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Jewel Shepherd

Koren Goodman

Manasi Sheth-Chandra
Old Dominion University

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A Decade of Diabetes Hospitalizations: Meaningful Information for Community-Based Health Services Administrators for Identifying and Assessing Risk

Jewel Shepherd[1]*, Koren Goodman[2] and Manasi Sheth-Chandra[3]

[1]*University of South Dakota, Beacom School of Business, Health Services Administration Program, USA*
[2]*Department of Surgery, Robert Wood Johnson Barnabas Health, 94 Old Short Hills Road, USA*
[3]*Old Dominion University, College of Health Sciences, Norfolk, USA*

Abstract

The American Diabetes Association has established that the largest contributor of expenditures related to the cost of care for diabetes is inpatient hospital care. Research has shown that when multiple hospitalizations have been examined, patients diagnosed with diabetes have higher same year readmission rates. Medicare-enrolled patients with coronary artery disease and diabetes who participated in a diabetes management intervention that included self-care behavior instructions and nurse management had fewer emergency room visits and hospitalizations for diabetes related care. In the US, an aging population and expected changes in the ethnic composition prompts an alert to actively address the need for prevention, early detection, reduction of associated complications experienced, and exploration of a cure of the chronic condition of diabetes. This study's purpose was two-fold: to examine the variability in hospitalization rates of diabetes by geographical location and age groups from 2000-2011 to examine any statistically significant relationships. The study further proposes the exploration of low-cost technology mechanisms to reduce diabetes related hospitalizations through the use of mHealth. Practical interventions using mHealth technologies are feasible solutions to addressing virtual prevention efforts and improving the outcomes of care among patients diagnosed with diabetes.

Keywords: Diabetes; Hospitalizations; mHealth; Technology-based interventions

Introduction

Diabetes mellitus is a debilitating, costly chronic condition, with prevalence rates expected to increase through the year 2050 [1]. In the United States (US), an aging population and anticipated changes in the ethnic composition prompts an alert to proactively address preventive measures focused on early detection, lifestyle and behavior modifications, decreasing associated complications experienced, and reducing readmissions using culturally appropriate interventions [2]. Diabetes is a serious public health concern and a societal burden [2]. In 2015, there were approximately 23.1 million diagnosed cases of diabetes among Americans and estimated additional 7.2 million undiagnosed cases [3]. Patients diagnosed with diabetes have health care costs nearly 2.3 times greater compared to individuals without diabetes [4,5]. Direct and indirect expenditures related to the costs of care totaled approximately $245 billion in 2012, up from $98 billion in 1997 [3-6]. The largest contributor of expenditures related to the cost of care for diabetes is inpatient hospital care [4-7] and hospital readmissions [5].

Diabetes and Hospitalizations in Urban Areas

With the scientific and clinical developments for prevention, early detection and advanced care, hospital readmission for treatment and therapy is a concern for diabetes care and management costs and quality of life [5]. Shang-Jyh et al. [8] evaluated inappropriate emergency department (ED) use among eight Louisiana hospitals among patients diagnosed with type 2 diabetes. Patients participating in a diabetes management program offering extended office hours, information on how to reduce ED visits for the management of diabetes, and personalized diabetes care management experience a decreased the likelihood of an inappropriate ED visit [8]. Approximately 56% of visits were identified as less urgent and inappropriately used by patients managing diabetes [8]. Higher utilization rates for less urgent visits were frequent among those patients with four or more co-morbid conditions [8]. The number of multiple hospitalization stays, and ED visits were reduced among Medicare-enrolled patients with coronary artery disease and diabetes who participated in a diabetes management intervention that included self-care behavior instructions and nurse management [9]. Hospital admission rates were slightly higher for participants who did not receive the intervention, suggesting diabetes self-management education and training programs play an integral role in reducing diabetes related complications and inpatient hospital stays.

