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REVIEW

Glucose control in diabetes: the impact of racial differences on monitoring and outcomes

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Abstract Type 2 diabetes is the seventh leading cause of death in the US and is projected to increase in prevalence globally. Minorities are disproportionately affected by diabetes and data suggest that clinical outcomes consistently fall below American Diabetes Association recommendations. The purpose of this systematic review was to examine ethnic differences in self-monitoring and outcomes in adults with type 2 diabetes. Medline was searched for articles published between January 1990 and January 2012 by means of a reproducible strategy. Inclusion criteria included (1) published in English, (2) targeted African Americans, Hispanic, or Asian adults, ages 18+ years with type 2 diabetes, (3) cross-sectional, cohort, or intervention study, and (4) measured change in glycemic control, BP, lipids, or quality of life by race. Twenty-two papers met the inclusion criteria and were reviewed. Overall, significant racial differences and barriers were found in published studies in diabetes management as it pertains to self-monitoring and outcomes. African Americans tend to consistently exhibit worse outcomes and control when compared to other minority populations and non-Hispanic Whites. In conclusion, significant racial differences and barriers exist in diabetes management as it pertains to self-monitoring and outcomes when compared to non-Hispanic Whites. Explanatory and intervention studies are needed to determine the mechanisms and mediators of these differences and strategies to reduce these disparities. In addition, more research is needed to investigate the impact of racial differences in self-monitoring and outcomes on quality of life.

Keywords Diabetes · Racial differences · Self-monitoring · Glucose control · Lipids · Blood pressure

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Introduction

Burden of diabetes

Diabetes affects more than 25.8 million people of the United States' (US) population. In 2010, 10.9 million adults 65 years and older and approximately 1.9 million people between the ages of 20 and 64 were newly diagnosed with type 2 diabetes mellitus (T2DM) [1]. Consequently, diabetes is the seventh leading cause of death based on US death certificates in 2007 [1]. The overall estimated cost of diabetes in the US in 2007, including direct and indirect costs, was $174 billion [1] and is predicted to increase to $192 billion by 2020 [2]. Several comorbid conditions and complications are influenced by T2DM, including nervous system disorders, kidney disease, amputations, periodontal disease, heart disease, and stroke, but not limited to blindness and eye problems [1]. In addition, the number of individuals with T2DM is predicted to increase to 29 million by 2050 [3].

On a global scale, it is estimated that 366 million people, or 8.3 % of adults, are diagnosed with diabetes,

leading to 4.6 million deaths in 2011 [4]. This number is expected to rise to 522 million by 2030 with T2DM prevalence increasing in every country [4]. The greatest number of people with diabetes is in the 40–59 age group, and there continues to be more people with diabetes living in urban areas than in rural areas [4]. It is the fourth or fifth leading cause of death in most high-income countries; however, 80 % of those with diabetes live in low and middle-income countries [4]. While 11 % of total health-care expenditures in adults are spent addressing diabetes, there is a large disparity between regions and countries [4]. Only 20 % of the global health expenditures were made in low- and middle-income countries, where often families bear almost the total cost of their medical care [4]. Considering low- and middle-income countries facing the greatest disease and economic burden, diabetes is considered one of the most challenging health problems of the twenty-first century [4].

Ethnic differences in burden of diabetes

Minorities are disproportionately affected by diabetes compared to non-Hispanic Whites. Within the US population, 8.4 % of Asian Americans, 11.8 % of Hispanics, and 12.6 % of African Americans have been diagnosed with T2DM [1]. Minority populations have also shown an increased likelihood to develop diabetes with African Americans being 77 %, Hispanic/Latinos 66 %, and Asian Americans 18 % more likely to develop diabetes and suffer from diabetes related complications, compared to non-Hispanic Whites [1]. Minority populations tend to suffer a greater burden of disease with African Americans being 2.6 times more likely than that of non-Hispanic Whites to develop end-stage renal disease. In addition, minority populations have higher mortality rates due to the direct and indirect complications of T2DM [5]. Evidence suggests that minority populations tend to have poorer self-management and diabetes outcomes as compared to non-Hispanic Whites, increasing the already disproportionate burden of disease and diabetes-related complications.

Ethnic differences in outcomes

According to the American Diabetes Association (ADA), optimal outcomes for diabetes management in adults living with T2DM include HbA1c <7.0 %, blood pressure <130/80 mmHg, and lipid levels of <100 mg/dL for LDL and >50 mg/dL for HDL [6]. Data on diabetes outcomes have shown that minority populations consistently fall below recommended guidelines in lipid, blood pressure, and glycemic control, as well as self-monitoring of blood glucose as compared to non-Hispanic Whites [7, 8]. A study recently assessing control for cardiovascular risk factors such as HbA1c >8.0 %, BP >140/90 mmHg, and LDL >100 mg/dL among ethnic minority populations found that Hispanics are less likely to have good control compared to non-Hispanic Whites with Mexican-Americans and African Americans being less likely to obtain good glycemic control as defined by HbA1c <7.0 % [9, 10].

