Racial and ethnic differences in patterns of treatment for acute peripheral arterial disease in the United States, 1998-2006

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Objective: **Prior studies have documented racial and ethnic disparities in rates of amputations for peripheral arterial disease (PAD) in the United States. We analyze whether there are underlying differences in the types of treatment provided to patients who are acutely hospitalized for PAD.**

Methods: **The 1998-2006 Nationwide Inpatient Sample was used to examine patterns of treatment. We considered a hospitalization an acute admission for PAD if (1) the primary diagnosis was PAD, and (2) the patient was admitted urgently or emergently or through an emergency department. Vascular interventions were designated as open bypass, endovascular intervention, or major amputation, defined as disarticulation at the ankle or higher amputation.**

Results: **From 1998 through 2006, the likelihood of an endovascular procedure being performed during an acute hospitalization for PAD increased from 11.5% to 35.3%, and open vascular procedures decreased from 34.9% to 25.4%. The likelihood of a major amputation during an acute hospitalization for PAD decreased from 29.7% to 20.3%. Black and Hispanic patients were more likely than white patients to undergo amputation and were less likely to have an endovascular or open revascularization.**

Conclusion: **Use of endovascular procedures has increased and use of open vascular bypass has decreased in the inpatient treatment of acute PAD. Although the overall likelihood of amputation has decreased, racial and ethnic differences persist, with black and Hispanic patients experiencing a higher likelihood of amputation. (J Vasc Surg 2010;51:21S-26S.)**

Peripheral arterial disease (PAD) poses a significant clinical and economic burden to individuals living in the United States. When left untreated, PAD can lead to significant morbidity, most importantly, extremity amputation. According to recent estimates, there are >143,000 hospitalizations each year for PAD and >40,000 amputations, incurring an economic burden to the United States health care system of >$4 billion per year.[1,2] The care of patients with PAD encompasses a wide range of treatment modalities, including preventive care, medical treatment, exercise, and revascularization (open surgical and endovascular). These modalities have proven effectiveness in improving patient quality of life and preventing the progression of the disease to the point of amputation. During the past decade, endovascular therapy has become the treatment modality of choice in the treatment of PAD.[2]

Within the United States, the treatment for PAD experienced by different racial/ethnic groups varies widely. Overall population-based rates of amputation are higher for black and Hispanic patients compared with white patients.[3-7] The degree of these differences is surprising—the rates of amputation in these minority groups are, depending on region, as much as four times higher than those in nonminority groups.[8] In this study, we examined the care provided to patients who are hospitalized for PAD. Our goal was to understand whether likelihood of obtaining a particular treatment (amputation or revascularization, or both) varies by race/ethnicity.

METHODS

This study was considered exempt from institutional review by the Institutional Review Board of the Health Sciences Campus of the University of Southern California.

Data source. The Nationwide Inpatient Sample (NIS) from 1998 to 2006, comprising 69 million discharge records, was used as source data for treatment patterns for patients with PAD. Since 1988, the NIS has collected information on approximately 20% of the hospital discharges within the United States. To develop a sample that most accurately represents hospitalizations within the United States, hospitals are sampled according to specific characteristics, including geographic region, hospital ownership, urban or rural location, and teaching status.[9]

The NIS reports data regarding admission type (eg, urgent, emergent, elective) and source (eg, transfer, emer-

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Competition of interest: none.

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Table I. Description of International Classification of Diseases, 9th Edition, *(ICD-9)* procedure codes used to search the Nationwide Inpatient Sample database

Description	*ICD-9 code*
Open vascular bypass procedures	
Incision/exclusion/occlusion of aorta, abdominal arteries, lower limb arteries	38.14, 38.16, 38.18
Resection of lower limb artery, replacement	38.48
Aortoiliac-femoral bypass	39.25
Other peripheral shunt/bypass	39.29
Other revision of vascular procedure	39.49
Repair of blood vessel with synthetic patch graft	39.57
Endovascular procedures	
Angioplasty or atherectomy of noncoronary vessel	39.50
Insertion of noncoronary artery stent or stents	39.90
Major amputation procedures	
Disarticulation of ankle	84.13
Amputation of ankle through malleoli of tibia and fibula	84.14
Other amputation below knee	84.15
Disarticulation of knee	84.16
Amputation above knee	84.17

gency department, newborn). Hospitalizations where the patient was admitted through an emergency department, or had an urgent or emergency admission type, were considered acute admissions. A hospitalization was considered an acute admission for PAD if the patient was acutely admitted and had a primary diagnosis of PAD (International Classification of Disease [ICD] code 440.2x).