Jiang et al. [10] examined multiple hospitalizations in five states and found that diabetes patients experienced higher rates of readmissions. More than half of total inpatient hospital stays were diabetes related, and female patients had the highest percent of total stays, accounting for 55%. Additionally, female patients, 18-64 years, and those 65 years and older experienced higher rates of readmissions. Compared to males, females diagnosed with diabetes have multiple hospitalizations as a result of complications experienced from diabetes [10]. Patients with government sponsored insurance accounted for the highest percent of hospital stays compared to patients with private, other insurance, and those uninsured. Regression analyses revealed that

government sponsored insured, Hispanics, non-Hispanic Blacks and patients from zip codes identified as low-income areas were significant predictors of multiple hospitalizations [10,11]. Kim et al. [5] observed similar disparity findings in that living in low-income, urban areas, having government sponsored or public insurance, and ethnicity were stronger predictors of unscheduled readmissions. Of the total sample population (n=124,967), results showed 87% were unscheduled admits, with 26% being readmitted within 90 days [10]. These findings support emphasis being placed on increasing efforts to increase quality self-care management behavior modifications in outpatient settings to decrease readmission rates [8,11,12]. While prevention is a preferred method of treatment [13], meaningful compliance, on-going training, education, and support improves quality of life and decreases morbidity and mortality among those diagnosed [14-16]. To reduce the disparity, the impact and the number of uncontrolled and undiagnosed cases of diabetes, access to care remains vital.

Diabetes and Health Care Centers

There existed a number of proponents who believed the Patient Protection and Affordable Care Act (PPACA) would lessen some of the responsibility of federally qualified health centers in providing low-cost yet high-quality care in underserved areas [17]. In establishing the new roles of Health Care Centers (HCCs) with the passing of the PPACA, HCCS are expected to expand their current service delivery models to take a novel approach at health education and promotion [17,18]. HCCs have taken a lead role in the initiation of cost-effective and resource-sharing projects to increase access to care for diabetes management and treatment [19]. HCCs strive to achieve a seamless fluidity of health services delivery that is both accessible and affordable for the surrounding community. In the history of their service role, HCCs serve as community builders and agents for change by partnering with other service organizations to improve care coordination and navigation while lessening the duplication of service bureaucracy [19].

In a study of publicly-funded health centers, data was collected from an urban city specific to diabetes related hospital discharges for the purpose of examining the impact of HCCs in reducing readmissions after hospitalizations [18]. The analysis revealed that patients who participated in usual care at an HCC were less likely to experience a readmission. The provision of care at an HCC for low income and uninsured patients prevented hospital readmissions among this group [18]. HCCs have further developed care models that provide adequate assessments and ultimately corresponding plans to meet the needs of patients and the local community to eliminate the disparities that exist in health care access among the medically underserved by offering a more comprehensive health care delivery model [19]. There still exists a strong need to increase awareness and cultivate healthy environments, prevent premature deaths and avoid disabilities among those populations that experience a disproportionate rate. In reaching out to serve communities, more creative strategic thinking coupled with practical applications alongside accessibility and affordability will be necessary [19].

Diabetes and Self-management with mHealth Technology

The success of clinic-based care initiatives that incorporate behavioral health education and self-care prompts depends heavily on patient engagement and technology usability [20]. Self-care management will be an ongoing activity for persons diagnosed with diabetes. As such, there is an uncertain future in determining the

length of time that these activities will continue. Patient perception, satisfaction, and continuous usage must reside at a high level. These facets can be impacted by clinician support, enhanced capabilities, confidence in self-management abilities, and indefinite use compliance [21]. In a study among participants with uncontrolled diabetes, patients were randomized into one of three intervention groups: the personal digital assistant (PDA), the Chronic Disease Self-Management (CDSM) program, a combination of PDA and CDSM, or the usual care group. The analysis recognized the significant ability of diabetes focused self-management programs utilizing mHealth technologies to delay time to hospitalization [22]. mHealth technology based interventions represent a realistic and convenient method for self-management support systems for diabetes [23]. A randomized control trial demonstrated real-time continuous glucose monitoring (RT-CGM) was a cost-effective measure as a self-management tool to reduce A1C levels. On-going primary care surveillance, continuity of care, lifestyle modifications, and both pharmaceutical and non-pharmaceutical therapies can delay or reduce costs, complications, hospitalizations and readmissions experienced from diabetes [19].