Patient outcomes above the ADA recommendations are linked to increased risk for microvascular and macrovascular complications [6]. In order to reduce complications, team-based approaches to diabetes management are recommended [6]. In one study, racial disparities in lipoprotein cholesterol levels were diminished due to a quality improvement program, but differences in glycemic control continued [8]. Unfortunately, data suggest that disparate quality of care exists among minority populations at both the patient level and at the provider level [11]. Studies have shown that when controlling for socioeconomic variables, as well as access to care, there is an improvement in self-monitoring behaviors; however, the racial/ethnic disparities in diabetes quality of care continued [12].

As a result, it is necessary to understand whether racial/ethnic differences exist in self-monitoring and diabetes-specific outcomes as compared to national and clinical recommendations for proper diabetes management. There has been little done to summarize the evidence regarding self-care outcomes by race. The purpose of this systematic review was to examine ethnic differences in self-monitoring and outcomes (including glycemic control, blood pressure control, lipid control, and quality of life) in adults (ages 18+) with T2DM using English language literature from 1990 to 2012.

Methodology

Search strategy and eligibility criteria

Medline was searched for articles published between January 1990 and January 2012 by means of a reproducible strategy. Fourteen searches were performed producing 1,310 articles. The first two search terms in all searches were *race* and *diabetes*. The third search term was different for each and included self-monitoring, self-management, glycemic control, hemoglobin A1c, HbA1c, blood pressure, BP, lipids, cholesterol, LDL, quality of life, SF-12, SF-36, and SF-20. Duplicates were removed, producing 324 citations. Titles were eliminated if they were obviously ineligible, for instance, describing childhood, Type 1 diabetes, or gestational diabetes. This produced 156 abstracts to examine for full article review.

The following inclusion criteria were used to determine eligible study characteristics: (1) full article must be published in the English language, (2) must target African

Americans, Hispanic or Asian adults, ages 18+ years with type 2 diabetes, (3) can be a cross-sectional, cohort or intervention study, and (4) must measure a change in glycemic control, BP, lipids, or quality of life by race.

Full articles were read and reviewed by means of a standardized checklist by three reviewers (JC, RW, BS). A fourth reviewer (LE) was asked to make the final decision regarding eligibility in the case of disagreement. Twenty-two eligible studies were identified based upon the predetermined inclusion criteria.

Data collection

Data collected from the eligible articles are shown in Tables 1, 2, 3, and 4. Data were extracted on the number of participants, sample population, duration of the study, setting of the study, study design, mean change in outcome, statistical significance, major findings, and limitations for the study (Tables 1, 2, 3, 4). A table was compiled for each of the four categories of this review with papers meeting inclusion criteria for self-monitoring, glycemic control, blood pressure, and lipid control.

Results

Twenty-two papers met the inclusion criteria set for this analysis. Three provided outcomes for self-monitoring, 17 provided outcomes for glycemic control, 6 provided outcomes for blood pressure, and 8 provided outcomes for lipids. Of the 22 meeting inclusion criteria, 8 studies measured glycemic control, lipids, and blood pressure within one analysis. These outcomes were extracted and discussed independent of one another. No papers reviewed provided outcomes for quality of life and met inclusion criteria. Twelve were cross-sectional studies, 9 were cohort studies, and 1 was a pooled dataset of intervention studies. Sample sizes range from 283 to 80,207 participants. Table 1 provides the results for self-monitoring articles, Table 2 provides the results for glycemic control outcomes, Table 3 provides the results for blood pressure outcomes, and Table 4 provides the results for lipid outcomes.

Racial differences in self-monitoring

Based on inclusion criteria of the database search, 3 papers were reviewed that examined racial difference in self-monitoring among those with T2DM. Two studies were cross-sectional and 1 study was a cohort study; no intervention studies were reviewed. The number of participants across studies ranged from 1,720 to 4,565 with sample populations including Hispanics, African Americans, and non-Hispanic Whites in adult managed care settings. Outcome assessments included likelihood, regularity, and incidence of self-monitoring of blood glucose (SMBG). Studies measured absolute change in outcome by race by means of odds ratio and hazard ratio. Major findings were consistent across studies with African Americans and Hispanics being significantly less likely to have control in SMBG as compared to non-Hispanic Whites [12–14].

