committees: Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute, for the PORTICO trial, funded by St. Jude Medical, now Abbott), Cleveland Clinic, Duke Clinical Research Institute, Mayo Clinic, Mount Sinai School of Medicine (for the ENVISAGE trial, funded by Daiichi Sankyo), Population Health Research Institute; Honoraria: American College of Cardiology (Senior Associate Editor, Clinical Trials and News, ACC.org; Vice-Chair, ACC Accreditation Committee), Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute; RE-DUAL PCI clinical trial steering committee funded by Boehringer Ingelheim), Belvoir Publications (Editor in Chief, Harvard

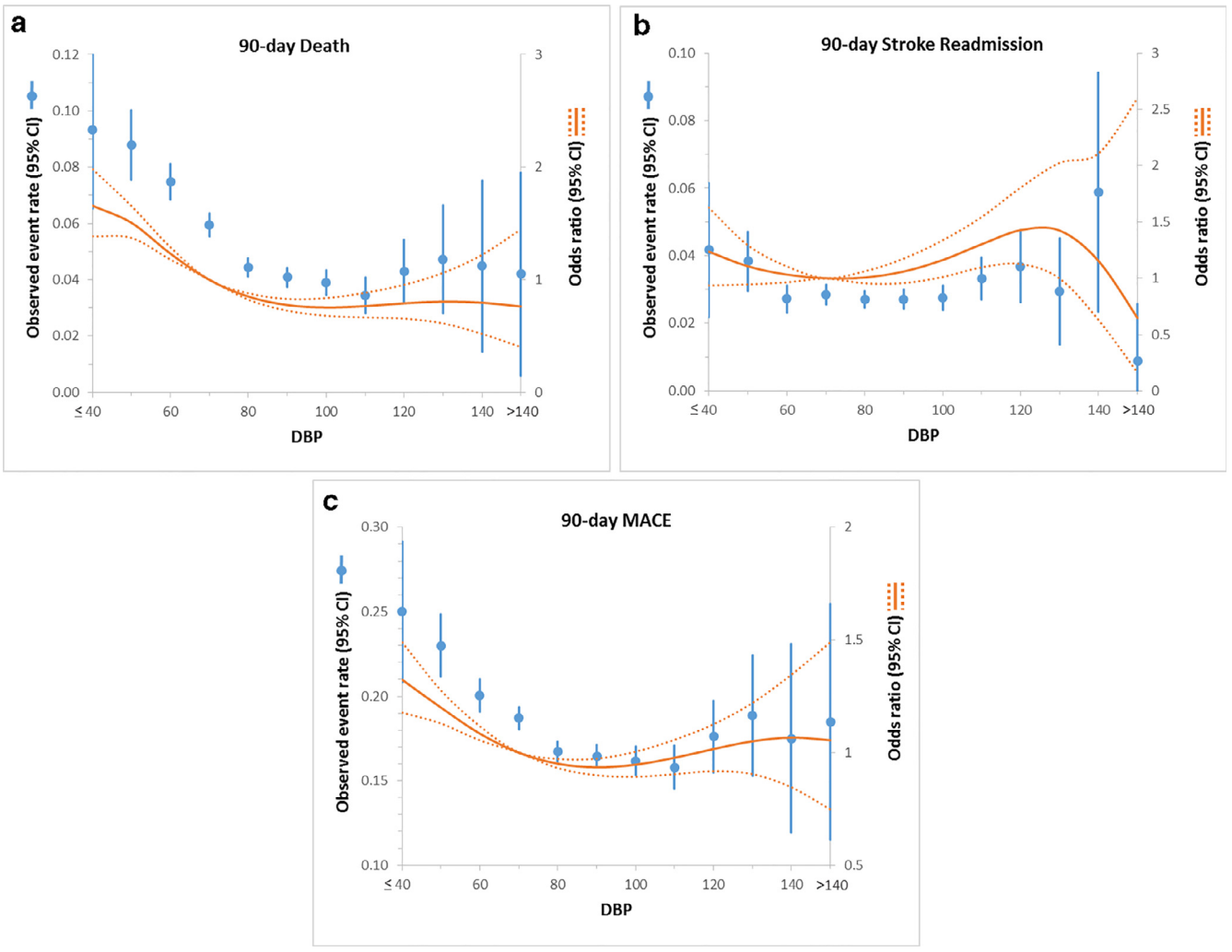

Figure 6. Relation between diastolic blood pressure and 90-day postdischarge outcomes. ORs are shown for each 10 mm Hg change away from the reference value (70).

