# Association of Anxiety With High-Cost Health Care Use Among Individuals With Type 2 Diabetes

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## OBJECTIVE

**People with type 2 diabetes vary greatly in their use of high-cost health care resources. We examined the association of anxiety with high-cost use after accounting for depression and medical comorbidity.**

## RESEARCH DESIGN AND METHODS

**Using electronic health record data, we assessed past anxiety diagnosis, health care use and costs, demographics, comorbidities, and diabetes control status and complications during 2008–2012 for 143,573 adult members of an integrated health care system with type 2 diabetes. Multivariable regression models estimated associations between anxiety and emergency department (ED) use, total hospitalization costs, and high-cost status (i.e., incurring total health care costs in the top 20% among all system members).**

## RESULTS

**During 2008–2011, 12.9% of participants received a diagnosis of anxiety, of whom 52.9% also had received a depression diagnosis. After adjusting for covariates including depression, anxiety was positively related to the number of ED visits in 2012 (incidence rate ratio 1.27; 95% CI 1.21, 1.34); the likelihood of visiting the ED on a chronic, frequent basis during 2010–2012 (odds ratio 2.55; 95% CI 1.90, 3.44); and high-cost status in 2012 (odds ratio 1.29; 95% CI 1.23, 1.36), but anxiety was not related to total hospitalization costs in 2012 (relative cost ratio 1.06; 95% CI 0.94, 1.21; $P = 0.33$).**

## CONCLUSIONS

**Anxiety is highly comorbid with depression among individuals with type 2 diabetes and is independently associated with high-cost resource use. Strategies to improve anxiety management among people with diabetes hold the potential to also reduce health care costs.**


Total medical costs for individuals with diabetes exceeded $414 billion in the U.S. in 2017, of which the largest portion (30%) was inpatient hospitalizations (1). People with diabetes account for one out of eight emergency department (ED) visitors (1) and, due to their often greater medical complexity, these individuals are several times more likely than the general population to be admitted to the hospital rather than treated and released (2). There is significant variability in ED visits and hospitalizations among people with diabetes, with an estimated 20–45% of hospitalizations considered potentially avoidable (3,4). To combat expanding costs, conserve limited hospital resources, and improve health and quality-of-life outcomes, it is important to identify modifiable factors that predict ED visits and hospitalizations for those with diabetes.

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The American Diabetes Association recommends clinical screening for mental health conditions, particularly anxiety and depression, due to their increased prevalence among individuals with diabetes and their adverse associations with self-management (5,6). Evidence suggests that mental health conditions also relate to costs, including increased hospitalization and total health care costs (7), greater ED use (8), and higher likelihood of visiting the ED on a chronic, frequent basis (9). Most prior studies in this area have focused on the role of depression (10). As with depressive disorders, anxiety disorders are common—affecting 12–20% of the general population with 20% higher prevalence among individuals with diabetes (11). Anxiety disorders involve persistent fear or worry, autonomic hyperarousal, and behavioral disturbance such as extreme avoidance and self-reassuring behaviors. The few diabetes-focused studies that have examined the role of anxiety in health care use have not isolated its independent effect apart from other mental health conditions (12–15) or have focused on an anxiety subtype (16,17). In the current study, we examined associations between anxiety diagnosis and a range of outcomes related to high-cost health care use. We hypothesized that anxiety would have positive associations with use and cost outcomes after adjusting for other predictors.

## RESEARCH DESIGN AND METHODS

### Study Population

Kaiser Permanente Northern California (KPNC) is an integrated health care delivery system covering >4 million members, comprising 31% of the regional population. KPNC members are covered by commercial insurance plans (45%), Medicare (28%), Medicaid (9%), or other coverage (18%) and reflect the demographic characteristics of the region as a whole. The population base was 824,145 KPNC adults who were continuously enrolled between 1 January 2008 and 31 December 2012 and were classified as having a chronic health condition, excluding those who were severely frail or near the end of life, based on previously described segmentation analyses (18,19). From this population base, we selected 143,573 adults with any electronic health record (EHR) diagnosis during 2008–2011 of type 2 diabetes (and not type 1 diabetes) using ICD-9-CM diagnostic codes 250.xx and the inclusion in the KPNC Diabetes Registry by 31 December 2011. This highly reliable registry identifies system members with diabetes using a clinically validated algorithm incorporating EHR diagnostic codes, medications, and laboratory results (20,21). The study was approved by the KPNC Institutional Review Board.