Purpose of the Study

This study (1) examined the variability in hospitalization rates of diabetes by geographical location and age from 2000-2011, and (2) explored low-cost technology mechanisms to reduce diabetes related hospitalizations through the use of mHealth. The following research questions were addressed:

- Does a statistically significant relationship exist among hospitalizations of patients diagnosed with diabetes and geographical location?

- Does a statistically significant relationship exist among age categories and hospitalizations of patients diagnosed with diabetes?

- Does a statistically significant relationship exist between age categories and geographical location and hospitalizations among patients with diabetes?

Methodology

Data source

The annual number of hospital discharges with the ICD-9-CM code of 250, diabetes and crude hospitalization rates and age specific rates by zip code between 2000-2011 were abstracted from the hospital discharge dataset from the Chicago Department of Public Health. Additionally, the number of residents in each of the zip codes from the city of Chicago stratified by age groups were utilized from the US Census 2000. Veteran hospital discharge data were excluded from the data.

Data analysis

The first goal was to determine if a statistically significant relationship existed among hospitalizations of patients diagnosed with diabetes and geographical location. The annual number of hospitalizations for the years 2000-2010 were summed and divided by the US Census 2000 Population to obtain location-specific hospitalization rates (per 1000 residents) for each of the zip codes [24]. Ninety-five percent (95%) confidence intervals for the location-specific hospitalization rates were calculated using binomial to normal approximation under theory of large sample. The second goal was to determine if a relationship existed among age categories and hospitalizations of diabetes patients. The

annual number of hospitalizations for the individual years of 2000-2010 was added to obtain the total number of hospitalizations. The total number of hospitalizations was then divided by the number of residents in each zip code to obtain age-group-specific hospitalization rates (per 1000 residents) for each of the age-groups. The hospitalization rates were then averaged for all the zip codes within each of the age-groups. Confidence intervals at 95% for these hospitalization rates were calculated using binomial to normal approximation under theory of large sample [25]. An overlap between the confidence intervals was considered to be significantly not different from each other. However, if the confidence intervals for any two groups did not overlap, then the groups were considered to be significantly different from each other.

ZIP code(s)	U.S. 2000 Census Population	Location-specific Hospitalization Rates (per 1000)	Location-specific Rate 95% Lower CI	Location-specific Rate 95% Upper CI
60621	35912	73.875	71.170	76.580
60636	40916	65.671	63.271	68.071
60624	38105	63.482	61.034	65.930
60628	72202	63.142	61.368	64.916
60644	48648	62.243	60.096	64.390
60649	46650	60.686	58.519	62.853
60653	29908	59.884	57.195	62.573
60620	72216	57.259	55.564	58.954
60619	63825	56.075	54.290	57.860
60651	64267	52.017	50.300	53.734
60617	84155	45.262	43.857	46.667
60612	33472	44.515	42.306	46.724
60643	49952	44.042	42.243	45.841
60637	49503	41.614	39.855	43.373
60609	64906	34.573	33.167	35.979
60827 and 60633	40873	32.613	30.891	34.335
60622 and 60642	71028	32.424	31.121	33.727
60647	87291	32.397	31.222	33.572
60623	92108	32.006	30.869	33.143
60615	40603	28.298	26.685	29.911
60639	90407	28.018	26.942	29.094
60640	65790	27.466	26.217	28.715
60616	48433	27.275	25.824	28.726
60707 and 60635	42920	27.144	25.607	28.681
60652	40959	25.953	24.413	27.493
60608	82739	24.837	23.777	25.897
60626	50139	24.831	23.469	26.193
60629	113916	24.685	23.784	25.586
60660	42752	24.654	23.184	26.124
60638	55026	21.826	20.605	23.047
60645	45274	18.951	17.695	20.207
60632	91326	18.242	17.374	19.110
60641	71663	17.875	16.905	18.845
60625	78651	17.775	16.852	18.698
60646	27177	17.073	15.533	18.613
60618	92084	16.583	15.758	17.408
60656	27613	16.297	14.804	17.790
60630	54093	16.028	14.970	17.086
60634	74298	15.976	15.074	16.878
60610 and 60654	52601	15.893	14.824	16.962
60659	38104	15.616	14.371	16.861
60655	28550	15.552	14.117	16.987
60631	28641	15.432	14.004	16.860
60601, 60602, 60603, 60604, 60605 and 60611	44403	14.301	13.197	15.405
60613	48281	14.084	13.033	15.135
60614	66617	11.333	10.529	12.137
60606, 60607 and 60661	33997	10.530	9.445	11.615
60657	65996	8.516	7.815	9.217
Total	2728990	31.559	31.351	31.766

