Missed dialysis sessions and hospitalization in hemodialysis patients after Hurricane Katrina

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In order to evaluate the factors that contributed to missed dialysis sessions and increased hospitalizations of hemodialysis patients after Hurricane Katrina, we contacted 386 patients from 9 New Orleans hemodialysis units. Data were collected through structured telephone interviews on socio-demographics, dialysis factors, and evacuation characteristics. Overall, 44% of patients reported missing at least one and almost 17% reported missing 3 or more dialysis sessions. The likelihood of missing 3 or more sessions was greater for those whose dialysis vintage was less than 2 years compared to those for whom it was 5 or more years, who had 38 or fewer billed dialysis sessions compared to those who had 39 or more in the 3 months before the storm, who lived alone before the storm, who were unaware of their dialysis facility's emergency plans, who did not evacuate prior to hurricane landfall, and who were placed in a shelter. The adjusted odds ratio of hospitalization among patients who missed 3 or more compared to those who did not miss any dialysis sessions was 2.16 (95% CI: 1.05–4.43). These findings suggest that when preparing for future disasters more emphasis needs to be placed on patient awareness and early execution of emergency plans.

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The recognition of special treatment needs and the urgency of care for renal patients in the aftermath of large natural and manmade disasters prompted the establishment of the Renal Disaster Relief Task Force (RDRTF) by the International Society of Nephrology in 1989. The primary goal of RDRTF advance response teams is to assess the dialysis treatment environment and infuse necessary manpower and materials in rapid succession.[1,2] The first major implementation of the European Branch of the RDRTF was in response to the 1999 Marmara, Turkey earthquake. This catastrophic event caused over 17,000 deaths and left 600,000 people homeless. The benefit of coordinated and streamlined response efforts informed by earlier disasters, and advance planning for disasters, was shown by the renal community in the aftermath of this disaster and others to follow, such as the 2005 Kashmir earthquake.[3,4] These emergency planning and response efforts were designed to assist disaster victims not only with acute kidney injuries but also chronic dialysis patients receiving treatment in a disaster-affected area.

One disaster with a potential impact on chronic dialysis patients was Hurricane Katrina. This immense storm made landfall on 29 August 2005 and became one of the deadliest storms in US history.[5] The storm forced the evacuation and relocation of over one million residents of New Orleans and the Gulf Coast of the United States. There were almost 6000 patients with end-stage renal disease (ESRD) on life-sustaining dialysis treatment in the region affected by the storm.[6]

Given the harmful impact of missed hemodialysis sessions on patient outcomes,[7–10] it is important to understand the extent of missed hemodialysis sessions in the post-disaster setting. The primary aim of the current study was to estimate the percentage of New Orleans area patients who missed hemodialysis sessions in the aftermath of Hurricane Katrina and to identify factors associated with missed sessions. In addition, the association between missed hemodialysis

sessions and hospitalization in the first month after the storm was examined.

RESULTS

The mean age of study participants was 56. 9 years. The study population consisted of a similar percentage of men and women, the majority of whom were black, and 23.6% had received health insurance coverage through Medicaid at the time they initiated ESRD treatment (Table 1). Overall, 33.9% of participants initiated treatment for ESRD within 2 years of Hurricane Katrina making landfall, 23.0% had fewer than 37 dialysis sessions billed from June through August 2005, and the majority of study participants lived with a spouse, partner, or other family members before the storm. A vast majority of participants (91.7%) evacuated because of Hurricane Katrina, most evacuated before the hurricane made landfall on 29 August 2005, and 14.5% reported first evacuating to a shelter. The majority of participants affirmed being aware of their dialysis clinic's evacuation plans and, among those aware, 73.2% stated they followed these evacuation plans.

Overall, 44.0% of participants reported missing at least one hemodialysis session in the aftermath after Hurricane Katrina, and 16.8% reported missing three or more sessions (Figure 1). Furthermore, in the first month after the storm, 8.6% of scheduled hemodialysis treatments were missed. Missing three or more hemodialysis sessions after Hurricane Katrina was more common among younger patients, blacks, those with Medicaid insurance at the initiation of ESRD treatment, those with a dialysis vintage <2 years, and patients with fewer billed dialysis sessions in the 3 months before the storm and less common among patients who lived with a spouse or partner (Table 2). In addition, a higher percentage of hemodialysis patients who evacuated on or after the date of the storm, who were placed in a shelter upon evacuation, and were unaware of their dialysis unit's evacuation plans missed three or more sessions in the aftermath of Hurricane Katrina.