### Anxiety and Depression

The presence of a range of mental health comorbidities was defined by diagnosis codes extracted from participants' EHRs. Anxiety was defined as present if the participant had any EHR diagnosis during 2008–2011 based on the following ICD-9-CM diagnosis codes: generalized anxiety disorder (300.02), panic disorder or agoraphobia (300.01, 300.21, 300.22), specific phobia (300.2x), social anxiety (300.23), obsessive compulsive disorder (300.3), post-traumatic stress disorder (309.81), and other anxiety (300.00, 300.09). Depression was defined as ICD-9-CM codes for a depressive disorder (296.2x, 296.3x, 296.82, 298.0, 300.4, 301.12, and 311) recorded in the EHR in 2008–2011.

### ED Use, Hospitalization Costs, and High-Cost Status

Use and cost data were obtained and summarized from the KPNC administrative and Cost Management Information Systems databases for the study period. ED use was examined in two ways: a count of the total number of visits in 2012, and a dichotomous indicator of being a chronic, frequent visitor to the ED (defined, as in past research [9], as three or more ED visits during 3 consecutive years, which in the current study were counted during 2010–2012).

Total hospitalization costs in 2012 included costs for visits to KPNC hospitals and billings from non-KPNC hospitals for inpatient services. High-cost status in 2012 was a dichotomous variable representing the participant's presence in the top 20% of all health system members with or without diabetes based on total costs in the year. Total costs reflected all within-system health care services and pharmacy costs, and billings from outside inpatient and outpatient claims.

### Covariates

Demographic variables extracted from the EHR included age, sex, race/ethnicity, and health plan type. Overall disease burden was assessed using 2011 DxCG, a validated measure used for prospective risk adjustment (22–24). In a past head-to-head comparison, DxCG performed equivalently to the Charlson comorbidity index in predicting which individuals would incur the highest levels of health care costs (25), making this measure appropriate for our study focusing on high-cost use. Glycemic control was based on the most recent laboratory value (from 2008 to 2011) for hemoglobin $A_{1c}$ ($HbA_{1c}$), excluding erroneous, out-of-range values. BMI was calculated from the most recent 2008–2011 EHR values for height and weight. $HbA_{1c}$ and BMI values from 2011 were available for nearly all participants (95.6% and 93.6%, respectively).

Diabetes complications and other health conditions were coded dichotomously by category based on the presence of relevant ICD-9-CM diagnosis codes during 2008–2011. Diabetes complications (see ICD-9-CM codes in Supplementary Fig. 1) included cerebrovascular disease, cardiovascular disease, peripheral vascular disease, nephropathy, retinopathy, neuropathy, lower limb ulcers or amputations, and metabolic complications. We also included dichotomous variables representing common, non–diabetes-related health conditions found previously to explain the preponderance of system-wide health care costs (26) (e.g., injury or poisoning, hypertension, lower back pain, asthma, chronic obstructive pulmonary disease, pneumonia, psychoses, and substance-related diagnoses) (see complete list with ICD-9-CM codes in Supplementary Fig. 2).

### Analytic Approach

We compared participants with and without anxiety using $\chi^2$ statistics and Wilcoxon rank sum tests. We used multivariable regression modeling, adjusting for age, sex, race/ethnicity, health plan type, overall disease burden, $HbA_{1c}$, BMI, diabetes complications, depression, and other health conditions to assess the independent association of anxiety with our clinical use and cost outcomes. Models also included an (anxiety × depression) interaction term to help distinguish between the additive and interactive effects of anxiety and depression. Multiple imputation was used to address the small proportion of missing $HbA_{1c}$ and BMI values.