Although the evidence supporting the efficacy of SMBG in those diagnosed with T2DM has not been widely documented, data suggest that individuals who maintain self-monitoring behaviors are more likely to achieve optimal outcomes in diabetes care [13]. The data retrieved from the current studies also indicate that there are racial/ethnic barriers that exist in quality of care, including initiation and in maintaining of SMBG [13]. In examining the racial differences between African Americans and non-Hispanic Whites in SMBG, Mah et al. [14] assessed whether the provision of free home glucose monitors would impact self-monitoring among African Americans as compared to non-Hispanic Whites and found that when both groups received free monitors, African Americans were as likely as non-Hispanic Whites to initiate self-monitoring behaviors and showed an increase in use up to 6 months following receipt of the monitor. However, the data showed that African Americans were at a higher rate of discontinuation than that of non-Hispanic Whites during followup periods [14]. This is suggestive of differences in rates of self-monitoring by race, indicating that differences in the barriers to SMBG may exist by ethnicity [14]. Other studies examining racial differences in SMBG among individuals with type 2 diabetes found significant racial/ethnic differences in self-care behaviors. However, when controlling for socioeconomic variables and access to care variables, the racial/ethnic differences in SMBG between Hispanics, African Americans, and non-Hispanic Whites were nonexistent. Overall, data extracted from the current studies showed a consistent trend in racial differences among SMBG with African Americans and Hispanics being less likely to self-monitor their blood glucose as compared to non-Hispanic Whites [12–14].

Racial differences in outcomes

Glycemic control

By means of the search strategy, 17 articles were retrieved that provided glycemic control outcomes by race/ethnicity. Of those meeting inclusion criteria, 9 were cross-sectional studies, 7 were cohort studies, and 1 was a pooled dataset of intervention studies [10, 15–29]. Sample sizes ranged from 283 to 80,207 participants. While the level of

Table 1 Articles reviewed that focused on racial differences in self-monitoring

Study author [reference]	Adams et al. [13]	Mah et al. [14]	Nwasuruba et al. [12]
Study design	Cross-sectional	Cohort	Cross-sectional
Number of participants (completed)	4,565	2,275	1,720
Sample population	Adult managed care (eastern MA)	Adult patients in HMO	2002–2004 adults with DM in the Texas Behavioral Risk Factor Surveillance Survey (BRFSS)
Study timeframe	N/A	4 years	N/A
Outcome assessment	Likelihood of any SMBG and regularity (filling scripts for 90 or more test strips) of SMBG*	Incidence (1 or more test strips in a given month) and discontinuation (>6 months w/out using test strip) of SMBG after receiving free home blood glucose monitors*	Self-management behaviors (physical activity, home blood glucose test, home foot examinations) and quality of care (HbA1c by provider, foot exam by provider, eye exam by provider, flu shot in last 12 m, pneumonia shot)
Absolute change in outcome by race (95 % confidence interval)	AA: OR 0.46 (0.26–0.81) Other: OR 0.32 (0.09–1.23)	AA in pre-policy: HR 1.14 (0.86–1.50) AA in post-policy: HR 1.33 (1.01–1.76)	AA: OR 1.0 (0.49–2.05) HW: OR 0.91 (0.43–1.95)
Statistical significance	NR	NR	NR
Major findings	AA and lack of glycemic control were significantly associated with less frequent SMBG	Promoting monitoring had greater effects in motivating new trials of SMBG among AA patients on oral therapy compared to NHW	Differences in home glucose testing and home foot care were no longer significant after controlling for SES and access to care variables
Limitations	Study design prevents causal inference; efficacy of SMBG on patient behavior has yet to be determined in literature	No control for other race related sociocultural factors; outcome measure based on test strip dispensing rather than actual use; SES differences between races were small in this study setting, so economic barriers may be greater in general population	Telephone surveys may be more biased due to exclusion of participants without access to phones; physical activity assessed was only leisure time

AA African American, *HW* Hispanic White, *AS* Asians, *MA* Mexican-American, *NR* not reported, *OR* odds ratio, *HR* hazard ratio, *SMBG* self-monitoring blood glucose

* Compared to NHW

evidence based on study design alone is relatively low, most studies included large sample sizes and agreement in results suggested higher HbA1c scores in minority participants [15–29]. Though there were a number of cohort studies, the changes in racial/ethnic gap in HbA1c over time were not often assessed [[8], [23–28]]. As a result, impacts on disparities in outcome cannot be addressed with the evidence at this time.

Since only one study meeting inclusion criteria was an intervention study, selection bias may be a concern for most of the available data [29]. Four studies used national representative NHANES data, 4 studies used specific practice or insurance groups, and 2 studies investigated Veterans [8, 10, 16–22, 25–28]. Nine studies provided outcomes by point estimate of HbA1c and 8 provided outcomes relative to a threshold [8, 10, 15–29]. Of the 8 studies using thresholds, 5 provided odds ratios and 3 provided percent above or below the threshold [8, 10, 20–22, 25, 27, 28]. All thresholds set were HbA1c of 7 %, except Jackson et al. [27] which set the threshold at 9 %. Two studies investigated whether HbA1c was above the threshold and 6 investigated whether HbA1c was below the threshold [8, 10, 20–22, 25, 27, 28]. Overall, regardless of the study population or the outcome measure used, a difference in glycemic control by racial/ethnic group was observed [15–29]. Unfortunately, without randomization it cannot be concluded with certainty whether these differences across studies are due to selection bias within the groups investigated or are representative of what obtains in the population overall.