Types of procedures were identified as open vascular bypass, endovascular bypass, and major amputation based on ICD procedure codes (Table I). A modified Charlson score was computed based on diagnosis codes present in the hospitalization abstract according to methods previously described.[10] Because the patients in our sample all had at least one comorbidity (vascular insufficiency), this element of the comorbidity scoring was eliminated from the computed Charlson score.

Analytic methods. Database manipulation was performed using Visual Foxpro 9.0 software (Microsoft Inc, Redmond, Wash). Statistical analyses were conducted with SAS 9.1.3 software (SAS Institute Inc, Cary, NC). Multivariate logistic regression was used to analyze dichotomous outcomes (eg, amputation performed = yes/no).

To account for insurance status within different age groups, we parsed the data set into patients aged <65 vs ≥65 years. This allowed us to analyze the specific effect of Medicare within these different age groups. Without this manipulation, Medicare insurance status becomes uninterpretable—patients aged <65 years who hold Medicare insurance are generally either disabled or have end-stage renal disease. These patients do dramatically worse than other patients of similar age. By dividing the data set, we were able to examine Medicare insurance status within that age group. We also sought to analyze temporal trends in our multivariate analyses. In these analyses, we considered year of discharge to be a predictor variable of interest, dummied into three categories: period 1 was 1998 to 2000, period 2 was 2001 to 2003, and period 3 was 2004 to 2006.

Missing data. Approximately 25% of the NIS discharge records are missing data elements for one or more key patient factors. Race was the most common missing variable because the states of Georgia, Illinois, Kentucky, Minnesota, Nevada, Ohio, Oregon, and West Virginia do not report race data on their discharge abstracts to the NIS. To avoid a potential source of bias, we excluded discharge data from these states. By excluding these records, however, we also altered the ability of the NIS sampling scheme to be nationally representative. We therefore chose to analyze NIS data without regard to discharge weights, because these weights would no longer be accurate after applying the above-described exclusion. In doing so, we accept that our analysis can no longer be considered truly representative of discharges in the United States.

RESULTS

Overall results. From within the NIS data set, we identified 87,337 discharges for patients who were admitted acutely with a diagnosis of PAD between 1998 and 2006. This number is a sampling of domestic discharges and therefore does not represent an estimation of total annual hospitalizations for PAD. Of the hospitalizations we analyzed, 27.0% included an amputation, 19.3% an endovascular procedure, and 30.2% an open vascular bypass.

Patient characteristics. The characteristics of the patients hospitalized in our study sample are summarized in Table II. Patients who underwent amputation were slightly older (mean, 73.8 years) than the overall cohort (mean, 71.9 years) or those who had an open bypass procedure (mean, 69.8 years) or an endovascular procedure (mean, 70.1 years). Men predominated in all population groups and subgroups.

Trends over time. The proportion of patients admitted for acute PAD who underwent one of the three procedures this study analyzed changed significantly during the study period (Fig 1). Changes were the most dramatic in the use of endovascular procedures, from 11.5% of admissions in 1998 to ≥35.3% in 2006. The use of open vascular procedures and amputations both declined significantly. The overall, unadjusted likelihood that an individual admitted for acute PAD will undergo an amputation before discharge is shown in Fig 2, categorized by race/ethnicity. Between 1998 and 2006, the likelihood for all races decreased from 29.7% to 20.3%. Although decreases were seen within all racial groups, a consistent difference is seen between racial/ethnic groups, with black and Hispanic patients more likely to undergo amputation than white patients during all years of the study.