After multivariable adjustment, the odds ratio of missing three or more, compared with no, hemodialysis sessions was 2.44 (95% confidence interval (95% CI): 1.14–5.24) for patients with a dialysis vintage <2 versus 5+ years, and 2.94 (95% CI: 1.11–7.80) and 4.97 (95% CI: 1.57–15.8) for patients with 37–38 and <37, compared with $\geqslant 39$, billed dialysis sessions in the 3 months before the storm, respectively (Table 3). Patients who lived alone were 4.37 (95% CI: 1.85–10.3) times more likely than their counterparts who lived with a spouse or partner to miss three or more hemodialysis sessions. The odds ratio of missing three or more hemodialysis sessions, compared with no sessions, was 7.00 (95% CI: 2.33–21.0) for patients who waited to evacuate until the day of, or after, the hurricane making landfall and 4.33 (95% CI: 1.49–12.6) for patients who were placed in a shelter upon evacuation. Finally, patients who were unaware of their dialysis unit's evacuation plans were more likely to miss three or more hemodialysis sessions.

Table 1 | Characteristics and evacuation and displacement experiences of hemodialysis patients after Hurricane Katrina

	% of study participants (*N*=386)
Age group (years)	
65+	32.6
50 to <65	36.5
<50	30.8
Men	52.1
Race/ethnicity	
White	28.5
Black	70.2
Other/unknown	1.3
Medicaid insurance coverage at the initiation of ESRD treatment	
Yes	23.6
No	76.4
Time since the initiation of ESRD treatment (years)	
5+	34.7
2 to <5	31.4
<2	33.9
Number of billed dialysis sessions in the 3 months before the hurricane[a]	
39+	41.5
37–38	35.6
<37	23.0
Co-habitation before Hurricane Katrina	
Lived with spouse or partner	40.3
Lived with other family members	37.1
Lived with a roommate	4.9
Lived alone	17.7
Evacuated due to Hurricane Katrina	
Yes	91.7
No	8.3
Date of evacuation due to Hurricane Katrina[b]	
On or before 27 August 2005	29.5
28 August 2005	47.6
On or after 29 August 2005	22.9
First evacuation location[b]	
Relative's house	35.2
Friend's house	8.2
Hotel[c]	42.1
Shelter	14.5
Aware of dialysis clinic's evacuation plans	
Yes	62.4
No	37.6
Followed dialysis clinic's evacuation plans, among those aware	
Yes	73.2
No	26.8
Hospitalized 1 month after Hurricane Katrina	
Yes	23.0
No	77.0

Abbreviation: ESRD, end-stage renal disease.
[a]These data were available for only a subset (*N*=270) of patients who initiated ESRD treatment before 1 June 2005.
[b]Among study participants who evacuated.
[c]This category includes study participants whose first evacuation location was unspecified.

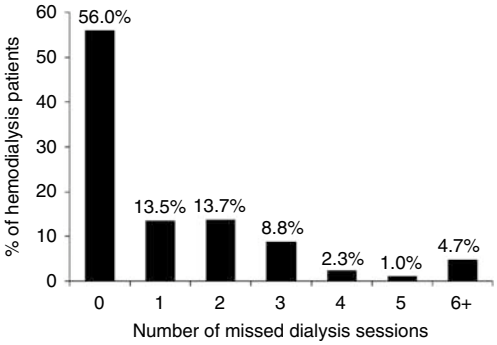

Figure 1 | Number of missed dialysis sessions in the immediate aftermath of Hurricane Katrina.

Overall, 23.0% of participants reported being hospitalized in the first month after Hurricane Katrina. Hemodialysis patients who missed three or more sessions were more likely than their counterparts who missed no sessions to be hospitalized in the first month after Hurricane Katrina (Figure 2). After adjustment for age, race, gender, Medicaid insurance at the initiation of ESRD treatment, dialysis vintage, pre-Hurricane Katrina dialysis clinic, and cohabitation status and compared with hemodialysis patients who missed no sessions, the odds ratio of being hospitalized was 1.26 (95% CI: 0.67–2.39) for hemodialysis patients who missed one or two dialysis sessions and 2.16 (95% CI: 1.05–4.43) for those who missed three or more dialysis sessions.