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All authors had access to the data and a role in writing the manuscript.

Author agreement

This statement is to certify that all authors have seen and approved the manuscript being submitted, have contributed significantly to the work, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission to the *American Journal of Cardiology*. We attest that the article is the Authors' original work, has not received prior publication and is not under consideration for publication elsewhere. We adhere to the statement of ethical publishing.

Table 4
Diastolic blood pressure and 30-day postdischarge outcomes

	Death within 30 days after discharge		Stroke readmission within 30 days after discharge		Major Adverse Cardiovascular Event within 30 days after discharge	
p value	<0.0001		0.19		0.012	
mm Hg	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*	Event rate % (CI) [n/N]	Odds Ratio (CI) vs reference*
≤ 40	3.3% (1.6, 5.0) [14/424]	1.38 (1.03,1.85)	3.2% (1.5, 4.9) [13/411]	1.32 (0.95,1.84)	15.6% (12.1, 19.1) [66/423]	1.26 (1.09,1.45)
41-50	3.0% (2.2, 3.7) [60/2,027]	1.34 (1.14,1.58)	2.2% (1.6, 2.9) [44/1,972]	1.10 (0.91,1.34)	12.7% (11.2, 14.1) [257/2,025]	1.12 (1.03,1.20)
51-60	2.7% (2.3, 3.1) [182/6,778]	1.19 (1.10,1.28)	1.6% (1.3, 1.9) [106/6,592]	1.02 (0.94,1.10)	10.9% (10.2, 11.6) [737/6,760]	1.04 (1.00,1.08)
61-70	2.4% (2.1, 2.6) [308/12,968]	reference	1.7% (1.5, 2.0) [219/12,668]	reference	10.7% (10.2, 11.3) [1,390/12,941]	reference
71-80	1.6% (1.4, 1.8) [258/16,081]	0.85 (0.80,0.90)	1.6% (1.4, 1.8) [259/15,810]	1.03 (0.97,1.10)	9.7% (9.3, 10.2) [1,559/16,042]	0.98 (0.96,1.01)
81-90	1.6% (1.4, 1.9) [214/13,048]	0.76 (0.67,0.85)	1.7% (1.5, 2.0) [223/12,833]	1.09 (0.96,1.24)	10.0% (9.5, 10.5) [1,301/13,021]	0.98 (0.93,1.03)
91-100	1.3% (1.0, 1.5) [97/7,726]	0.73 (0.61,0.87)	1.7% (1.4, 2.0) [131/7,624]	1.18 (0.99,1.40)	9.7% (9.1, 10.4) [749/7,707]	0.99 (0.92,1.07)
101-110	1.4% (1.0, 1.8) [46/3,246]	0.77 (0.61,0.96)	1.8% (1.4, 2.3) [59/3,204]	1.26 (1.02,1.56)	9.1% (8.1, 10.1) [296/3,240]	1.02 (0.93,1.12)
111-120	2.0% (1.3, 2.8) [26/1,278]	0.87 (0.64,1.18)	2.5% (1.6, 3.3) [31/1,255]	1.29 (0.95,1.75)	11.0% (9.3, 12.7) [140/1,275]	1.05 (0.92,1.19)
121-130	1.7% (0.5, 2.9) [8/473]	1.00 (0.64,1.56)	1.3% (0.3, 2.3) [6/462]	1.19 (0.74,1.89)	11.9% (9.0, 14.8) [56/471]	1.08 (0.89,1.30)
131-140	2.2% (0.1, 4.3) [4/183]	1.06 (0.55,2.02)	3.4% (0.7, 6.0) [6/179]	0.90 (0.39,2.08)	9.3% (5.1, 13.5) [17/183]	1.08 (0.80,1.44)
> 140	1.7% (0.0, 4.0) [2/120]	0.90 (0.28,2.93)	0.0% (0.0, 0.0) [0/118]	0.50 (0.07,3.49)	10.0% (4.6, 15.4) [12/120]	1.02 (0.65,1.58)

* OR is for the *upper* end of the category range shown vs the reference value (70). For example, for the category 91-100, the OR shown is for 100 vs 70. For the topmost category (>140), the OR shown is for 150 vs 70. Confidence intervals (CI) are 95%.

On behalf of all Co-Authors, the corresponding Author shall bear full responsibility for the submission.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2018.12.037.

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