Multivariate analysis. We conducted six multivariate analyses to understand the effect a broad range of factors on

Table II. Patient demographics from acute admissions for peripheral arterial disease

Variable	*All admits*	*Procedure performed during admission*		
		Open bypass (n = 21,214)	*Amputation (n = 18,980)*	*Endovascular (n = 13,539)*
Age, mean ± SD, y	71.9 ± 12.5	69.8 ± 11.8	73.8 ± 12.4	70.1 ± 11.9
Female gender, %	47.3	43.9	48.6	47.4
Race/ethnicity, %				
White	66.5	70.0	56.6	73.6
Black	19.6	16.6	29.1	14.1
Hispanic	6.4	5.3	7.1	5.4
Other/missing	7.5	5.6	7.2	6.9
Age group, %				
<65 y[a]	27.0	31.2	22.7	26.4
≥65 y[b]	73.0	68.8	77.3	69.1
Age <65 y, %				
Private insurance	36.7	42.2	23.3	47.1
Medicare	35.2	29.3	47.8	28.6
Medicaid	18.7	18.5	22.1	14.5
Other/unknown	9.1	9.7	6.6	9.4
Age ≥ y, %				
Medicare	91.4	90.2	92.4	91.3
Private insurance	5.7	7.1	4.3	6.6
Other/unknown	2.8	2.7	3.3	2.1
Charlson score, %				
0	27.4	34.6	18.4	34.6
1	14.0	11.8	15.1	11.8
2	26.1	27.0	24.8	27.0
≥3	18.7	15.6	24.9	15.6

[a]Figures in this row represent the proportion of patients in the column who are aged <65 years.
[b]Figures in this row represent the proportion of patients in the column who are aged ≥65 years.

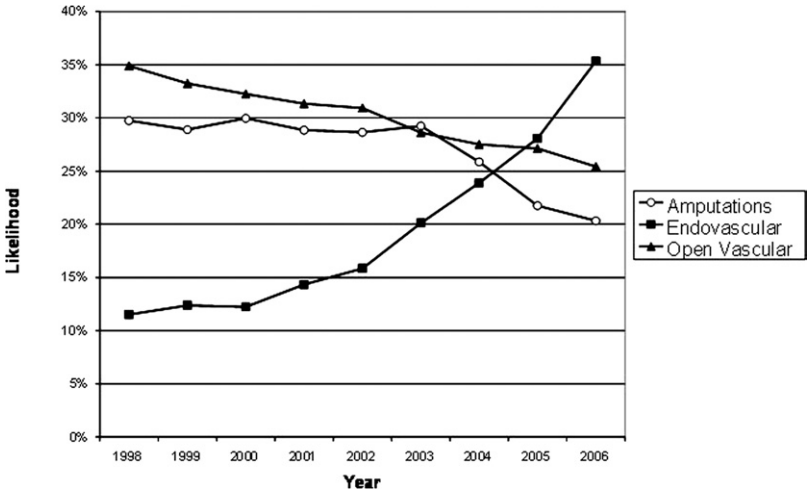

Fig 1. Likelihood of amputation *(white circles)*, endovascular bypass *(black squares)*, or an open vascular bypass *(black triangle)* procedure is shown during an acute admission for peripheral arterial disease.

a patient's likelihood of undergoing (1) open vascular procedure (Table III, *A*), (2) amputation (Table III, *B*), and (3) endovascular procedure (Table III, *C*). These analyses were stratified by age into patients <65 years vs ≥65 years to provide better interpretation of insurance status.

Temporal trends. The unadjusted analysis of temporal trends shown in Fig 1 was confirmed in our multivariate analysis. Open vascular bypass procedures and amputations were less likely to be used in periods 2 and 3 than in period 1, and this finding was consistent across age groups. Endovascular procedures showed the most rapid change in likelihood of use (Table III, *C*). The adjusted odds ratio (AOR) for undergoing an endovascular procedure during an acute admission for PAD was 3.23 (95% confidence interval [CI], 3.05-3.43)

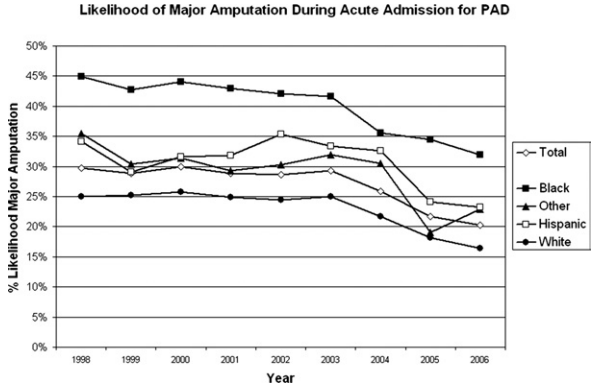

Fig 2. Likelihood of a major amputation during an acute admission for peripheral arterial disease is shown by race/ethnicity.