Logistic regression models tested associations with the two dichotomous outcomes (chronic, frequent ED use during 2010–2012 and high-cost status in 2012). The high-cost status model additionally adjusted for prior high-cost status (classification in the top 20% of costs among all KPNC members every year during 2009–2011). To assess predictors of the number of ED visits in 2012, we conducted zero-inflated negative binomial regression to handle this right-skewed and overdispersed count outcome containing a high frequency of zero values (27). We modeled the zero-inflation factor on all predictors/covariates and also the number of ED visits in 2011. Negative binomial model estimates were reported as incidence rate ratios (IRRs) to reflect the multiplicative effect on average annual ED visits associated with each predictor. We estimated a generalized linear model using a gamma distribution with log link for the analysis of total hospitalization costs in 2012 due to the right-skewed, nonnegative, continuous nature of these data (28). This model yielded relative cost ratios (RCRs) signifying the multiplicative effect of each predictor on average 1-year total hospitalization costs. Data analyses were performed in STATA 15 (29).

## RESULTS

During the 2008–2011 period, 12.9% of participants received at least one anxiety diagnosis (Table 1). Participants with anxiety, relative to those without, were younger (mean age 62.1 ± 12.6 vs. 63.7 ± 12.5 years, $P < 0.001$) and more likely to be women (63.2% vs. 45.9%, $P < 0.001$) or individuals covered by a health plan for those with low income or disability (e.g., 5.6% vs. 2.9% Medicare with special needs, $P < 0.001$). There were different proportions of participants by race/ethnicity across anxiety status; most notably Asians and Pacific-Islanders were less represented among those with an anxiety diagnosis (13.0% vs. 21.5% without an anxiety diagnosis). Participants with anxiety also had higher overall disease burden, higher BMI (mean BMI 33.1 vs. 32.1, $P < 0.001$), and higher prevalence of obesity (i.e., BMI ≥ 30; 62.0% vs. 57.0%, $P < 0.001$) compared with those without anxiety. A statistically significant but clinically minimal difference in $HbA_{1c}$ was noted (mean $HbA_{1c}$ 7.3% [56 mmol/mol] vs. 7.4% [57 mmol/mol] for those with and without anxiety, $P < 0.001$). Participants with anxiety were generally more likely to be diagnosed with diabetes complications and with other health conditions compared to those without anxiety (Supplementary Table 1).

Compared with participants without anxiety, those with anxiety were more likely to visit the ED in 2012 (35.2% vs. 23.6% had any visit; mean annual visits 0.75 ± 1.7 vs. 0.40 ± 0.98; both $P < 0.001$) (Table 2). Over the 2010–2012 period, 568 participants (0.4%) visited the ED three or more times all 3 years, with proportions much higher among participants with anxiety (1.5% vs. 0.2% among participants without anxiety, $P < 0.001$). Average 2012 hospitalization costs were higher for participants with anxiety ($5,790.45) compared with those without anxiety ($4,105.89; $P < 0.001$). A higher proportion of participants with anxiety (61.0%) were classified as having high-cost status in 2012 (vs. 42.1% of participants without anxiety, $P < 0.001$).

### Anxiety, Depression, and Indicators of High-Cost Health Care Use

Results from multivariable models found that anxiety and depression each accounted for 27% and 13% higher rates of ED visits, respectively (IRR 1.27 [95% CI 1.21, 1.34] for anxiety and 1.13 [95% CI 1.09, 1.18] for depression) (Table 3). Anxiety was associated with 2.55 times higher odds of visiting the ED on a chronic, frequent basis (odds ratio [OR] 2.55 [95% CI 1.90, 3.44]); depression was also positively related to this outcome (OR 1.66 [95% CI 1.29, 2.14]).

Depression diagnosis was related to 15% higher average hospitalization costs in 2012 (RCR 1.15 [95% CI 1.04, 1.26]), but, contrary to expectations, anxiety was not significantly associated with this outcome after adjusting for other covariates. Both anxiety and depression were significantly associated with high-cost status in 2012 as hypothesized; each related to 29% higher odds of being in the top 20% of system members by cost (OR 1.29 [95% CI 1.23, 1.36] and 1.29 [95% CI 1.24, 1.34], respectively).

