ORIGINAL RESEARCH

Time to Recovery in Diabetes and Comorbidities Following Hurricane Katrina

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ABSTRACT

Background: The impact of a natural disaster on self-care and health care delivery has been well documented. The objective of the study was to document the recovery pattern from the impact of a natural disaster such as Hurricane Katrina on clinical and biochemical measures of diabetes and its comorbidities.

Methods: Patients were selected from Tulane University Hospital and Clinic, Southeast Louisiana Veterans Health Care System, and the Medical Center of Louisiana at New Orleans. Adults with diabetes and A_{1c} measurement 6 months before (pre-K) Hurricane Katrina (February 28, 2005–August 27, 2005) and 6 to 16 months after (post-K) Katrina (March 1, 2006–December 31, 2006) were identified within the 3 facilities. Follow-up data (January 1, 2007–December 31, 2007) were 1 year after the first post-K visit. The outcome measures were hemoglobin A_{1c} (HbA_{1c}), systolic and diastolic blood pressure (BP), and lipids (low-density lipoprotein cholesterol, high-density lipoprotein cholesterol [HDL], triglycerides).

Results: Averaged across the 3 facilities, the parameters significantly different in the follow-up period compared with pre- and post-K were HbA_{1c} ($P=.04$), HDL, and systolic and diastolic BP ($P<.0001$). Parameters with significantly different patterns of change in the 3 facilities over time were HbA_{1c}, HDL, systolic and diastolic BP ($P<.0001$), and low-density lipoprotein ($P<.01$).

Conclusions: Our results suggest that a variety of clinical and biochemical parameters related to diabetes and its comorbidities affected by natural disaster have varied the rate of recovery to predisaster levels.

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Key Words: Hurricane Katrina, disaster, recovery, diabetes

When Hurricane Katrina struck New Orleans in August 2005, it had a major impact on self-care and health care delivery, including a considerable deterioration in diabetes management in the short term,[1] which has been well documented.[2,3] We have described this significant association with diabetes management for a longer period of time, 6 to 16 months after the hurricane.[4] Furthermore, the health care disparities that existed before the disaster were exacerbated by the hurricane because patients who did not have adequate health insurance coverage experienced a fundamental worsening of their hemoglobin A_{1c} (HbA_{1c}), blood pressure, and lipid profile in the aftermath of the storm.[4]

At that time, we estimated longer-term effects using linear regression models that were fitted for the changes in the primary outcomes. To our knowledge, there have been few similar descriptions of the long-term impact of a disaster and chronic disease. We also used a simulation model to estimate the long-term cost implications of a loss of diabetes control on the population of New Orleans, following the transition probabilities estimated from the United Kingdom Prospective Diabetes Study.[5]

With the gradual recovery of the city, there has been some improvement in health care facilities, particularly with respect to reopening primary care clinics; however, the hospitals are still not at their predisaster levels in terms of bed availability. Data suggest that the health of the New Orleans population with diabetes continues to be affected.[6] Because we had developed a cohort of patients on whom we had pre- and postdisaster values for diabetes and comorbidities, we carried out a further analysis of these parameters in the time frame 2 to 3 years following the disaster.

METHODS

This study was approved by the Tulane Human Research Advisory Committee. Subsequently, jurisdiction for the Department of Veterans Affairs (VA) Clinic was moved to the Jackson, Mississippi, VA Medical Center, which also gave its approval for the collection of data. A waiver of written informed consent was granted.

Study Population

The population for our initial study has been described elsewhere.[4] Tulane University Health Sciences Center is a major provider of health care in the city of New Orleans and has established long-standing diabetes care

TABLE 1

Baseline Characteristics of Patients Post-Katrina

	Total	TUHC/Private	VA	MCLNO/Public	*P*
No.	1523	375	668	480	
Age, y*	63.4 ± 11.6	60.0 ± 13.6	67.4 ± 10.6	60.4 ± 9.2	<.0001
Sex, male, %	63.0	44.5	97.8	29.0	<.0001
Race, %					
African American	56.0	50.7	41.6	80.2	<.0001
White	48.2	45.3	54.3	16.5	<.0001
Other	3.8	4.0	4.1	3.3	<.0001

MCLNO = Medical Center of Louisiana at New Orleans; TUHC = Tulane University Hospital and Clinic; VA = Veterans Affairs.
* Age as of August 2007.

centers within 3 health care systems. For the initial study of 1795 subjects, 452 were from the Tulane clinics, 748 were from the Southeast Louisiana Veterans Health Care System, and 595 were from the Medical Center of Louisiana at New Orleans (MCLNO). The overall mean age of the subjects was 61.9 years, with a predominance of men (61.2%). The MCLNO system consisted of >80% African American patients (96.9%), which was higher than the VA system (44.9%) and Tulane (28.7%). The patients were grouped accordingly; the baseline characteristics of patients from the post-Katrina (post-K) period are described in Table 1.