DISCUSSION

Almost half of hemodialysis patients interviewed in this study reported missing at least one dialysis session in the aftermath of Hurricane Katrina, and a substantial proportion missed three or more sessions. Certain patient groups, including those with a dialysis vintage <2 years, with fewer billed sessions before the hurricane, and patients who lived alone, were observed to be more likely to miss three or more dialysis sessions after Hurricane Katrina. Several salient evacuation characteristics predicted missing hemodialysis sessions after the storm, including a late evacuation, placement to a shelter, and patients' lack of awareness regarding their dialysis clinic's evacuation plan. Importantly, an association between missing three or more hemodialysis sessions and being hospitalized was identified.

Administrative data indicate that, in the non-disaster setting, between 5 and 9% of US hemodialysis patients miss at least one treatment per month.[7,8,11] The current study identified a substantially higher percentage (44.0%) of hemodialysis patients who missed one or more dialysis sessions in the aftermath of Hurricane Katrina. Similarly, a brief report describing the impact of the Kobe earthquake of 1995 on hemodialysis treatment delivery cited a substantial proportion of patients whose first dialysis session after the disaster was at least 3 days after the previous session.[12] Earlier studies also report that hemodialysis patients miss between 1.2 and 1.7% of scheduled treatments.[9,11,13] In the current

Table 2 | Percentage of hemodialysis patients missing 0, 1–2, and 3+ dialysis sessions in the immediate aftermath of Hurricane Katrina

	Dialysis sessions missed		
	0	1–2	3+
Age group (years)			
65+	69.8	19.8	10.3
50 to <65	52.5	27.0	20.6
<50	45.4	35.3**	19.3*
Gender			
Men	58.7	23.4	17.9
Women	53.0	31.4	15.7
Race/ethnicity			
White	62.7	27.3	10.0
Black	52.8	27.7	19.6*
Medicaid insurance coverage at the initiation of ESRD treatment			
Yes	46.5	31.4	22.1*
No	59.9	25.5	14.7
Time since initiation of ESRD treatment (years)			
5+	51.5	32.8	15.7
2 to <5	62.0	28.1	9.9
<2	55.0	20.6	24.4*
Number of billed dialysis sessions in the 3 months before the hurricane[a]			
39+	67.0	21.4	11.6
37–38	49.0	33.3	17.7
<37	37.1	37.1*	25.8[†]
Cohabitation before Hurricane Katrina			
Lived w/spouse or partner	66.5	23.2	10.3
Lived w/family members	49.7	34.3*	16.1*
Lived w/roommate	63.2	15.8	21.1
Lived alone	42.7	25.0	32.4[‡]
Evacuated due to Hurricane Katrina			
Yes	57.3	26.6	16.1
No	40.6	34.4	25.0
Date of evacuation due to Hurricane Katrina[b]			
On/before 27 August 2005	67.7	24.2	8.1
28 August 2005	65.0	23.1	11.9
On/after 29 August 2005	32.5	36.4[†]	31.2[‡]
First evacuation location[b]			
Relative's house	66.1	24.2	9.7
Friend's house	62.1	17.2	20.7
Hotel[c]	57.4	26.4	16.2
Shelter	33.3	37.3[†]	29.4[‡]
Aware of dialysis clinic's evacuation plans			
Yes	61.0	24.9	14.1
No	47.6	31.0	21.4*
Followed dialysis clinic's evacuation plans, among those aware			
Yes	62.9	25.1	12.0
No	54.7	25.0	20.3

Abbreviations: ESRD, end-stage renal disease.
*$P<0.05$; [†]$P<0.01$; [‡]$P<0.001$; *P*-values represent comparisons with the group missing 0 sessions. The *P*-trend was assessed for age, time since the initiation of ESRD treatment, and number of billed dialysis sessions in the 3 months before the hurricane.
[a]These data were available for only a subset (*N*=270) of patients who initiated ESRD treatment before 1 June 2005.
[b]Among study participants who evacuated.
[c]This category includes patients whose first evacuation location was unspecified.