Table III. A, Multivariate logistic regression for likelihood of open vascular bypass during acute admission for peripheral arterial disease

Variable	*Patient age, AOR (95% CI)*	
	<65 y (n = 18,935)	*≥65 y (n = 51,318)*
Year of admission		
Period 1: 1992-2000	1.00	1.00
Period 2: 2001-2003	0.87 (0.80-0.93)	0.88 (0.84-0.92)
Period 3: 2004-2006	0.68 (0.63-0.73)	0.73 (0.70-0.77)
Age, y		
45-64 (vs 18-44)	1.37 (1.22-1.54)	. . .
≥75 (vs 45-64)	. . .	0.65 (0.62-0.67)
Female gender	0.86 (0.81-0.92)	0.92 (0.88-0.96)
Race/ethnicity		
White	1.00	1.00
Black	0.88 (0.82-0.95)	0.69 (0.65-0.72)
Hispanic	0.78 (0.69-0.89)	0.75 (0.69-0.82)
Other/missing race	1.11 (0.99-1.25)	1.02 (0.94-1.09)
Primary payer (<65 years)		
Private	1.00	. . .
Medicare vs private	0.71 (0.66-0.76)	. . .
Medicaid vs private	0.86 (0.79-0.94)	. . .
Other/unknown vs private	0.91 (0.82-1.02)	. . .
Primary payer (≥65 years)		
Medicare	. . .	1.00
Private	. . .	1.23 (1.14-1.33)
Other	. . .	0.94 (0.84-1.06)
Charlson score		
0	1.00	1.00
1	1.05 (0.94-1.18)	0.83 (0.79-0.88)
2	0.87 (0.80-0.93)	0.97 (0.92-1.01)
≥3	0.59 (0.54-0.65)	0.77 (0.73-0.81)

AOR, Adjusted odds ratio; *CI,* confidence interval.

when patients admitted in period 3 were compared with period 1.

Age. Among patients aged <65 years, those aged 45 to 64 were more likely than patients aged <45 years to undergo open or endovascular revascularization. There was no difference, however, in likelihood of amputation. Among patients aged ≥65, those >75 were less likely to undergo open or endovascular revascularization and were more likely to undergo amputation.

Table III. B, Multivariate logistic regression for likelihood of amputation during acute admission for peripheral arterial disease

Variable	*Patient age, AOR (95% CI)*	
	<65 y (n = 18,935)	*≥65 y (n = 51,318)*
Year of admission		
Period 1: 1992-2000	1.00	1.00
Period 2: 2001-2003	1.00 (0.92-1.09)	0.92 (0.88-0.96)
Period 3: 2004-2006	0.70 (0.64-0.76)	0.67 (0.64-0.71)
Age, y		
45-64 vs 18-44	1.01 (0.89-1.15)	. . .
≥75 vs 45-64	. . .	1.37 (1.31-1.42)
Female gender	0.89 (0.83-0.96)	0.95 (0.91-0.99)
Race/ethnicity		
White	1.00	1.00
Black	1.60 (1.47-1.73)	2.49 (2.37-2.62)
Hispanic	1.29 (1.13-1.47)	1.43 (1.32-1.55)
Other/missing race	1.03 (0.90-1.19)	1.19 (1.10-1.28)
Primary payer (<65 years)		
Private	1.00	. . .
Medicare vs private	2.11 (1.93-2.30)	. . .
Medicaid vs private	2.04 (1.84-2.26)	. . .
Other/unknown vs private	1.23 (1.07-1.43)	. . .
Primary payer (≥65 years)		
Medicare	. . .	1.00
Private	. . .	0.71 (0.65-0.78)
Other	. . .	1.14 (1.02-1.28)
Charlson score		
0	1.00	1.00
1	1.12 (0.97-1.29)	1.28 (1.21-1.36)
2	1.37 (1.25-1.50)	1.06 (1.01-1.11)
≥3	2.45 (2.24-2.69)	1.55 (1.47-1.64)

AOR, Adjusted odds ratio; *CI,* confidence interval.

Gender. Women were less likely to undergo amputation or open vascular procedures than men and were more likely to receive an endovascular procedure during an acute hospitalization for PAD. These findings were true among patients aged <65 or ≥65.