For three of four outcomes, there was no significant anxiety × depression interaction effect ($P$ values = 0.37–0.97), suggesting that these two diagnoses posed simple additive risks when found in the same individuals. For high-cost status, there was a small but significant interaction effect in an inverse direction (OR 0.90 [95% CI 0.83, 0.98]; $P = 0.01$), suggesting that the combined effect of anxiety and depression was slightly lower than what would have been predicted from simply adding the two effects together (data not shown).

We repeated the analysis predicting chronic, frequent ED visits but limited the outcome measurement to the year 2012 (likelihood of three or more visits in that year) to avoid overlap with the anxiety measurement time frame. Anxiety and depression comorbidity continued to independently predict the outcome, with anxiety showing a stronger effect than depression (anxiety: OR 1.61 [95% CI 1.46, 1.77]; $P < 0.001$; depression: OR 1.33 [95% CI 1.24, 1.44]; $P < 0.001$; data not shown). To reduce the impact of including possibly misclassified individuals with another type of diabetes, we also conducted a sensitivity analysis excluding the 1.3% of participants <35 years of age. Since results were unchanged, we present only findings from data with all participants.

## CONCLUSIONS

In this large, diverse sample of people with type 2 diabetes, anxiety diagnosis was independently associated with more annual visits to the ED and a pattern of chronic, frequent ED visits over multiple years, even after accounting for other types of complexity such as depression, glycemic control, diabetes complications, and non–diabetes-related health conditions. Participants with anxiety were disproportionately among the costliest segment of health system members. This cost burden appeared driven in part by ED use, as total hospitalization costs, which are known to drive overall health care expenditures for people with diabetes, were not elevated for those with anxiety after accounting for other factors. By addressing multiple sources of medical and mental health complexity, our results expand upon past work suggesting that comorbid anxiety predicts higher overall health care costs in diabetes but not due to increased hospitalization costs (14). These results support the potential system-level benefit of increasing clinical efforts to identify and treat individuals' anxiety in tandem with their diabetes.

**Table 1—Characteristics of participants with and without diagnosed anxiety**

| | No anxiety diagnosis | Any anxiety diagnosis | Total sample | *P* value |
|---|---|---|---|---|
| Number of people | 125,012 (87.1) | 18,561 (12.9) | 143,573 (—) | |
| Characteristics in 2011 | | | | |
| Age | 63.7 ± 12.5 | 62.1 ± 12.6 | 63.5 ± 12.5 | <0.001 |
| 18–39 | 4,266 (3.4) | 825 (4.4) | 5,091 (3.6) | <0.001 |
| 40–64 | 62,685 (50.1) | 10,126 (54.6) | 72,811 (50.7) | <0.001 |
| ≥65 | 58,061 (46.4) | 7,610 (41.0) | 65,671 (45.7) | <0.001 |
| Women | 57,355 (45.9) | 11,723 (63.2) | 69,078 (48.1) | <0.001 |
| Race/ethnicity | | | | |
| White | 58,683 (46.9) | 9,751 (52.5) | 68,434 (47.7) | <0.001 |
| Non-White Hispanic/Latino | 24,987 (20.0) | 4,529 (24.4) | 29,516 (20.6) | <0.001 |
| Asian/Pacific Islander | 26,896 (21.5) | 2,413 (13.0) | 29,309 (20.4) | <0.001 |
| Black/African American | 13,610 (10.9) | 1,728 (9.3) | 15,338 (10.7) | <0.001 |
| Native American | 836 (0.67) | 140 (0.75) | 976 (0.68) | 0.19 |
| Health plan type | | | | |
| Commercial plan | 69,257 (55.4) | 10,216 (55.0) | 79,473 (55.4) | 0.36 |
| Medicare with special needs | 3,596 (2.9) | 1,047 (5.6) | 4,643 (3.2) | <0.001 |
| Other Medicare | 51,272 (41.0) | 7,021 (37.8) | 58,293 (40.6) | <0.001 |
| Medicaid for seniors/people with disabilities | 297 (0.24) | 132 (0.71) | 429 (0.30) | <0.001 |
| Other Medicaid | 590 (0.47) | 145 (0.78) | 735 (0.51) | <0.001 |
| DxCG | 0.84 ± 0.85 | 1.06 ± 0.99 | 0.87 ± 0.87 | <0.001 |
| $HbA_{1c}$ | | | | |
| % | 7.4 ± 1.5 | 7.3 ± 1.5 | 7.4 ± 1.5 | <0.001 |
| mmol/mol | 57 ± 16.4 | 56 ± 16.4 | 57 ± 16.4 | |
| Missing | 577 (0.46) | 69 (0.37) | 646 (0.45) | 0.09 |
| BMI | 32.1 ± 7.0 | 33.1 ± 7.5 | 32.2 ± 7.1 | <0.001 |
| <18.5 | 349 (0.28) | 45 (0.24) | 394 (0.28) | 0.37 |
| 18.5–24.9 | 15,562 (12.5) | 2,030 (11.0) | 17,592 (12.3) | <0.001 |
| 25–29.9 | 37,737 (30.3) | 4,981 (26.9) | 42,718 (29.8) | <0.001 |
| ≥30 | 71,055 (57.0) | 11,489 (62.0) | 82,544 (57.6) | <0.001 |
| Missing | 309 (0.25) | 16 (0.09) | 325 (0.23) | <0.001 |
| Other behavioral health diagnoses in 2008–2011 | | | | |
| Depression | 17,176 (13.7) | 9,811 (52.9) | 26,987 (18.8) | <0.001 |
| Alcohol use disorders | 3,179 (2.5) | 1,138 (6.1) | 4,317 (3.0) | <0.001 |
| Psychoses | 2,419 (1.9) | 1,635 (8.8) | 4,054 (2.8) | <0.001 |
| Drug use disorders | 1,146 (0.92) | 926 (5.0) | 2,072 (1.4) | <0.001 |