Table 3 | Adjusted odds ratios of missing 1–2 and 3+ dialysis sessions among hemodialysis patients after Hurricane Katrina

	Odds ratios of missing 1–2 sessions (95% CI)[a]	Odds ratios of missing 3+ sessions (95% CI)[a]
Age group (years)		
65+	1.00 (ref)	1.00 (ref)
50 to <65	1.49 (0.78–2.84)	1.93 (0.85–4.38)
<50	2.44 (1.21–4.95)	2.21 (0.91–5.37)
Gender		
Men	1.00 (ref)	1.00 (ref)
Women	1.38 (0.79–2.40)	1.02 (0.51–2.02)
Race/ethnicity		
White	1.00 (ref)	1.00 (ref)
Black	0.79 (0.40–1.56)	1.31 (0.51–3.37)
Medicaid insurance coverage at the initiation of ESRD treatment		
Yes	0.94 (0.50–1.76)	0.99 (0.45–2.22)
No	1.00 (ref)	1.00 (ref)
Time since initiation of ESRD treatment (years)		
5+	1.00 (ref)	1.00 (ref)
2 to <5	0.88 (0.47–1.67)	0.75 (0.33–1.68)
<2	0.86 (0.44–1.67)	2.44 (1.14–5.24)
Number of billed dialysis sessions in the 3 months before the hurricane[b]		
39+	1.00 (ref)	1.00 (ref)
37–38	1.97 (0.90–4.30)	2.94 (1.11–7.80)
<37	2.72 (1.12–6.58)	4.97 (1.57–15.8)
Cohabitation before Hurricane Katrina		
Lived w/spouse or partner	1.00 (ref)	1.00 (ref)
Lived w/family members	1.48 (0.78–2.80)	1.87 (0.77–4.58)
Lived w/roommate	0.53 (0.12–2.36)	1.72 (0.43–6.88)
Lived alone	1.34 (0.57–3.11)	4.37 (1.85–10.3)
Evacuated due to Hurricane Katrina		
Yes	1.00 (ref)	1.00 (ref)
No	0.96 (0.34–2.74)	2.05 (0.60–6.99)
Date of evacuation due to Hurricane Katrina[c]		
On/before 27 August 2005	1.00 (ref)	1.00 (ref)
28 August 2005	0.89 (0.44–1.78)	1.29 (0.44–3.79)
On/after 29 August 2005	3.22 (1.34–7.71)	7.00 (2.33–21.0)
First evacuation location[c]		
Relative's house	1.00 (ref)	1.00 (ref)
Friend's house	0.90 (0.27–3.03)	1.52 (0.40–5.82)
Hotel[d]	2.09 (1.06–4.12)	1.71 (0.71–4.13)
Shelter	4.62 (1.94–11.0)	4.33 (1.49–12.6)
Aware of dialysis clinic's evacuation plans		
Yes	1.00 (ref)	1.00 (ref)
No	1.74 (1.01–3.02)	2.21 (1.15–4.24)
Followed dialysis clinic's evacuation plans, among those aware		
Yes	1.00 (ref)	1.00 (ref)
No	1.38 (0.63–3.03)	2.17 (0.81–5.79)

Abbreviations: CI, confidence interval; ESRD, end-stage renal disease.
[a]Odds ratios are adjusted for age, gender, race, Medicaid insurance coverage at the initiation of ESRD treatment, dialysis vintage, pre-Hurricane Katrina dialysis clinic, and cohabitation status. The reference group consists of those who missed no sessions.
[b]These data were available for only a subset (*N*=270) of patients who initiated ESRD treatment before 1 June 2005.
[c]Among patients who evacuated.
[d]This category includes patients whose first evacuation location was unspecified.

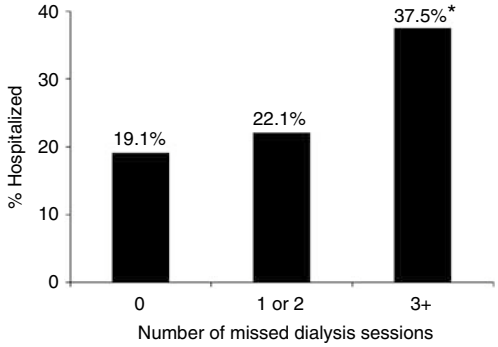

Figure 2 | Percentage of hemodialysis patients hospitalized in the 1 month after Hurricane Katrina by the number of missed dialysis sessions. *P-value=0.003 compared with missing 0 sessions.

study, the percentage of scheduled hemodialysis sessions missed in the month after the storm was 8.6%. This indicates that Hurricane Katrina resulted in a five- to seven-fold increase in the percentage of hemodialysis sessions missed. Interestingly, patients with fewer billed dialysis sessions in the 3 months before the storm, a possible marker of non-compliance with dialysis in the non-disaster setting, were more likely to miss treatments after Hurricane Katrina. This represents a group that is identifiable and may benefit from targeted communication and preparedness efforts.