Table 1: Chicago hospitalization location – Specific rates stratified by ZIP code(s).

Age Groups	Mean Hospitalization Rate (per 1000)	Mean Hospitalization Rate 95% Lower CI	Mean Hospitalization Rate 95% Upper CI
Under 5 years	510.80	432.773	588.832
5 to 9 years	591.391	508.015	674.768
10 to 14 years	611.943	525.576	698.310
15 to 19 years	512.848	450.014	575.681
20 to 24 years	459.308	374.463	544.153
25 to 29 years	450.139	349.120	551.082
30 to 34 years	475.856	370.100	581.612
35 to 39 years	502.879	401.330	604.429
40 to 44 years	532.360	435.022	629.698
45 to 49 years	518.893	437.232	600.713
50 to 54 years	526.792	448.211	605.373
55 to 59 years	619.167	524.951	716.383
60 to 64 years	763.023	640.608	885.439
65 to 69 years	1061.353	898.447	1224.259
70 to 74 years	1363.176	1167.777	1558.575
75 to 79 years	1796.102	1534.520	2057.684
80 to 84 years	2420.89	2019.645	2822.135
85 years or above	2799.661	2224.752	3374.570

Table 2: Mean hospitalization (per 1000) rate stratified by age groups (n=48 each).

Results

Table 1 displays the crude rates as well as the 95% upper and lower confidence intervals for hospitalizations of an urban city in the US stratified by zip code(s). The crude rates for the zip code(s) 60621, 60636 and 60651 were significantly different from each other as well as from the other zip code(s). Significant results were not obtained for the zip code(s) when compared with at least one other zip code(s). A possible limitation in utilizing this calculation is that the population may not be representative of the actual population for each of the zip codes over the years 2000-2010 since the number of residents being hospitalized annually may not be unique from year-to-year. The actual number of residents was unavailable for each year; therefore, actual hospitalization rates may be an underestimate compared to those provided in Table 1.

Table 2 shows the hospitalization rate on average for the various age groups. Each age group had hospitalizations rates reported for 48 different zip codes for the city of Chicago. These rates were then

averaged to obtain a mean hospitalization rate per 1000 residents for each of the zip codes. 95% confidence intervals are also provided for each of the age groups. Results demonstrated that the mean hospitalization rate per 1000 residents was significantly higher for ages 65 or above as observed in Figure 1. The confidence intervals for these age groups were wider possibly due to the variability of health conditions amongst these "older" age groups.

Figures 2a-2f shows the hospitalization rates on an average for the years 2000 to 2011 stratified by zip codes. Each line represents the crude