Based on the 17 studies meeting inclusion criteria, African Americans, Hispanic, and Asian Americans show higher HbA1c values than non-Hispanic Whites [15–29]. When compared to non-Hispanic Whites, the difference in

Table 2 Articles reviewed that focused on racial differences in glycemic control

Study author [reference]	Adams et al. [23]	Adams et al. [24]	Brown et al. [15]	Davidson et al. [29]	Hausmann et al. [16]	McWilliams et al. [17]	Suh et al. [18]	Wendel et al. [19]	Chew et al. [20]
Study design	Longitudinal cohort	Retrospective cohort	Cross-sectional	Pooled data analysis of 11 interventions	Cross-sectional	Cross-sectional	Observational cohort	Cross-sectional	Cross-sectional
Number of participants (completed)	2,986	1,806	7,456	1,455	283	1,733	19,539	338	14,822
Sample population	Group practice in Massachusetts	Group practice in Massachusetts	Managed health care plan (CA, HI, IN, MI, NJ, PA, TX)	11 multinational clinical trials	Baseline assessment of behavioral intervention in Pittsburg	NHANES 1999–2006	NHANES (1988–1994, 1999–2004)	Southwest U.S. Veteran Administration Medical Centers	Diabetics who received continuity of care for at least 2 years with 2 outpatient interactions at 1 of 6 hospitals
Study timeframe	8 years	10 years	N/A	12–24 weeks	N/A	N/A	N/A	N/A	N/A
Outcome assessment	HbA1c at baseline, average annual	HbA1c at baseline, 6-months, 12-months	HbA1c	HbA1c baseline; 12, 16 or 24 weeks	Baseline HbA1c	HbA1c (8 year mean)	HbA1c	HbA1c	HbA1c <7 %
Absolute change in outcome by race (95 % confidence interval)	AA women previously diagnosed 0.3 % higher than NHW; AA men newly diagnosed 0.49 % higher than NHW	Baseline AA 9.8 %, NHW 8.9 %; 12-months average difference between races controlling for medication adherence 0.46 %	HW 8.1 %, AS/PI 8.1 %, AA 7.9 %, NHW 7.7 %	BASAL therapy HW 0.9 % and NHW 0.4 % decrease; LMBID therapy HW 0.9 % and NHW 1.3 % decrease; LMBID therapy AS 0.8 % and HW 1.3 % decrease	AA 8.14 %; NHW 7.40 %	NHW 7.0 %, AA 7.7 %, HW 7.7 %	NHW 8.07 and 7.32 %; AA 8.6 and 8.11 %; HW 8.35 and 8.08 %; Other 7.63 and 8.16 %	NHW 7.9 %; HW 8.2 %; AA 8.8 %	Predictor of Good HbA1c: HW: 0.77 (0.67–0.89) Predictor of Poor HbA1c: HW: 1.58 (1.46–1.71) AA: 1.62 (1.31–2.01)
Statistical significance	Women previously diagnosed, $p = 0.0002$; Men newly diagnosed, $p = 0.002$	Baseline $p < 0.001$; 12-months average $p < 0.0001$	HW and AS/PI $p < 0.001$; AA, $p = 0.0009$	BASAL $p < 0.01$; LMBID Hispanic $p < 0.05$; LMBID Asian $p < 0.05$; LMTID not statistically significant	$p < 0.01$	AA, $p < 0.001$; HW, $p = 0.005$	NHW, $p < 0.001$; AA, $p = 0.048$; HW, $p = 0.112$; Other, $p = 0.091$	$p = 0.05$	Good HbA1c: Poor HbA1c: HW, $p < 0.0001$ AA, $p < 0.0001$ HW, $p < 0.0001$
Major findings	Consistently higher HbA1c in AA; race effect remained when access and quality of care as covariates	Persistent racial disparity; racial difference not explained by adherence; multiple med assoc with lower HbA1c in AA	Few clinically significant racial/ethnic disparities in care for group of insured patients	Difference in efficacy and safety of insulin therapy with different outcomes based on type of insulin and intensity	AA have higher HbA1c even after controlling for demographic, clinical and psychosocial factors	Differences in racial/ethic groups did not decrease, difference with HW increased	Mean HbA1c declined in all stratified groups except HW	AA and HW had poorer glycemic control and less intensive insulin treatment	AA and HW were less likely than NHW to have good control; health disparities requires a comprehensive approach that considers the broader society
Limitations	Possible selection bias; additional confounders	Claims based measure may overestimate adherence; no causal inference	May not generalize to non-insured; unable to examine reason for disparities	Post hoc analysis of pooled data; lack of large numbers for all ethnic groups	Population self-selected to be in intervention study; limited generalizability; no causal inference	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes	Did not compare differences between racial/ethnic groups	Possible selection bias; may not generalize to younger population and non-veterans	Potentially unreliable administrative data; inability to fully assess confounders; inability to explain disparities