Data are *n* (%) or mean ± SD, unless otherwise specified.

Future studies should examine what might drive an association between anxiety disorders and ED use among people with diabetes, and what strategies might address these use patterns more effectively. By virtue of enrollment in the KPNC system, study participants had access to comprehensive primary care and specialty outpatient services. Other research has found that individuals with diabetes and high ED use also use more primary care, behavioral health, and other outpatient services (30), suggesting that a lack of health care access does not drive these ED visits. Rather, there may be important obstacles related to lack of care coordination and integration across the management of chronic disease and mental health conditions. As one example in diabetes management, some individuals might struggle to distinguish anxiety symptoms (e.g., panic attack) from potential diabetes complications (e.g., severe hypoglycemia) leading to potential mismanagement of the underlying condition. Additionally, some anxiety symptoms are intrinsically linked with diabetes itself, as in the case of hypoglycemia-related fear (31) and needle-related anxiety (32), both of which could interfere with self-management. The clinical response to these challenges should involve consideration of both

**Table 2—High-cost health care use by anxiety diagnosis**

| High-cost health care use | No anxiety diagnosis | Any anxiety diagnosis | Total sample | *P* value |
|---|---|---|---|---|
| Number of people | 125,012 (87.1) | 18,561 (12.9) | 143,573 (—) | |
| ED visits in 2012 | | | | |
| Any | 29,457 (23.6) | 6,530 (35.2) | 35,987 (25.1) | <0.001 |
| Total number | 0.40 ± 0.98 | 0.75 ± 1.7 | 0.44 ± 1.1 | <0.001 |
| Chronic, frequent ED visitor status in 2010–2012 | 285 (0.23) | 283 (1.5) | 568 (0.40) | <0.001 |
| Total 2012 hospitalization costs | $4,105.89 ± 20,172.35 | $5,790.45 ± 27,274.29 | $4,323.67 ± 21,232.06 | <0.001 |
| High-cost status in 2012 relative to all system members | 52,572 (42.1) | 11,314 (61.0) | 63,886 (44.5) | <0.001 |

Data are *n* (%) or mean ± SD, unless otherwise specified.