hospitalizations rates reported for each of the 48 different zip codes for the city of Chicago. There were clusters of zip codes with substantial changes in their crude hospitalization rates over the period of 12 years: 60612, 60617, 60621,60622; 60642, 60637, 60827; and 60653, 60633 and 60660. To explain, zip codes cluster 60612, 60617, 60621 and 60622 have a low socioeconomic status with the average household income of those areas as $29,721 annually; and for 60653,60633 and 60660, at $29,763with at least one zip code in each of the clusters populated with more than 98% non-Hispanic Blacks (Table 3).
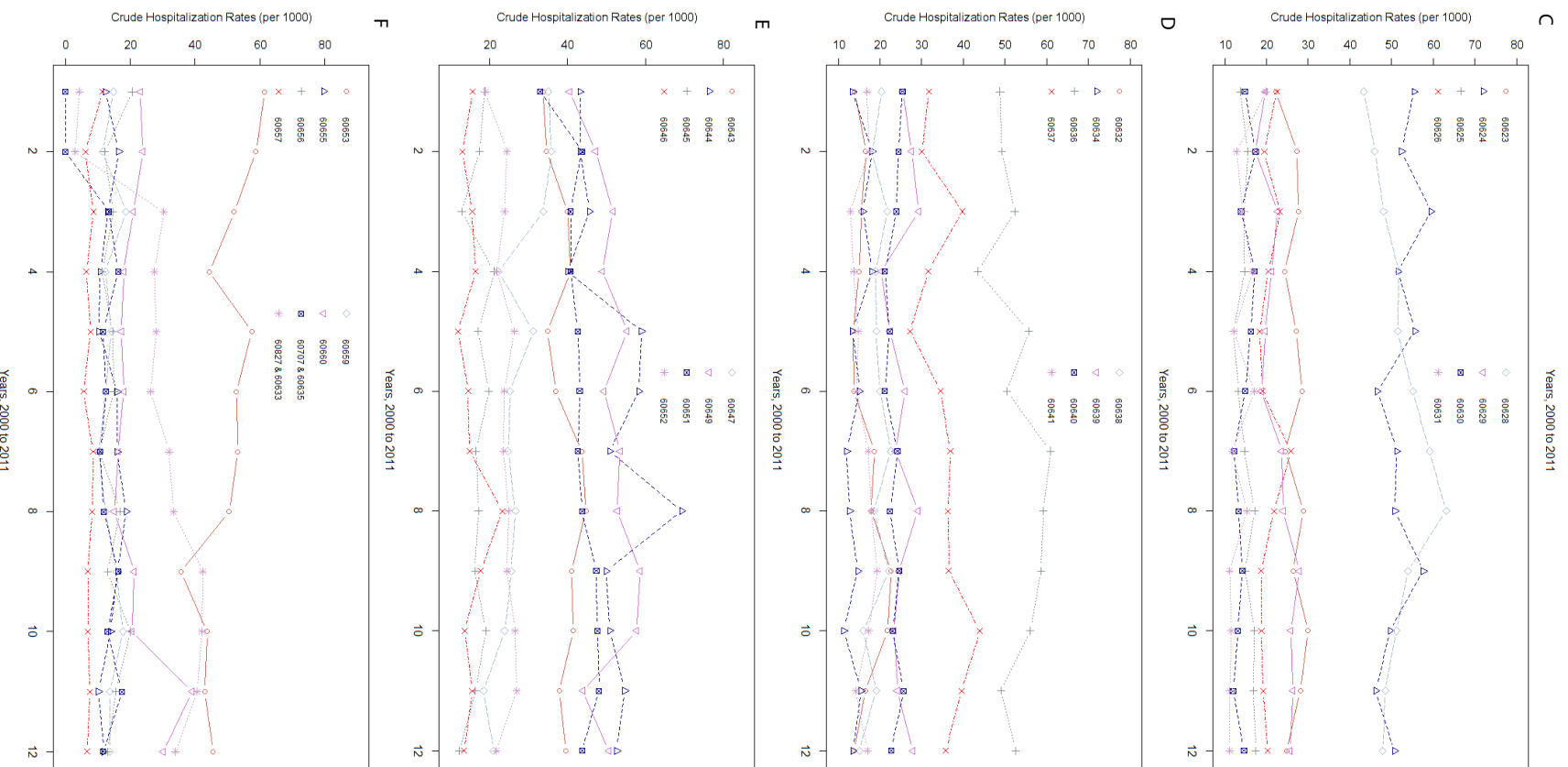