Tulane University Hospital and Clinic (TUHC) are private hospitals and clinics that reopened in January 2006. Clinics that reopened within a few weeks post-K, including the diabetes center, were located near undamaged Tulane University partner hospitals. Thus, private patients (usually with health insurance) had access to the diabetes center within a few weeks following the hurricane.

Southeast Louisiana Veterans Health Care System is a system that caters to veterans of the armed services almost exclusively. The VA hospital reopened outpatient primary care clinics in New Orleans 3 months and specialty clinics 5 months after the hurricane. In addition, veterans had access to VA services and medications in other parts of Louisiana and the United States.

MCLNO (also known as the Louisiana Charity System) is a state-funded system that provides acute and chronic care for all patients irrespective of insurance status, and has a significant proportion of uninsured patients. MCLNO specialty clinics were closed for more than 1 year post-K; however, primary care was available at a variety of community clinics, which provided fragmented health care services. No diabetes-specific specialty clinic was available to these patients for approximately 1 year.

Adults with diabetes and an A_{1c} measurement 6 months before Hurricane Katrina (pre-K; February 28, 2005–August 27, 2005) and 6 to 16 months post-K (March 1, 2006–December 31, 2006) were identified from databases within the 3 health care systems. All of the patients examined at TUHC and MCLNO who had such measurements of interest were included in the study population. Follow-up data were obtained for these patients from January 1, 2007 to December 31, 2007. Because there were many more such patients in the VA system, we randomly selected 750 patients who had records on data points of interest. For the purpose of this study, 748 of the 750 patients had data available on all of the study-related parameters in the pre- and post-K periods. After identification of these patients, their other laboratory parameters (lipids) were obtained and their records were reviewed for blood pressure (BP) measurements that occurred within the study time period. Because of a lack of outpatient follow-up in health care facilities and/or appropriate laboratory testing there was a decline in the number of patients with A_{1c} in the follow-up period, which varied among the 3 institutions. Though there was a decrease in the patients who had outpatient follow up after Hurricane Katrina, there were a sufficient number of patients with complete data were for our analyses of changes to these parameters on follow up. For the statistical analyses, only those patients with HbA_{1c} data and data on the other parameters were included.

We compared the level of glycemic control (A_{1c}), BP, and lipids in patients for whom data were available in the 6-month period pre-K with levels after resumption of clinical activities (March 1, 2006–December 31, 2006) and from that point on to the follow-up period. In patients who had multiple measurements of A_{1c}, BP, or lipids, the values at the last visit of the pre-K period and the first visit of the post-K period were included in the final analysis. In each time period, only 1 measurement from each period was used for comparison.

Data Sources

Laboratory data at all 3 institutions were computerized and were available for both pre- and post-K periods. TUHC used a computerized medical record for all of the laboratory data and some clinical data. Medical records for most patients previously examined at TUHC were intact. All of the laboratory and clinical data at VA were available electronically. The laboratory records at MCLNO were computerized, but data on BP were available on only a subset of patients, whose clinic records were salvaged.

Follow-up

The follow-up period data were obtained between January 1, 2007 and December 31, 2007. We attempted to obtain medical records from the 3 health care systems on follow-up at least 1 year after the first visit post-K. For HbA_{1c}, data on follow-up were available in 1389 of the original 1795 observations in the pre-K period (77.4%). At TUHC, HbA_{1c} data were available on follow-up for 324 of 452 patients in the pre- and post-K period, whereas in the VA system, HbA_{1c} was available for 591 of 748 patients, and in the MCLNO system, HbA_{1c} was available for 474 of 595 patients in the pre- and post-K period. The availability of data varied considerably, and laboratory testing was more easily available in the VA system because they have an electronic medical record system.

Statistical Analysis

Repeated measurement models were fitted for each of the above variables. Only patients who had follow-up information were used. These analyses were performed using SAS PROC GLM with the "Repeated" option (version 9.1.3 for Windows 2005, SAS Institute, Cary, NC).

RESULTS

The mean time between the last pre-K visit and the first visit post-K was 11.7, 10.5, and 11.7 months for HbA_{1c}, BP, and lipid measurements, respectively. The mean time between the post-K to the follow-up period was 27.7, 13.5, and 12.9 months for HbA_{1c}, BP, and lipid measurements, respectively. Table 2 and the Figure provide details of the parameters in the 3 groups.