Table 2 continued

Study author [reference]	Kirkbride and Wallace [21]	Harris [25]	Zhu et al. [26]	Jackson et al. [27]	Resnick et al. [28]	Silververman et al. [22]	Saydah et al. [10]	Sequist et al. [8]
Study Design	Retrospective, cross-sectional	Cohort, observational	Retrospective cohort	Cohort	Cohort	Cross-sectional	Cross-sectional	Cohort
Number of participants (completed)	6,267	1,480	3,976	80,207	998	500	944	7,088
Sample population	Individuals who had been enrolled in Oregon's Medicaid Plan (Oregon Health Plan) and diagnosed with diabetes	Adults ≥25 years old, diagnosed with diabetes by a physician before taking the survey (NHANES III)	Indianapolis hospitals and clinics	Veterans who have been diagnosed with type 2 diabetes, ≥18 years old	Adults ≥18 years that self-reported diagnosis of type 2 diabetes	Adults ≥18 presenting at emergency department for acute medical problem	NHANES 1999–2002	Adults ≥18 years continuously insured for 24 months
Study Timeframe	N/A	6 years	8 years	1 year	3 years	N/A	N/A	4 years
Outcome Assessment	HbA1c >7 %	% achieving HbA1c >7 %	Baseline HbA1c	HbA1c <9 %*	% achieving HbA1c <7 %	HbA1c <7 %*	HbA1c <7 %*	Proportion achieving HbA1c <7 %
Absolute change in outcome by race (95 % confidence interval)	AA: OR 1.139 (0.854–1.520) HW: OR 1.038 (0.793–1.361)	AA: 58.2 % MA: 65.5 %	AA: 7.38 %; NHW 6.85 %	AA: OR 0.68 (0.63–0.74) AS: OR 0.65 (0.49–0.87) HW: OR 0.56 (0.37–0.85)	AA: 45 % MA: 44 %	AA: OR 1.88 (1.24–2.85) AS: OR 1.51 (0.91–2.51) Other: OR 1.71 (0.86–3.42)	Unadjusted: MA: OR 0.5 (0.32–0.78) AA: OR 0.58 (0.37–0.92) Adjusted for treatment: MA: OR 0.43 (0.25–0.73) AA: OR 0.61 (0.36–1.03)	AA: 24 % NHW: 34 %
Statistical significance	No statistically significant findings	MA, $p < 0.01$	$p < 0.001$	AA, $p < 0.05$ AS, $p < 0.05$ HW, $p < 0.05$	AA, $p < 0.13$ MA, $p < 0.13$	NR	NR	$p < 0.001$

Table 2 continued

Major findings	Disparities between urban and rural diabetes patient outcomes; rural health centers have an impact on diabetic primary care	Suboptimal health status of all three race groups relative to treatment goals; health status does not seem to be influenced by access to care	Significant difference in medication adherence (10 % lower) and HbA1c (0.5 % lower); AA becoming adherent may decrease disparity	Low level of simultaneous control of HbA1c, LDL, and BP among patients with diabetes; there needs to be more emphasis clinically concerning the simultaneous control of HbA1c, LDL, and BP	Glycemic control has not materially improved in US adults over the past 10 years; AA women and MA men have worst glycemic control; AA and MA diabetics met A1c goals less frequently than NHW 27.4 % diabetic adults met	High frequency of uncontrolled HbA1c levels in patients with type 2 diabetes presenting at emergency department	Glycemic control low among all racial/ ethnic groups but lower among AA and MA	Racial disparities diminished in some aspects of care following quality improvement but difference in glycemic control persisted
Limitations	Potentially unreliable administrative data; potentially additional confounders	Hard to control for current diabetes therapies	No causal inference; possible selection bias	Potential additional confounders; veteran patients lack generalizability; rate of simultaneous control is high	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes	Single department used so limited generalizability; could not classify all diabetes types	Cross sectional nature of study	May not generalize beyond insured population

AA African American, *HW* Hispanic White, AS Asian, *MA* Mexican-American, *PI* Pacific Islander, *NR* not reported, *NHANES* National Health and Nutrition Examination Survey, *LMTID* insulin lispro mix 75/25 twice/day, *LMBID* insulin lispro mix 50/50 three times/day

* Compared to NHW

average HbA1c for statistically significant point estimate studies ranged from 0. 2 to 0.9 for African Americans, 0.28 to 0.76 for Hispanics, and 0.4 to 0.5 for Asian Americans/Pacific Islanders [15–19, 23, 24, 26, 29]. Seven of the 9 studies using thresholds showed significantly better control in non-Hispanic Whites than in minority populations [8, 10, 20–22, 25, 27]. Studies reported different groups of racial/ethnic minorities; however, when measured, Hispanics showed worse control in 2 of 3 studies, African Americans showed worse control in 5 of 7 studies, Mexican-Americans showed worse control in 2 of 3 studies, and Asian Americans showed worse control in 1 of 2 studies [15–29].

