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Living well with diabetes in Alaska

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ABSTRACT

Many people with diabetes mellitus experience minimal or no complications. Our objective was to determine the proportion of Alaska Native people who experienced four major complications or mortality and to identify factors that may be associated with these outcomes. We used records in a diabetes registry and clinical and demographic variables in our analyses. We used logistic regression and Cox Proportional Hazards models to evaluate associations of these parameters with death and complications that occurred prior to 2013. The study included 591 Alaska Native people with non-type 1 diabetes mellitus, diagnosed between 1986 and 1992. Over 60% of people in this study remained free of four major diabetes-related complications for the remainder of life or throughout the approximately 20-year study period. Lower BMI, higher age at diagnosis of diabetes, and use of at least one diabetes medication were associated with death and a composite of four complications. A majority of Alaska Native people with DM had none of four major complications over a 20-year period. Lower BMI and use of diabetes medications were associated with higher hazard for some deleterious outcomes. This suggests that goals in care of elders should be carefully individualised. In addition, we discuss several programme factors that we believe contributed to favourable outcomes.

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Introduction

Diabetes mellitus (DM) is a well-documented risk factor for several complications [1]. However, many people with DM do very well with minimal to no complications. The long history of the Alaska Native Diabetes Registry, which began in 1985, has made it possible to look at several long-term indicators of well-being and complications among Alaska Native people diagnosed with DM prior to 1 January 1993. The registry tracks diagnostic basis, demographic, mortality, incidence of lower extremity amputation (LEA) and end-stage renal disease (ESRD) on an ongoing basis. Cases of myocardial infarction (MI) and stroke (CVA) have been ascertained periodically for specific purposes. Incidence of LEA, ESRD, CVA, MI, and death were previously published [2–6].

The Alaska Native Tribal Health System consists of a network of rural clinics, most of which are staffed by Community HealthAides/Practitioners, subregional clinics staffed primarily by physician assistants and nurse practitioners, six regional referral hospitals, and a tertiary referral centre (Alaska Native Medical Center, ANMC) in Anchorage.

Each year since 1986, the Indian Health Service has required an audit of randomly selected medical records of people with DM who are ambulatory and living in the community. These reviews document metabolic parameters, blood pressure, and process of care according to care standards at the time of the audit. We present here an analysis of longevity and complications (CVA, MI, LEA and ESRD) among Alaska Native people with DM diagnosed prior to 1 January 1993. The analysis is based on data available as of 31 December 2012 and includes information from records of complications from the registry, detailed review of medical records, and causes of death as stated on death certificates, and metabolic parameters included in the audits. Our objectives were three-fold: 1) to determine the number and proportion of people who have lived at least 20 years following the diagnosis of DM; 2) to determine the proportion that have experienced each of the four major complications noted above; 3) to identify factors that may be associated with mortality and complications. The project plan, including a request for waiver of consent, was approved by the Alaska Area Institutional Review Board (AAIRB) (protocol # 2017-04-021). Approval was granted by appropriate Tribal organisations.

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Methods

Since the registry's inception in 1985, electronic clinical databases have been searched for pertinent ICD-9 or-10 codes. Individual records are reviewed for verification of diagnoses. Dates and causes of deaths are ascertained from state of Alaska vital statistics. We reviewed all available electronic medical records through 31 December 2012 at regional and subregional facilities, ANMC, and associated outpatient clinics for two groups of Alaska Native people diagnosed with diabetes prior to 1 January 1993 whose last known residence was in Alaska. Complications and deaths included in this study occurred prior to 1 January 2013.

We divided study subjects into two groups. One group (204 people) consists of those who were diagnosed prior to 1 January 1986 and who lived a minimum of 20 years following diagnosis. Because we do not have actual diagnosis dates for these people, and therefore do not know the age at diagnosis, we did not include them in statistical analyses. However, we did determine the proportions experiencing complications during 20 years of observation.

The other group consists of 601 Alaska Native people diagnosed with DM from 1 January 1986 through 31 December 1992. Since we have actual dates of diagnosis for this group, we can include age at diagnosis in models that examine the association of age at diagnosis with complications and/or death.

For statistical analyses of associations of events with audit data, cases of diabetes were classified as type 1 versus non-type 1. Persons with gestational diabetes were not included in the study. To determine the type of diabetes, we reviewed the diagnoses made by the primary clinician and considered factors such as age at presentation, treatment with insulin versus other medications, and other clinical factors. Non-type 1 included persons for whom factors such as prescription of steroids or other underlying conditions may have contributed to the development of DM.

At the inception of the registry and in medical records, Alaska Native individuals were designated as belonging to one of three groups, referred to in this report as "ethnicities". Group 1 included people of Athabascan, Tlingit, Haida, or Tsimshian ancestry. Group 2 included people living on or descended from people of the Aleutian or Pribilof Islands, most of the Alaska Peninsula, and the Kodiak Region. Group 3 included individuals living in or descended from people of the coastal regions of the northern, western, and southwestern mainland as well as St. Lawrence and Nunivak Islands. Because these groupings were found to correlate with complications and mortality in the past [3,6], we examined the occurrence of these outcomes by group as described above.