HbA_{1c}

There was a significant difference in the pre-K ($P < .01$), and post-K measurements ($P < .0001$) of HbA_{1c} among the 3 facilities. On follow-up measurements in 2007, these parameters remained significantly different among the 3 facilities ($P = .05$). Averaged across the 3 facilities, the mean HbA_{1c} values are different at the 3 time points ($P = .04$). In addition, there is a significant difference in the mean HbA_{1c} across the 3 facilities averaged over time ($P < .0001$).

HbA_{1c} changed with different patterns across the 3 facilities ($P < .0001$) over time. In particular, among patients of the MCLNO, the mean post-K value rose drastically when compared with pre-K values; however, at follow-up, the mean value dropped below the pre-K value. Although the mean pre-K value was relatively low among patients at Tulane, their post-Katrina mean dipped to a lower value and rose at follow-up to baseline. Finally, mean values remained fairly constant, with a moderate upward trend for patients at VA. These patterns are delineated in the profile plot in panel A of the Figure.

There was a significant difference in the pre- and post-K measurements among the 3 facilities. On follow-up measurements in 2007, these parameters remained significantly different among the 3 facilities ($P = .0499$). There was a significant difference in HbA_{1c} over time ($P = .0391$). It changed at different rates across the 3 facilities ($P < .0001$).

TABLE 2

Change in Clinical and Laboratory Parameters Pre-K, Post-K, and for a 2-y Period (Follow-up)

Variable	Time Period	Mean	SD	Median
A_{1c}	Pre-K	7.49	1.73	7
	Post-K	7.6	1.86	7.1
	Follow-up	7.49	1.62	7.1
LDL	Pre-K	101.34	34.31	96
	Post-K	107.44	38.53	101
	Follow-up	96.32	35.19	92
HDL	Pre-K	43.53	12.45	42
	Post-K	41.08	13.33	38
	Follow-up	42.05	12.58	40
Triglycerides	Pre-K	160.8	119.83	130
	Post-K	158.65	145.68	125
	Follow-up	140.16	93.5	114
Cholesterol	Pre-K	181.9	46.33	176
	Post-K	181.39	52.5	175
	Follow-up	163.55	42.31	158
DBP	Pre-K	70.99	11.98	70
	Post-K	74.88	12.2	74
	Follow-up	71.25	11.63	70
SBP	Pre-K	130.73	17.01	130
	Post-K	141.27	19.66	140
	Follow-up	132.53	18.52	131

DBP = diastolic blood pressure; HDL = high-density lipoprotein; LDL = low-density lipoprotein; SBP = systolic blood pressure.

Low-Density Lipoprotein

Although the pre-K measurements for low-density lipoprotein (LDL) are different across the 3 facilities ($P < .01$), the differences in post-K measurements and on follow-up were not statistically different across the 3 facilities ($P = .06$ and 0.24, respectively). When averaged across the 3 facilities, LDL demonstrates a significant difference over time ($P < .0001$). When averaged over time, the 3 facilities have different overall means ($P = .03$). Similar to HbA_{1c}, LDL over time changed, with different patterns across the 3 facilities ($P < .01$, panel B of Figure).

High-Density Lipoprotein

The pre- and post-K high-density lipoprotein (HDL) measurements and those on follow-up differed across the 3 facilities ($P < .0001$ at all time points). When averaged across the 3 facilities, HDL significantly differed over time ($P < .0001$). When averaged over time, there is a facility effect ($P < .0001$), and as with the previous 2 variables, HDL changed at different patterns across the 3 facilities ($P < .0001$, panel C of Figure).