Figure 1: Mean hospitalization rate by age groups.
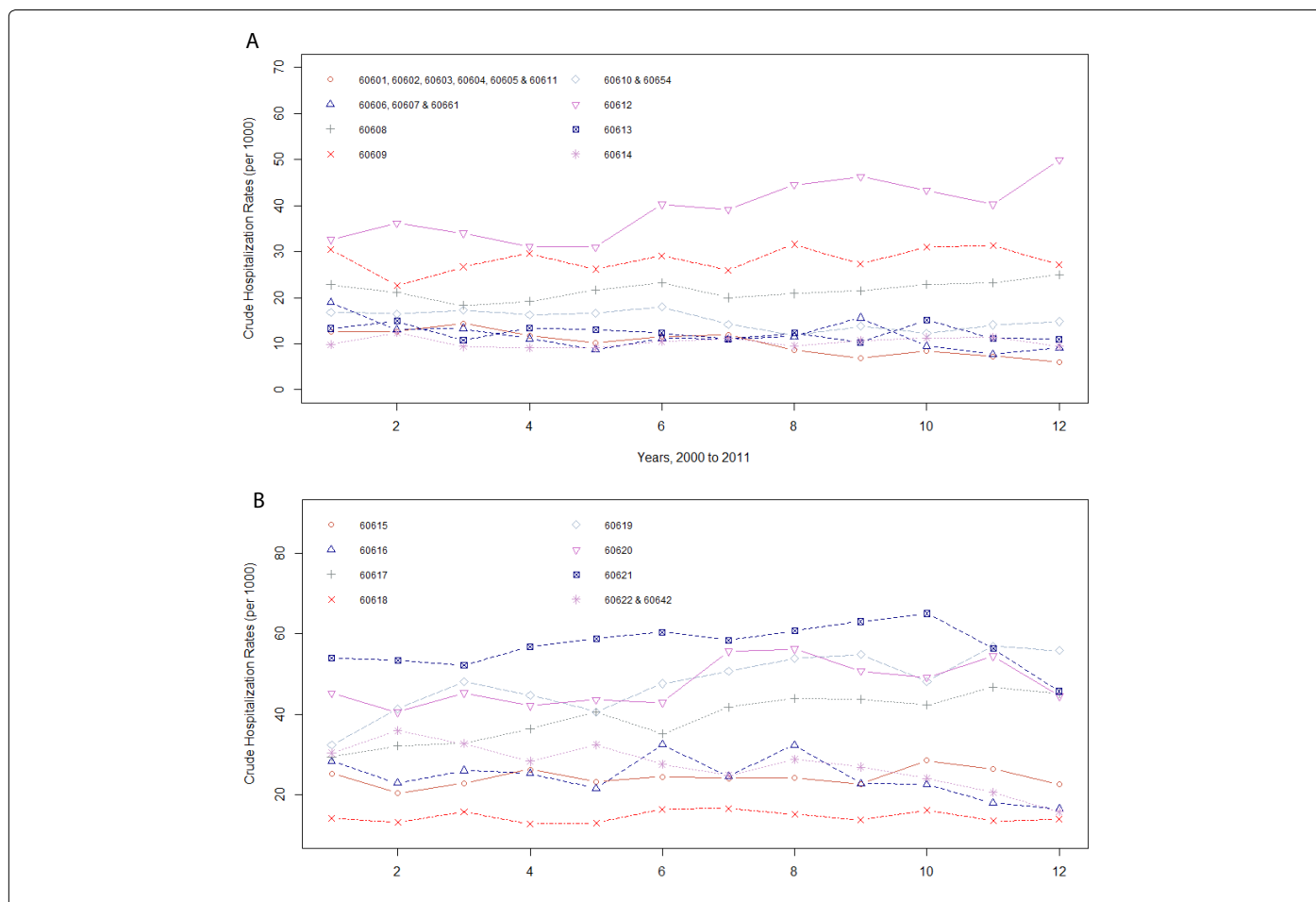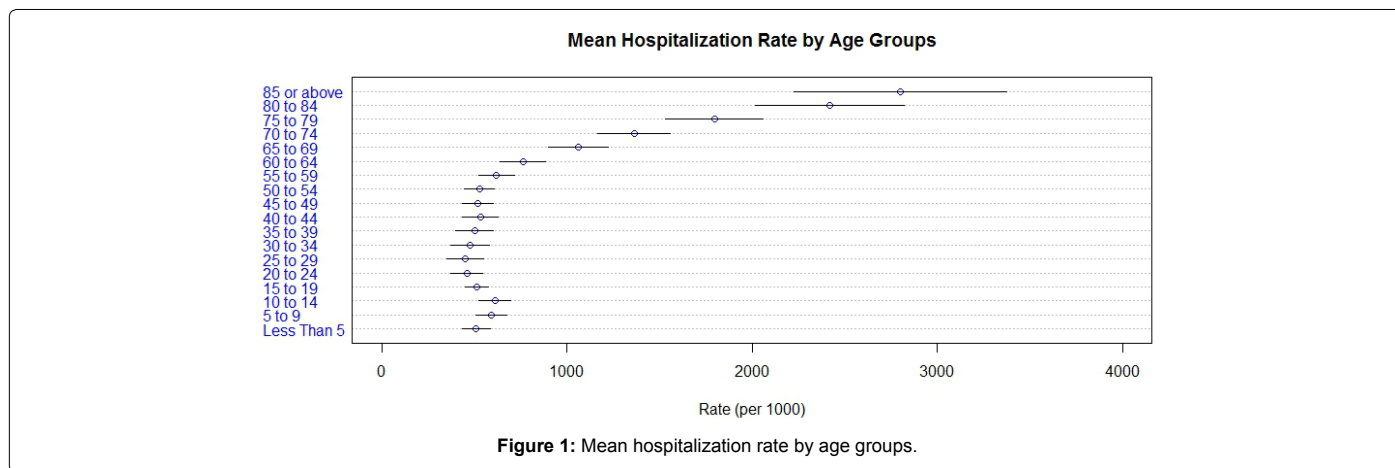
Figure 2: Crude hospitalization rates (per 1000), years 2000 to 2011.