Race and ethnicity. Compared with white patients, black and Hispanic patients of both age groups were less likely to undergo an endovascular or open vascular procedure during an admission for PAD. They were more likely to undergo amputation. The magnitude of this effect for the likelihood of amputation was larger among older patients and also greater among black vs white patients than for Hispanic vs white patients.

Payer. Among younger patients, private insurance was associated with a greater likelihood that a patient would receive an open vascular or endovascular procedure and would have a lower likelihood of amputation. The likelihood of amputation was highest among those with Medicare (AOR, 2.11; 95% CI, 1.93-2.30). Among older patients, those with private insurance were more likely to have an open or endovascular revascularization and less likely to undergo amputation than patients covered with Medicare.

Table III. C, Multivariate logistic regression likelihood of an endovascular revascularization during an acute admission for peripheral arterial disease

	Patient age, AOR (95% CI)	
Variable	*<65 y (n = 18,935)*	*≥65 y (n = 51,318)*
Year of admission		
Period 1: 1992-2000	1.00	1.00
Period 2: 2001-2003	1.47 (1.34-1.63)	1.55 (1.46-1.65)
Period 3: 2004-2006	2.87 (2.62-3.14)	3.23 (3.05-3.42)
Age, y		
45-64 vs 18-44	1.17 (1.02-1.34)	. . .
≥75 vs 45-64	. . .	0.70 (0.66-0.73)
Female gender	1.25 (1.16-1.35)	1.09 (1.04-1.14)
Race/ethnicity		
White	1.00	1.00
Black	0.72 (0.66-0.79)	0.53 (0.49-0.57)
Hispanic	0.70 (0.60-0.81)	0.66 (0.59-0.73)
Other/missing race	0.81 (0.71-0.93)	0.77 (0.70-0.84)
Primary payer (<65 y)		
Private	1.00	. . .
Medicare vs private	0.59 (0.54-0.64)	. . .
Medicaid vs private	0.52 (0.47-0.58)	. . .
Other/unknown vs private	0.69 (0.61-0.79)	. . .
Primary payer (≥65 y)		
Medicare	1.00	1.00
Private	. . .	1.15 (1.04-1.26)
Other	. . .	0.79 (0.68-0.93)
Charlson score		
0	1.00	1.00
1	0.89 (0.78-1.02)	0.72 (0.67-0.77)
2	0.91 (0.84-0.99)	0.94 (0.89-0.99)
≥3	0.70 (0.63-0.77)	0.72 (0.67-0.77)

AOR, Adjusted odds ratio; *CI,* confidence interval.

Comorbidity. Patients with higher levels of comorbidity (higher modified Charlson score) had a lower likelihood of undergoing an open vascular or endovascular revascularization. A higher Charlson score was also associated with a higher risk of amputation. These findings were consistent across age categories.

DISCUSSION

The main goal in the management of patients with PAD is to maximize duration and quality of life, and avoidance of lower extremity amputation is a benchmark of success in achieving this goal. Patients who are hospitalized with an acute manifestation of PAD are at a crossroads, and their outcome surely depends on the ability of their treating physicians to arrest the progression of their disease. In this study, we used data from a nationally representative data set to analyze the patterns of treatment provided to this population of patients—patients who are hospitalized acutely for PAD.

Our study clearly documents a changing pattern of treatment for patients who are hospitalized acutely for PAD. During the 9-year period of our study, we saw a distinct trend toward a lower likelihood of amputation and increased likelihood of obtaining an endovascular intervention, especially in patients aged >65 years. Although our analyses cannot prove that endovascular technology is the root cause of these improvements in amputation rates, the circumstantial evidence for a causal link is strong.

Race/ethnicity remains an important correlate of outcomes in patients with PAD. Our analysis demonstrates that minorities are less likely than white patients to undergo an open or endovascular revascularization and are more likely to have a major amputation during an acute admission for PAD. The magnitude of our findings is somewhat surprising. Of patients aged ≥65 years, black patients had an AOR of 2.49 relative to white patients for amputation, 0.69 for open vascular bypass, and 0.53 for endovascular revascularization. Findings were similar for Hispanic patients, albeit less dramatic. Patients <65 years also had demonstrably different patterns of treatment across race/ethnic lines. It is worth noting that the likelihood of amputation decreased for all groups during the course of our study, suggesting that recent implementations of improving the care of patients with PAD have traversed across all racial/ethnic boundaries. Despite the improvements in all racial groups, the question still remains: Why the persistent difference in the likelihood of amputations in Hispanic and black patients?