In the non-disaster setting, compliance with dialysis is influenced by internal patient factors, including demographic and psychosocial factors and health beliefs, as well as by factors external to the patient.[14] Limitations in social support, transportation, and financial issues may exert pressure on patients, precipitating skipped or shortened sessions. The current study identified several factors related to missing treatment in the disaster setting that have also been related to non-compliance in the non-disaster setting.[9,11,14–16] For example, consistent with earlier studies, younger patients were more likely to miss hemodialysis sessions. Also, patients who reported living alone before the storm were significantly more likely to miss three or more hemodialysis sessions. Indeed, living alone and less social support have been reported in non-disaster situations to be associated with poor dialysis compliance.[8,17,18] The current study failed to provide evidence for significant differences in the number of missed dialysis sessions by Medicaid insurance coverage at ESRD treatment initiation (a surrogate measure for socioeconomic status), gender, race, or evacuation occurrence, but does provide evidence that patients with a shorter dialysis vintage and those who live alone may benefit from more intensive preparedness efforts before a disaster.

A unique aspect of the current study is the assessment of factors related to missed hemodialysis sessions introduced by an evacuation and the post-disaster climate. For example, a delayed evacuation and being placed in a shelter were associated with an increased risk of missing hemodialysis sessions after the hurricane. Although all of the dialysis units reported having an evacuation plan, only two-thirds of

patients reported knowledge of these plans. In general, before Hurricane Katrina, these plans consisted of recommendations for patients to find an alternate location for treatment if their dialysis unit closed or they evacuated, to identify themselves to officials as a 'special needs' individual or dialysis patient during an evacuation or displacement, to follow emergency diet guidelines, and to bring a list of medications and information on their hemodialysis prescription in the event of an evacuation. Although these plans address salient issues surrounding an evacuation, they are ineffectual if not properly disseminated and reinforced among patients. Being unaware of their dialysis unit's evacuation plans substantially increased the likelihood that hemodialysis patients would miss three or more dialysis sessions. All of these findings point toward the importance of making patients aware of evacuation plans before an event, and having frequent reminders of best practices to reduce the number of missed sessions in future emergencies. Existing emergency plans recommend that hemodialysis patients make alternate treatment arrangements when the threat of an emergency arises.[19] Our findings support newly published emergency plans prepared by the Kidney Community Emergency Response Coalition (KCERC) for dialysis patients that state, in addition to this preparation, patients should also plan to evacuate early and establish an evacuation residence.[20]

Missing hemodialysis sessions has been associated with adverse biochemical and metabolic changes. In an earlier study including 430 patients, missing even a single hemodialysis session was associated with a 2% reduction in hematocrit.[21] Weight gain and increased serum phosphate levels have also been significantly correlated with skipped hemodialysis treatments.[8] Also, missing treatment has been reported to result in increased blood pressure.[22] Beyond the immediate biochemical consequences, a growing body of literature suggests that missed hemodialysis sessions are associated with adverse outcomes. Hemodialysis patients in the Dialysis Outcomes and Practice Patterns Study who reported skipping at least one treatment per month had a 13% increased hospitalization risk, and several studies have observed missed hemodialysis sessions and other measures of non-compliance to be associated with 14–30% increases in mortality risk.[7–10,23] In the current study, missing three or more hemodialysis sessions because of Hurricane Katrina was associated with an increased risk of being hospitalized. Hemodialysis patients should be reminded of the consequences of missing treatment as they prepare for future emergencies.

The number of patients with acute renal failure may increase greatly during earthquakes as a result of crush injuries. However, hurricanes, earthquakes, and other disasters can impact the renal community in its entirety, as chronic hemodialysis patients need facilities with uninterrupted power and water supplies, equipment, and personnel.[12,24,25] Given the extended warning times before a hurricane makes landfall, preparation of chronic hemodialysis patients through extra dialysis sessions or the administration of potassium binders as well as the staging of surrounding dialysis facilities for a possible influx of patients should be key responsibilities of dialysis providers.[25] Finally, as is true in any disaster setting, lessons learned and identified deficiencies from earlier disasters, including Hurricane Katrina, should translate to better preparedness for future disasters.