Based on a clinically significant difference in HbA1c of 0.5, and the ADA clinically recommended threshold for HbA1c of 7 %, these disparities in glycemic control by racial/ethnic group appear to be clinically important [30]. Since most of the studies were cross-sectional or cohort designs, the reasons for these differences cannot be determined. In addition, when cohort designs are used, the change in HbA1c within a race/ethnicity has been investigated, but rarely has the change over time between racial/ethnic groups [8, 23–28]. This is an important trend to understand to investigate and influence apparent disparities in glycemic control.

Blood pressure

Six papers examining racial differences in blood pressure among individuals with T2DM were reviewed based on inclusion criteria. Three of those studies were cross-sectional, 2 were cohort studies, and 1 was a retrospective cohort study [7, 15, 17, 25, 27, 28]. Across studies, participants included Hispanics, African Americans, Asian Americans, and non-Hispanic Whites with sample size ranging from 998 to 80,207 within managed care clinics and Veteran Administration Medical Center (VAMCs) [7, 15, 17, 25, 27, 28]. Study timeframes ranged from 1 to 10 years; no intervention studies were reviewed in the search. Outcome assessment of blood pressure across papers was BP >140/>90 mmHg [7, 15, 17, 25, 27, 28].

Of the studies reviewed, 4 reported statistically significant racial differences in BP outcome assessments at $p < 0.05$ [7, 15, 17, 27]. Lower levels of control in BP among minority populations were consistently reported among study samples with African Americans showing consistently lower rates of BP control as compared to non-Hispanic Whites and other minority populations [7, 15, 17, 25, 27, 28]. Axon et al. [7] found in a retrospective cohort study that among veterans in the southeastern United States that ethnic veterans with T2DM were at an increased risk of poor BP control when compared to non-Hispanic Whites [7].

Table 3 Articles reviewed that focused on racial differences in blood pressure

Study author [reference]	Brown et al. [15]	Harris [25]	Jackson et al. [27]	McWilliams et al. [17]	Axon et al. [7]	Resnick et al. [28]
Study design	Cross-sectional	Observational cohort	Cohort	Cross-sectional	Observational Cohort	Cohort
Number of participants (completed)	7,456	1,480	80,207	1,733	5,319	998
Sample population	Managed health care plan (CA, HI, IN, MI, NJ, PA, TX)	Adults ≥25 years old, diagnosed with diabetes by a physician before taking the survey (NHANES III)	Veterans who have been diagnosed with type 2 diabetes ≥18 years old	NHANES 1999–2006	VAMC Southeastern US	Adults ≥18 years that self-reported a diagnosis of type 2 diabetes
Duration of intervention	N/A	6 years	1 year	N/A	10 years	3 years
Outcome assessment	Proportion above 140/90 mmHg	Proportion below 140/90 mmHg	Below 140/90 mmHg*	Systolic BP (8 year mean)	BP diastolic <140 mmHg, systolic <90 mmHg*	Proportion below 130/80 mmHg
Absolute change in outcome by race (95 % confidence Interval)	AA: 55.5 % NHW: 41.1 % HW: 38.1 %	AA: 39.6 % MA: 34.7 %	AA: OR = 0.76 (0.71–0.82) AS: OR = 1.18 (0.96–1.45) HW: OR = 1.02 (0.92–1.13)	NHW: 137.8 mmHg AA: 143.5 mmHg HW: 143.8 mmHg	AA: OR 1.38 (1.2–1.5) HW/Other: OR 1.57 (1.3–1.8)	AA: 34 % MA: 43 %
Statistical significance	AA, $p < 0.0001$ NHW, $p = 0.004$	There was no statistical significance	AA, $p < 0.05$ AI, $p < 0.05$	AA, $p < 0.001$ HW, $p < 0.001$	AA, $p < 0.0001$ HW/Other, $p < 0.0001$	AA, $p = 0.18$ MA $p = 0.65$
Major findings	Few clinically significant racial/ethnic disparities in care for group of insured patients	Health status does not seem to be influenced by access to healthcare	Low levels of simultaneous control of HbA1c, LDL, and BP among patients with diabetes; more emphasis needed concerning the simultaneous control of HbA1c, LDL, and BP	Differences in racial/ethic groups did not decrease, difference with HW increased	AA are 38 % less likely to be controlled than NHW; proportion of uncontrolled BP has remained higher in AA and other minority patients	Low levels of simultaneous control of HbA1c, LDL, and BP among patients with diabetes; more emphasis needed concerning the simultaneous control of HbA1c, LDL, and BP
Limitations	May not generalize to non-insured; unable to examine reason for disparities	Potentially unreliable administrative data; inability to fully assess confounders; inability to explain disparities	May be difficult to generalize beyond Veteran population	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes	Unmeasured factors may confound relationship between race/BP; study sample was largely male so may not generalize to female patients; low % of Hispanic patients	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes

AA African American, *HW* Hispanic White, *AS* Asian, *MA* Mexican-American, *NHANES* National Health and Nutrition Examination Survey, *NR* not reported

Although awareness, promotion, and treatment of hypertension has increased in recent years, little progress has been seen in the treatment outcomes of diabetics who have co-morbid conditions such as hypertension, a major risk factor of cardiovascular disease [7]. Investigations within the current literature search suggest that hypertension among ethnic minority populations are consistently less controlled to that of their non-Hispanic White