**Table 3—Adjusted effects of anxiety and depression on high-cost health care use**

| Predictors | High-cost health care use | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of ED visits in 2012* | | | Chronic, frequent ED visitor status 2010–2012 | | | Total hospitalization costs in 2012 | | | High-cost status in 2012† | | |
| | IRR | (95% CI) | *P* | OR | (95% CI) | *P* | RCR | (95% CI) | *P* | OR | (95% CI) | *P* |
| Anxiety | 1.27 | (1.21, 1.34) | <0.001 | 2.55 | (1.90, 3.44) | <0.001 | 1.06 | (0.94, 1.21) | 0.33 | 1.29 | (1.23, 1.36) | <0.001 |
| Depression | 1.13 | (1.09, 1.18) | <0.001 | 1.66 | (1.29, 2.14) | <0.001 | 1.15 | (1.04, 1.26) | 0.004 | 1.29 | (1.24, 1.34) | <0.001 |

All models adjusted for age, sex, race/ethnicity, health plan type, overall disease burden, $HbA_{1c}$, BMI, diabetes complications, other health conditions, and an anxiety ×depression interaction term. *Model included a zero-inflation factor regressed on all predictors/covariates and also number of ED visits in 2011. †Model also adjusted for 2009–2011 cost status.

diabetes- and anxiety-related factors, as each complicates the other.

Past research has found that treatment strategies integrating behavioral and physical health objectives benefit individuals' outcomes and health care delivery, including through reduced depressive symptoms and $HbA_{1c}$; improved diabetes self-management; and better health care quality, use, and cost outcomes (33,34). The current findings also suggest the value of screening for anxiety symptoms among people with diabetes, an area that has received little research focus to date (6). Systematic psychological screening using validated measures can identify individuals who may benefit from treatment (35). The presence of a small number of participants (<300) with comorbid anxiety and chronic, frequent ED visits suggests the potential for a feasible intervention directed to individuals fitting this costly use pattern.

This study had several limitations, which future research should address. The use of EHR codes allowed us to measure anxiety and other comorbidities among a large cohort. Because we could not confirm these diagnoses through gold standard clinical interviews, it is possible that individuals' diagnostic status was misclassified in some instances. However, such misclassification would tend to bias our results toward the null. For some participants, their anxiety symptoms may have been better described as diabetes distress, which was not systematically captured in the EHR data. Diabetes distress encompasses a range of negative emotional reactions specific to diabetes self-management (36), and it remains to be understood how diabetes distress relates to high-cost health care use. Our study also did not focus on mechanisms explaining ED visits among people with diabetes and anxiety disorders. Future work should study factors related specifically to ED visits, for example, by examining (and validating) diagnoses recorded during ED visits, tracking clinical follow-up processes, and gathering qualitative data through chart reviews or interviews with patients. A more detailed longitudinal data set establishing the onset of diabetes, anxiety disorder, and other comorbidities in relation to ED visit timing would strengthen our understanding of the causal relationships among these variables. The current study also did not account for medication regimen, which is known to relate to symptoms of psychological distress in diabetes (6). Our models partially addressed the role of more advanced diabetes, which is associated with insulin treatment, through the inclusion of many relevant variables (e.g., age, diabetes-related complications, BMI, glycemic control).

Our results suggest that identifying and mitigating anxiety may be one route to controlling costs, increasing health care efficiency, preventing individuals' unnecessary exposure to medical risks, and improving health and quality-of-life outcomes in this population of people facing complex challenges. Anxiety disorders, which are identifiable and treatable through well-validated and time-efficient strategies (37), appear to impact many areas of health and quality of life in diabetes. The current study, by demonstrating a unique link between anxiety and high-cost health care use in diabetes, provides an additional rationale for why this common human experience requires closer study.

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**Author Contributions.** E.I. developed the study concept, performed the literature review, analyzed and interpreted the data, and wrote the manuscript. F.W.C. contributed to the study concept, data acquisition, data interpretation, and manuscript revision. R.W.G. contributed to the study concept, data interpretation, and manuscript revision. C.W. contributed to the study concept and manuscript revision. L.V.D. contributed to data interpretation and manuscript revision. A.P. and S.B. contributed to data acquisition. P.M. and R.P. contributed to the study concept. S.A.S. contributed to the study concept, data acquisition, data interpretation, and manuscript revision. E.I., F.W.C., R.W.G., C.W., L.V.D., A.P., S.B., P.M., R.P., and S.A.S. critically reviewed the manuscript. E.I. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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