The findings from the current study need to be interpreted in the context of its limitations. A large percentage of patients (18.9%) died before an attempt could be made to recruit them into the study. The high mortality rate limited the current study to survivors. These patients may have had different experiences during and after Hurricane Katrina. Also, information on missed sessions in the current study was collected by self-report, was limited to the month after the storm, and was assessed a median of 11 months after the hurricane. Although some patients may have had recall difficulties, using self-report allowed investigators to account for hemodialysis sessions at field sites and triage centers after the hurricane that were not captured in administrative databases. In addition, patients in the current study were not asked to report the occurrence of shortened dialysis sessions in the weeks after Hurricane Katrina, or the specific dates and reasons for reported hospitalizations. Anecdotes indicate shortened hemodialysis treatment times were common at some evacuation sites. An *a priori* decision to exclude patients utilizing peritoneal dialysis limits the generalizability of the study findings to hemodialysis patients. Future studies examining the impact of large disasters on the peritoneal dialysis population may identify unique factors associated with adverse outcomes. Finally, data on residual renal function were not collected as part of the current study, despite the potential for this factor to influence patient behavior with regard to missing treatment. Despite these limitations, the current study maintained several strengths, including the large sample of hemodialysis patients interviewed about their experiences after Hurricane Katrina. An additional strength is the high generalizability of the results. This is reflected in the 86% participation rate, and the results of an earlier analysis showing characteristics of participants were similar to all hemodialysis patients in the entire New Orleans area and the Gulf Coast impacted by Hurricane Katrina.[26] In addition, the current study included a large number of patients still displaced after the hurricane, and is the first, to our knowledge, to report on factors associated with missing hemodialysis sessions after a region-wide natural disaster.

Missing hemodialysis sessions was common in the aftermath of Hurricane Katrina. The current study indicates that Hurricane Katrina resulted in a five- to seven-fold increase in missed hemodialysis sessions. Social isolation may play an important role in mediating discontinuity of dialysis care in the disaster setting. Having hemodialysis patients evacuate early, having a pre-defined set of alternate dialysis units with contact information, evacuating to a site other than a shelter, and being aware of their dialysis unit's evacuation plans may

prevent excess missed dialysis sessions. Preparation of hemodialysis patients for future disasters should include recommendations of best practices from the RDRTF, KCERC, and Hurricane Katrina to reduce the number of missed sessions and, subsequently, hospitalizations. The results from the current study suggest that an emphasis on awareness and early execution of emergency plans for hemodialysis patients should be a priority among patients and providers in future disasters.

MATERIALS AND METHODS

Study population

Participants in the current study were identified from the rosters, as of 27 August 2005, for nine dialysis facilities in New Orleans and four surrounding parishes. These units were selected due to the relationship between the study investigators and medical directors at these facilities and ability to get Institutional Review Board and corporate approval for including these facilities in a timely manner given the limited infrastructure in New Orleans after the hurricane. The facilities were from three separate dialysis providers, each had its own medical director, three of the facilities were not for profit and six were for profit. All of these clinics were closed during the immediate aftermath of Hurricane Katrina and two remained closed throughout the conduct of the study in 2006. To be eligible for the current study, patients had to be receiving hemodialysis treatment for ESRD at one of the nine participating facilities during the week preceding Hurricane Katrina making landfall ($N = 593$). Study investigators contacted ESRD Network 13, which serves the ESRD patient population of Louisiana, to update information on the treatment location of patients. There were 112 patients who died before they could be contacted for the study, of whom two died in the week after the storm (that is, between 30 August and 5 September 2005) and an additional nine patients died in the subsequent 3 weeks (i.e., between 6 and 26 September 2005). According to the Centers for Medicare and Medicaid Services representatives, no dialysis patient deaths in the 2 months after Hurricane Katrina was reported to be directly related to the storm.[27] Dialysis unit staff were consulted by the study investigators to assess whether the remaining patients met the study inclusion criteria. Exclusions were made for patients under the age of 18 years ($N = 2$), cognitive impairment ($N = 15$), the inability to complete the study interview in English ($N = 5$), severe aphasia ($N = 1$), and prerogative of the study coordinator ($N = 1$), leaving 457 patients eligible for participation. Study interviews were completed with 391 patients between 1 April 2006 and 30 October 2006 (median time from Hurricane Katrina: 11 months) for a study participation rate of 86%. Five patients could not recall how many dialysis sessions they missed after Hurricane Katrina and were, thus, excluded from the current analyses, resulting in a final sample size of 386 participants. Participants were living in 18 states and 34% had not returned to the New Orleans area at the time they completed the survey. According to the National ESRD Data compiled by the United States Renal Data System (USRDS), 9% of participants, who were displaced at the time they completed the survey, subsequently returned to the New Orleans area by December 2006. The study population was similar with respect to demographics and ESRD-related characteristics to all hemodialysis patients receiving treatment when Hurricane Katrina made landfall at: (1) the nine participating clinics, (2) all New Orleans area dialysis clinics, and (3) dialysis clinics in the geographic region affected by Hurricane Katrina.[26] Of non-participants, 11 patients completed a partial interview, 29 patients declined participation, and 26 individuals were unable to be reached during the study period.