Table 4 Articles reviewed that focused on racial differences in lipids

Study author [references]	Zhu et al. [31]	Chew et al. [20]	Kirkbride and Wallace [21]	Harris [25]	Jackson et al. [27]	Resnick et al. [28]	Brown et al. [15]	McWilliams et al. [17]
Study design	Cross-sectional	Cross-sectional	Retrospective cross-sectional	Observational cohort	Cross-sectional	Cohort	Cross-sectional	Cross-sectional
Number of participants	4,350	14,822	6,267	1,480	80, 207	998	7.456	1,733
Sample population	Diabetics with at least one pharmacy claim for statin	Diabetics who received continuity of care for at least 2 years with 2 outpatients interactions at 1 of 6 hospitals	Individuals who had been enrolled in Oregon's Medicaid (Oregon Health Plan) and diagnosed with diabetes	Adults ≥25 years old, diagnosed with diabetes by a physician before taking the survey (NHANES III)	Veterans who have been diagnosed with type 2 diabetes, ≥18 years old	Adults ≥18 years that self-reported a type 2 diabetes diagnosis	Managed health care plan (CA, HI, IN, MI, NJ, PA, TX)	NHANES
Duration of intervention	N/A	N/A	N/A	6 years	1 year	3 years	N/A	N/A
Outcome assessment	LDL*	LDL*	Lipids*	LDL <100, HDL <35, Triglycerides <200	LDL*	HDL	LDL	Total cholesterol (8 year mean)
Absolute change in outcome by race (95 % confidence intervals)	AA: OR 0.89 (0.78–1.03) HW: OR 0.78 (0.47–1.28)	Predictor of Good LDL: H: OR 0.88 (0.85–0.91) AS: OR 0.85 (0.74–0.96) Predictor of Poor LDL: AA: OR 1.09, (1.04–1.14) AS: OR 1.18 (1.16–1.20)	AA: OR 0.947 (0.733–1.222) HW: OR 1.137 (0.861–1.427)	HDL / Triglycerides / LDL AA 13.0 % / 74.8 % / 19.6 % MA 20.1 % / 57.3 % / 21.1 %	AA: OR 0.66 (0.60–0.72) HW: OR 1.07 (0.92–1.25) AS: OR1.18 (0.86–1.62)	AA: 29 % MA: 26 %	AA: 118 mg/dL NHW: 111 mg/dL	NHW: 203.9 mg/dL AA: 201.7 mg/dL HW: 200.2 mg/dL
Statistical significance	AA, $p = 0.1156$ HW, $p = 0.3307$	Good LDL: H, $p < 0.001$; AS, $p < 0.01$ Poor LDL: AA, $p < 0.001$; AS, $p < 0.0001$	Findings were not statistically significant	MA + HDL, $p < 0.05$ AA + HDL, $p < 0.001$; MA + LDL, $p < 0.05$ AA + triglycerides, $p < 0.001$	AA, $p < 0.05$	AA + HDL, $p < 0.003$ MA was not statistically significant of any predetermined outcomes	$p < 0.0001$	AA, $p = 0.45$ HW, $p = 0.41$
Major findings	Better adherence to statins lead to better lipid control in diabetes; risk factors for suboptimal LDL-C control and non-adherence to statins	AA and HW were less likely than NHW to have good lipid control; health disparities requires a comprehensive approach that considers the broader society	Disparities between urban and rural diabetes patient outcomes; rural health centers have an impact on diabetic primary care	Suboptimal health status of all three race groups relative to treatment goals; health status does not seem to be influenced by access to care	Low level of simultaneous control of HbA1c, LDL, and BP among patients with diabetes; there needs to be more emphasis clinically concerning the simultaneous control HbA1c, LDL, and BP	Glycemic control has not materially improved in US adults over the past 10 years; AA women and MA men have worst glycemic control; AA and MA diabetics met A1c goals less frequently than NHW 27.4 % diabetic adults met	Few clinically significant racial/ethnic disparities in care for group of insured patients	Differences in racial/ethic groups did not decrease, difference with Hispanics increased

Table 4 continued

Limitations	Statin dispensing information was from Medicaid and could be inaccurate; dispensing does not reflect medication taking behavior;	Potentially unreliable administrative data; inability to fully assess confounders; inability to explain disparities	Potentially unreliable administrative data; there may be additional confounders	Hard to control for current diabetes therapies	Potential additional confounders; veteran patients lack generalizability; rate of simultaneous control is high	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes	May not generalize to non-insured; unable to examine reason for disparities	Serial cross-sectional nature of dataset can differentially alter distribution of outcomes

AA African American, *HW* Hispanic White, *AS* Asian, *MA* Mexican-American, *NR* not reported, *NHANES* National Health and Nutrition Examination Survey

* Compared to NHW

counterparts. Consequently, the racial and ethnic differences among those with T2DM who suffer from high blood pressure still persist.