Triglycerides

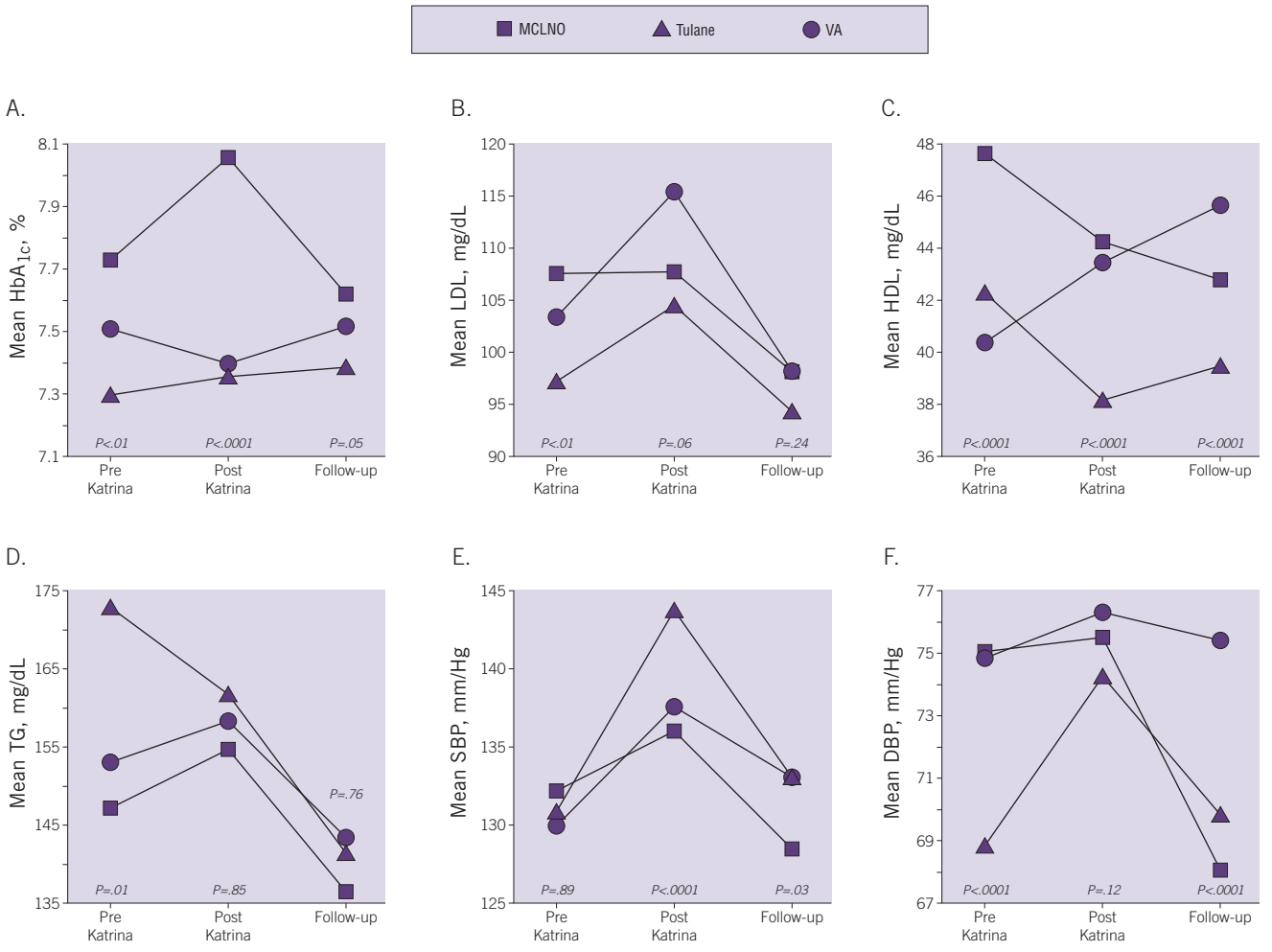
The pre-K measurements for triglycerides were different across the 3 facilities ($P = .01$); however, there was no statistically significant difference in the post-K and follow-up measurements across the 3 facilities ($P = .85$ and 0.76, respectively). When averaged across the 3 facilities, triglycerides show a significant difference over time ($P < .01$). When averaged over time, there is no facility effect ($P = .28$). Moreover, unlike with the other parameters, there is no statistically significant difference in the patterns of their changes ($P = .22$, panel D of Figure).

Systolic BP

Although the pre-K measurements of systolic BP (SBP) were not different across the 3 facilities ($P = .89$), the post-K measurements were different across the 3 facilities ($P < .0001$), as

FIGURE

Time to Recovery in Diabetes and Comorbidities Following Hurricane Katrina.



were the follow-up measurements in 2007 ($P = .03$). When averaged across the 3 facilities, SBP differs significantly over time ($P < .0001$). Averaged over time, there is a facility effect ($P < .01$). Also, SBP changed with different patterns across the 3 facilities from pre-K to follow-up ($P < .0001$, panel E of Figure).

Diastolic BP

The pre-K measurements for diastolic BP were different across the 3 facilities ($P < .0001$). Although the post-K measurements were not different across the 3 facilities ($P = .12$), the follow-up measurements were different across the 3 facilities ($P < .0001$). When averaged across the 3 facilities, diastolic BP differs significantly over time ($P < .0001$), and averaging over time, there is a facility effect ($P < .0001$). The patterns of the changes among the 3 facilities are significantly different ($P < .0001$, panel F of Figure).