Data collection

Study questionnaires were administered over the telephone by trained interviewers using a standardized script. To ensure universal access to participation in the study, eligible patients without home or cellular telephones were asked to complete the study questionnaire at their dialysis unit. In addition to a set of validated psychosocial scales, including the Post Traumatic Stress Disorder Checklist (PCL-17), the Center for Epidemiologic Studies Short Depression Scale (CES-D), the Hurricane Coping Self-Efficacy (HCSE) measure, and the Short Form-12 Health Survey (SF-12),[28–31] the interview included questions developed by the investigators to assess demographics, patients' evacuation experiences, awareness of their dialysis center's evacuation plans, and hospitalization in the first month after Hurricane Katrina. To assess missed dialysis sessions, patients were asked, 'Did you miss any dialysis sessions because of Hurricane Katrina?' If the response was affirmative, patients were then asked, 'How many sessions did you miss due to Hurricane Katrina?' In addition, patients were asked whether they lived with a spouse, partner, other family members, a roommate, or alone before Hurricane Katrina, and whether or not they evacuated because of the storm. Patients who evacuated were asked the date of their evacuation and their first evacuation location (for example, relative's house, friend's house, shelter, hotel, or other). The date of death for deceased patients and the number of billed dialysis sessions between June and August 2005 (that is, before the hurricane made landfall), a measure of non-compliance in the non-disaster setting, were obtained from the USRDS. Data on the number of billed dialysis sessions between June and August 2005 were not available for 116 participants in the current analysis.

All aspects of the current study were approved by the Institutional Review Boards of Tulane University and the Ochsner Health System. A partial Health Insurance Portability and Accountability Act waiver was obtained from the Institutional Review Boards to obtain patient information, contact patients, and request their participation in the current study. A consent script was read and verbal informed consent was obtained from all patients before administration of the study interview.

Statistical analysis

The distribution of missed hemodialysis sessions in the aftermath of Hurricane Katrina and self-reported evacuation and displacement experiences was calculated. Next, the percentage of hemodialysis sessions missed in the first month after Hurricane Katrina was calculated based on the scheduled 14 sessions during this time period (that is, three sessions per week). On the basis of an *a priori* decision by the investigators, missed hemodialysis sessions were grouped into three categories: none, 1–2, and $\geqslant 3$ sessions (that is, an equivalent of a full week of missed treatment). Using these categories, the distribution of missed hemodialysis sessions was calculated by sub-grouping defined by socio-demographic and dialysis-related characteristics, social support, and evacuation characteristics. Differences in the percentage of patients who missed 1–2 and $\geqslant 3$ hemodialysis sessions, separately, compared with no missed sessions, across sub-groupings were calculated by contrast using maximum likelihood. Multinomial logistic regression models were used to calculate the multivariable-adjusted odds ratios of missing 1–2, and $\geqslant 3$ hemodialysis sessions versus no missed

sessions. Next, the percentage of patients hospitalized in the 1 month after Hurricane Katrina and the multivariable-adjusted odds ratios of hospitalization were computed by the number of missed hemodialysis sessions. All odds ratios were adjusted for age, gender, race, Medicaid insurance coverage at the time of initiation of ESRD treatment, dialysis vintage, pre-Hurricane Katrina dialysis clinic, and co-habitation status before the hurricane. We performed all analyses using SAS 9.1 (Cary, NC, USA) and SUDAAN 9.0.1 (Research Triangle Park, NC, USA).

DISCLOSURE

All the authors declared no competing interests.

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