ZIP Code Clusters	Population	Percentage of Non-Hispanic Blacks (%)	Mean Household Annual Income ($)
60612	37,990	65.57	25,143
60617	96,288	54.56	35,534
60621	47,514	98.19	19,718
60622	76,015	10.94	38,487
60637	57,090	82.24	-
60642	-	-	-
60827	-	-	-
60633	13,262	18.63	40,792
60653	34,502	97.91	14,205
60660	47,726	17.81	34,293

Table 3: ZIP codes cluster by population, percentage of non-Hispanic blacks and mean household income.

Discussion and Conclusion

Coordinated care processes reduce inappropriate emergency department services utilization in addition to improving clinical processes and outcomes [8,15]. This study demonstrated that hospitalizations of patients with diabetes crude rates for the zip code(s) 60621, 60636 and 60651 were significantly different from each other as well as from the other zip code(s). The data shows that the mean hospitalization rate per 1000 residents were significantly higher for ages 65 or above.

Preventable hospitalization rates

Preventable hospitalization rates by neighborhood poverty decreased from 2008 to 2013 among a studied region in a northeastern state of the US [26]. Bocour [26] evaluated gaps between very high and low poverty neighborhoods by examining trends over a five-year period. Information specific to demographic groups identified as having higher rates of preventable hospitalizations is beneficial to geographically identify areas for improvement in access to primary care. Although hospitalization rates decreased during the five-year period, disparities remained among gender, race, socioeconomic status, access and complications due to lack of self-management. Such findings underscore the need to improve adequate access to quality and timely primary care for individuals residing in low-sociodemographic areas and communities [26]. Cost effective diabetes care incorporates measures that are on-going, efficient and safe [7]. Treatment modalities may include those that are offered in the patient's primary medical home, technology based, practical, age specific, and those that are culturally sensitive with targeted audiences [2,7,27-29]. Practical technological interventions using mHealth technologies are feasible solutions to addressing virtual prevention efforts and improving the outcomes of care among patients diagnosed with diabetes.

Technology based interventions, the challenges that yet exist

There is a growing preference of mobile technology use among patients expected to actively participate in self-managed care. Integrating access to resources seamlessly into patients' daily lives through the use of technology improves engagement in self-care management. With the more than 700 mobile applications geared toward diabetes, an evaluation is warranted to review the usability and clinical achievements of these interventions [30]. Patient-centered medical homes are increasingly offering a myriad of interprofessional approaches to address continuity of care as it relates to the self-care management of chronic diseases such as diabetes. Issues such as connectivity, cost, and the forethoughts of challenges yet to be determined are the concerns that lay ahead.