COMMENT

Several studies have demonstrated the short-term impact of a disaster on diabetes and its comorbidities, such as hypertension.[4,7-10] For the initial study, data from the 2000 US Census for the greater New Orleans area was used. Based on the 2006 Louisiana Department of Health and Hospital statistics report, the following assumptions were made: MCLNO represented 20% of the population, VA represented 5%, and TUHC/privately insured represented 75%; the adult population in the greater New Orleans area affected by Hurricane Katrina was 964 677; and a diabetes prevalence of 9.2% estimated by the Centers for Disease Control and Prevention was used.[11]

The present study details the follow-up data and documents the recovery patterns of change in a variety of clinical parameters over time post-K. Our data document a severe disruption for at least 1 year after the disaster in several important clinical parameters relevant to the care of people with diabetes, with recovery occurring in most diabetes-related parameters during the subsequent year.

Although the recovery is reassuring, it highlights a long period of time during which people with diabetes were exposed to the impact of poor glucose, BP, and lipids control, putting them at further risk for future diabetes complications and cardiovascular events. The long duration of follow-up needed to demonstrate recovery is unique in descriptions of recovery from other disasters because no other similar data are available. Clearly, any agency planning disaster management needs to take into account the prolonged length of time it takes for recovery.

The study has also documented differences in the rate of recovery in different parameters among the various risk factors measured. For example, the LDL cholesterol and triglycerides recovered fastest and best, whereas HDL cholesterol actually fell. The reason for these differences is not clear and elucidation of reasons was beyond the scope of our study. One possible explanation is that LDL cholesterol is more easily treatable with drugs, which have become generic and less expensive. HDL, however, is much harder to treat and is more closely related to lifestyle choices, such as ability to diet and exercise, which may have been adversely affected in this population post-K. Glucose control, as determined by the A_{1c}, also showed only partial recovery, partly explained by the natural history of the disease, which is characterized by gradual deterioration over time. There was a gap of 27.7 months for the HbA_{1c} between the post-K period and the follow-up period. This prolonged gap between the assessments for the HbA_{1c} may in part reflect the inability to assess the immediate recovery pattern. Waiting for a long time to obtain HbA_{1c} levels may also be responsible in part for some improvement in the HbA_{1c} levels observed in the follow-up period as compared to the post-K period. This reflects improved glycemic control over time as the health care system started the recovery process and the patients started gaining access to health care. HbA_{1c} is an average of 3-month glucose levels and does not provide information on the fluctuations of blood glucose levels.[12] We did not use discrete time points because this was an observational study, and we did not have control over the patient follow-up and laboratory measurements, which varied between institutions. Once the data were collected and analyzed and it was evident from the analysis that the variables of interest had returned to baseline, we did not follow these patients further.

Also important is the fact that some discrepancies and disparities in health care may persist if they were present before the disaster and reflect differences in several factors including health literacy and health economic status of the population. Furthermore, following a disaster, people with limited health care resources experienced greater exposure to risk factors for a considerable length of time that would put them at risk of future complication, because tissue damage resulting from poorly controlled diabetes is usually irreversible. These findings, therefore, may be of interest to public health officials and health economists who are evaluating the long-term consequences of a disaster and who are planning and implementing cost-effective prevention measures.[13]

Our study is limited by its design because it was an observational study with data points obtained at various points pre- and post-K. Some of the medical records were destroyed in the hurricane. Data availability and patient follow-up also vary according to institutions because not all of the institutions opened at the same time, which in turn reflects on the patient data during those time periods. This being an observational study, we could not control the timing of patients' follow-up visits, and thus there is interpatient variability in the follow-up period. We therefore modeled the time of follow-up over months. Also, the data available are for some biochemical and clinical parameters and not for the clinical events that this patient population may have experienced as a consequence. It is of interest that preliminary data suggest an increase in admissions for coronary artery disease,[5] although there is possible selection bias in the patients admitted to a particular hospital with such a problem. Despite these limitations, our observations may be helpful in preparation for the management of chronic disease in the face of future disasters.

CONCLUSIONS

Natural disasters can disrupt health care in communities affected by them for a period of time that depends on several factors. We have previously published data documenting disruption in the health care of the population of New Orleans due to Hurricane Katrina, which was characterized by uncontrolled diabetes and other comorbidities. Our data now demonstrate that these parameters did return to baseline; however, the pattern of recovery is dependent on several factors. This highlights the importance of accounting for these facts in preparation for dealing with disasters and their aftermath, with a focus on short- and long-term effects.

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