Lipids

By means of the search strategy of electronic databases, 8 studies met the inclusion criteria for having an outcome measure of lipids. Two of the studies were cohort observational studies and 6 were cross-sectional studies; [15, 17, 20, 21, 25, 27, 28, 31]. All studies assessed the difference in lipids, whether HDL, LDL, triglycerides, or a comprehensive lipid panel, which includes HDL, LDL, and triglycerides. There were no intervention studies that met our predetermined study requirements. Within the studies that were included, 4 reported their results in terms of odds ratios, 2 used percentages within each race to express proportions of the race that had American Diabetes Association recommended lipid levels, and the 2 remaining studies used the mean lipid level for each race evaluated [15, 17, 20, 21, 25, 27, 28, 31].

In addition, study timeframes differed ranging from 1 to 8 years (median 2.5 years). Two studies lasted for 1 year, but only 1 indicated statistical significance [21, 27]. The 8-year observational study showed no statistical significance in the difference of lipids over time by race [31]. Based on these results, the length of a study may not give greater insight into significant differences in lipids by race. In addition, the absence of intervention studies decreases the level of evidence concerning lipid outcomes by race in those with type 2 diabetes.

Along with low levels of evidence, sample population characteristics and sample size also varied, which could have affected the outcome measure and statistical significance [15, 17, 20, 21, 25, 27, 28, 31]. All studies included participants who had been diagnosed with type 2 diabetes; however, there were several differences between sample populations. For instance, Zhu et al. had a sample population of 4,350 adult diabetics with at least one pharmacy claim for a statin; Chew et al. had over 14,000 participants who had to have had continuity of care for at least 2 years with at least 2 outpatient interactions in 1 of 6 hospitals; and Harris conducted a study that included 1,480 participants and defined adults as individuals 25 years and older [20, 25, 31]. Each study tailored its sample population for a specific purpose; therefore, the sample populations may not be comparable.

Despite the variation in sample size and sample population characteristics, the studies did show differences between minority groups in lipid control [15, 17, 20, 21, 25, 27, 28, 31]. Zhu et al. found that African Americans were more likely to have poor lipid control than non-Hispanic Whites and 2 observational cohorts showed that at

least 13 % of their cohorts had lipid levels above recommended levels [25, 28, 31]. Two studies showed Hispanics are more likely to have poor lipid control but only one study was statistically significant [20, 31]. An additional 2 studies indicated that only 20–25 % of Mexican-Americans in the sample population had ADA recommended lipid levels [25, 28]. Asians were less likely to have poor lipid control than any other minority group [20, 27].

Quality of life

As previously mentioned, no papers that investigated quality of life by race and met the inclusion criteria were reviewed for this review.

Summary of evidence

In this literature review, racial differences in monitoring and outcomes among individuals with T2DM were examined by self-monitoring, glycemic control, blood pressure control, lipid control, and quality of life. Of the 22 papers reviewed, 3 papers provided outcomes for self-monitoring, 17 for glycemic control, 6 for blood pressure, and 8 for lipid outcomes by racial/ethnic group [12–31]. Of the self-monitoring papers reviewed, all 3 reported statistical significance in racial differences in self-monitoring when compared to non-Hispanic Whites, suggesting race/ethnicity as a barrier to self-monitoring behaviors [12–14]. Fifteen of the 17 glycemic control studies reported statistical significance in racial differences for glycemic control with a persistent racial gap being present between African Americans and non-Hispanic Whites [8, 10, 13, 15–20, 23–27, 29]. Of the 6 papers reporting differences in blood pressure control, 4 reported statistical significance among minority populations compared to non-Hispanic Whites [7, 15, 17, 27]. Finally, among the 8 studies examining lipid outcomes between races, 5 reported statistical significance; however, sample sizes and the lack of intervention studies may have reduced the level of statistical significance [15, 20, 25, 27, 28].

Overall, this review reveals that significant racial differences and barriers exist in diabetes management as it pertains to self-monitoring and outcomes when compared to non-Hispanic Whites. Explanatory and intervention studies are needed to determine the mechanisms and mediators of these differences and strategies to reduce these disparities. In addition, more research is needed to investigate the impact of racial differences in self-monitoring and outcomes on quality of life.

There are several limitations to this systematic review worth addressing. First, the search was limited to the articles published in English between 1990 and 2012. Second, since studies with positive results are more likely to be published, the studies in this review may reflect this publication bias. Finally, the small number of randomized controlled trials and differences in study methodology prevented a meta-analysis from being performed. Conclusions from this review are therefore qualitative and meant to guide future research rather than provide conclusive answers.

Evidence provided from this search shows that racial/ethnic disparities exist as compared to national and clinical recommendations for proper diabetes management. African Americans tend to consistently exhibit worse outcomes and control when compared to other minority populations and non-Hispanic Whites. Further research is needed to determine the barriers leading to these disparities and investigate the impact on quality of life.

Conflict of interest The authors declare that they have no conflict of interest.

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