A large body of population-based studies has consistently documented higher rates of amputations in minority patients, especially black patients. Initial studies performed in the early 1990s used Medicare data to show that black patients had higher rates of amputation and lower rates of revascularization compared with white patients.[5,6,11] More recently, Eslami et al[3] used the same NIS data set during a 4-year span (1998 to 2002) and analyzed multiple variables thought to affect the disparity in the likelihood of amputations. They concluded that the higher amputation likelihood in Hispanic and black patients was secondary to advanced disease at presentation (ie, gangrene), lower socioeconomic status, and lack of access to tertiary care centers.

Although each study mentioned possible root causes, few have offered an in-depth analysis. One interesting study by Rucker-Whitaker et al[12] proposed a unique explanation for higher amputation rates among black patients. Using data from a single academic institution, they concluded that the differences in amputation rates in black patients might be partially due to a higher likelihood of repeat amputations. The extent to which the findings from the Rucker-Whitaker study can be generalized to a broader population is unknown, but their approach raises the possibility that minorities receive the same intensity of treatment but have worse outcomes.

In 2007, we conducted a review of surgical outcomes in patients undergoing lower extremity revascularization at our large, urban public institution.[13] In this setting, we postulated a level playing field, with a population that was homogenous to considerations of referral bias, poor compliance, payer, and socioeconomic status. Our report showed that black patients undergoing open surgical bypass for symptomatic PAD had statistically worse limb

salvage and graft patency rates compared with white patients at 18 months of follow-up. Although this single-institution study was preliminary, it did mandate consideration of possible inherent differences (ie, upregulated inflammatory markers, coagulation abnormalities, among others) or responses to surgery among different populations of patients with PAD. The current study was not designed to assess the degree to which these considerations are important. A longitudinal evaluation of individual PAD patients that assesses comorbidities and the burden of disease at the time of diagnosis as well as surgical outcomes is important.

Given the results of our study and the existing literature to date, what do these findings mean? We have used the term *difference* instead of *disparity* in the interest of adhering to the definitions of the terms as described by Rathore and Krumholz.[14] They describe a "difference" as the observed variation in health care use by race. A "disparity" is when a racial difference in health care use reflects shortfalls in appropriate care that cannot be explained by other patient factors and are associated with adverse health consequences. With this report, the noted differences could be considered disparities if all other reasonable patient factors were similar. These patient factors should include patient preferences, access to care, and anatomic differences, among others. Given the limitations of the data source used in this study, we believe our investigation is not clearly able to ascertain the presence of disparity. This distinction between difference and disparity, however, should not cloud the importance of understanding the underlying reason for the differences noted in our study and others.

Our study has several notable limitations. We were only able to examine hospital-based care that occurred within the context of an inpatient hospitalization. Admissions—not procedures or patients—were the observations of interest, making it impossible to analyze serial episodes of patient care. Also, our data source only captures inpatient procedures, and we were not able to analyze outpatient procedures performed for PAD and thus could not account for secular trends that might have resulted in procedures shifting from inpatient to outpatient environments. For this reason, the rise in endovascular procedures in our decade of interest may actually be underestimated.

Finally, we excluded data from nine states because they do not report race data on their discharge abstracts to the NIS. We have no reason to believe that this exclusion was a source of bias, but we acknowledge that it does impair the degree to which one considers our findings as truly nationally representative.

CONCLUSIONS

We have shown that for a subset of patients with PAD—those who are acutely hospitalized—that there are significant differences in the types of treatment that are provided across racial/ethnic groups. Black and Hispanic patients undergo amputations more often and receive revascularization less often, and these differences are dramatic. To understand and potentially address the underlying causes of these differences, population-based research that encompasses a rich amount of clinical data is necessary. Allowing these findings to continue unexamined is unacceptable.

AUTHOR CONTRIBUTIONS

Conception and design: VR, FW, JL,
Analysis and interpretation: VR, JL, DE
Data collection: DE
Writing the article: VR, DE
Critical revision of the article: VR, FW, DE
Final approval of the article: VR, FW, DE
Statistical analysis: JL, DE
Obtained funding: Not applicable
Overall responsibility: VR, DE

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