Collaborative care approach

Because diabetes is a debilitating disease, providers are instrumental in connecting patients to lifestyle modifications to reduce the associated complications experienced [24,25,31]. Patient centered medical homes are particularly appropriate for patients managing diabetes to receive ongoing surveillance and a team centered approach to support prevention and wellness. The facilitation of integrated care is coordinated through the medical home, as the primary care provider authorizes specialty referrals as required by many health maintenance organization [32-35]. A study evaluating the link between mortality and healthcare utilization effects of an intervention that combined care management and telehealth integrated a content-driven telehealth system with care management [32]. The target population included patients diagnosed with congestive heart failure, chronic obstructive pulmonary disease, and / or diabetes living in the northwest area of the US The "Health Buddy" program participants experienced reductions in risk-adjusted all-cause mortality and in the number of quarterly inpatient admissions. The study concluded that care management combined with content-driven telehealth technology has great potential in improving health outcomes among high-cost Medicare beneficiaries [32].

Absent a model that involves the possible interaction and effects of all of the body's systems, a patient could experience increased risks for further preventable complications of the chronic condition diabetes [32]. Healthcare delivery has been redesigned to acknowledge the need for interdisciplinary approaches to structuring programs that meet the varying needs of patients, particularly those in underserved communities, to lessen the impact of poor care management at the individual and system level. Davis et al. [36] defined inter-professional education as those opportunities for multiple professionals to both learn from and about one another's responsibilities to providing overall quality care. This occasion for sharing in the tasks of problem solving and decision making enhances the goal of increased service for the patient and increased participation and communication among the involved professionals. Diabetes is a model illness for chronic disease management that requires inter-professional collaboration [32].

Identifying and assessing risk for culturally appropriate interventions

Ethnic minority groups diagnosed with diabetes are disproportionately affected by diabetes and associated complications of this debilitating disease. As such, there is an increasing need to develop interventions focused on prevention and those that address disparities. Additionally, ethnic minorities are often vulnerable and receive inadequate care as a result of factors associated with educational barriers, linguistic differences, religious, health, and illness beliefs often unfamiliar to mainstream society. Patient-centered, culturally competent interventions are required to effectively maximize opportunities to deliver compassionate care, healthcare excellence, quality health services, and cost-effective care. Addressing the patient's behaviors, needs, and beliefs from a culturally competent perspective will yield improved diabetes-related clinical outcomes among ethnic minority populations. In a study examining the risk for developing diabetes, reports showed that interventions comprised of aggregated electronic health records reviewed by a routine centralized reporting of patient-level data was successful in providing a novel approach to identifying at-risk communities and providing targeted, community-based interventions. Reports focused on such patient level performance measures as hemoglobin A1C (HgbA1c). The authors examined geographic variation in A1C among participants residing of two urban and one rural county in a Midwestern state of the US [37].

Essential to diabetes care are self-care practices, lifestyle modifications, and quality clinical preventive care management [38,39]. When compared to standard or even a non-mHealth approach, technology based interventions can impact positively glycemic control among patients with diabetes. mHealth shows potential as a diabetes self-management tool that will aid clinical decision making and improve patient outcomes [40-41]. As such, these technologies are increasingly becoming standard in clinical practice. Of importance is the necessity to utilize free mobile applications requiring minimal cost and having ease of use. Particularly, users normally prefer those free mobile applications that do not require internet connection and consist of all the desired features in a single function. Because the availability and quality of mobile health techniques and usability have been increasing as a result of the high usage of mobile devices in clinical practice, newly appointed health services administrators should be inclined to consider its usefulness in health education, promotion and maintenance regimens offered by clinicians and lay professionals for increasing positive outcomes among patients managing chronic conditions. The data presented here are a useful tool for identifying geographic areas with increased rates of avoidable hospitalizations and readmissions that require increased access to quality primary care and education on better health maintenance with self-management tools.

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