Ascertainment of complications

To ascertain records of complications (LEA, ESRD, CVA, and MI), we reviewed all available electronic medical data at regional facilities, ANMC and associated outpatient clinics, and existing records in the registry. Records of LEA and ESRD have been maintained in the registry on an ongoing basis since 1 January 1986. Case ascertainment is based on searches for pertinent ICD and procedure codes at ANMC and all regional referral hospitals and clinics, and by active surveillance of diabetes care coordinators at each of the facilities. Cases of LEA are classified as diabetes-related if they occurred after the diagnosis of diabetes and were not clearly caused by trauma or frostbite. Cases of ESRD are classified as diabetes-related if they occurred after the diagnosis of diabetes and were not clearly caused by some other condition. In this study, renal failure listed as a first cause of death for people with DM who had not received renal replacement therapy was counted as cases of diabetic ESRD. Keyword searches of medical records for terms indicating LEA and ESRD were also used to verify completeness of the registry data.

To ascertain cases of CVA and MI, we performed key word searches followed by a detailed review of outpatient and inpatient notes, imaging studies and readings of electrocardiograms. Quality of evidence for MI and CVA varied so degrees of certainty were established. If the actual date of a CVA or MI could not be determined, the earliest date of mention in the record was taken as the event date.

Cases of CVA were classified as confirmed if they met any of the following criteria: clearly stated diagnosis by a neurologist; clear evidence on imaging; definite statement of localised deficits attributed to stroke that were anatomically compatible with the diagnosis; stroke as first cause of death on a death certificate. CVAs were classified with lesser degrees of certainty if supporting details were not found, transient ischaemic attack (TIA) was not ruled out, or CVA was listed as an underlying cause of death without any other evidence.

Cases of MI were classified as confirmed if they met any of the following criteria: clearly stated diagnosis by a cardiologist; clearly stated evidence from imaging or ECG; definite description of details such as affected anatomic regions of the myocardium; a statement of type of MI such as STEMI or NSTEMI; MI as first cause of death on a death certificate. MIs were classified with lesser degrees of certainty if supporting details were not found, doubt was expressed by the diagnosing clinician, or MI was listed as an underlying cause of death without other evidence.

Audit methods

Each year in each regional facility, charts were randomly selected for audit. The most recent values within the prior year of the following were recorded: lipids, HbA1C, blood pressure (most recent up to three readings), weight, and diabetes medications. Only data obtained within the prior year were recorded [7–11]. Median values of audited parameters were calculated for each person and were used in analyses, with the precision of the median used differing depending on the number of audits. Tobacco use was inconsistently coded from year to year and proved to be unusable in our analyses.

Statistical analyses

We performed statistical analyses to evaluate associations of demographic and audit data with complications and death among people with non-type 1 DM diagnosed in 1986–92. We used logistic regression models to examine the presence or absence of complications and Cox proportional hazards models when considering time to event. Log rank tests were used to compare survival in univariate analyses, and contingency tables were evaluated with chi-square tests as appropriate. Covariates in multivariable models were selected based on their clinical relevance and contribution to overall model fit. All analysis was done using R version 4.13 [12].

Results

Among 805 Alaska Native people diagnosed with DM prior to 1 January 1993, 204 were diagnosed at an unspecified date prior to 1986 but survived at least 20 years beyond 31 December 1985. Six-hundred one individuals were diagnosed on a specified date in 1986–1992. Among these, 303 (50.4%) survived at least 20 years beyond the date of diagnosis.

Among the 805 study subjects, only 18 had no ANMC record and a local record that was judged to be inadequate; 15 were among the 601 diagnosed in 1986–1992.

The proportions experiencing complications were fairly comparable in the different diagnosis date and survival groups (Table 1). Among those diagnosed prior to 1986, 117 people (57.4%) had no complications documented during at least 20 years of survival past diagnosis.

Among all 601 people diagnosed in 1986–92, 108 (18%) had at least one stroke (one had type 1 DM), 103 (17.1%) had at least one MI, 30 (5.0%) had at least one LEA, 11 (1.8%) had chronic renal replacement, and 7 (1.2%) died of renal failure without renal replacement (Table 1). Three hundred sixty-eight people (61.2%) had no complications documented during their remaining life or prior to 2012.

Among the 591 people with non-type 1 diabetes diagnosed in 1986–1992, records on 464 (77.2%) were randomly selected for at least one audit. However, for each parameter, some audits had missing data, so the number of persons included for each audit parameter differed. The number of audits varied widely among these 464 persons. The maximum was 15, and the median was 5 with lower and upper quartiles of 3 and 8 audits per person. The likelihood of any audit and the number of audits increased with the duration of time that a person was alive. The medians and means for each parameter are expressed in Table 2.

Table 1. Demographics, complications, and longevity among Alaska Native people diagnosed with diabetes prior to 1 January 1993.

	Diagnosed <1986, survived ≥20 years (15 type 1) N (%)	Diagnosed 1986–92, all (10 type 1) N (%)	Diagnosed 1986–92, survived ≥20 years (8 type 1) N (%)	Diagnosed 1986–92, survived <20 years (2 type 1) N (%)
	204 (100)	601 (100)	303 (50.4)	298 (49.6)
Group 3	64 (31.4)	193 (32.1)	90 (46.6)	103 (53.4)
Group 1	87 (42.6)	288 (47.9)	147 (51.0)	141 (49.0)
Group 2	53 (26.0)	120 (20.0)	66 (55.0)	54 (45.0)
Men	74 (36.3)	259 (43.1)	117 (45.2)	142 (54.8)
Women	130 (63.7)	342 (56.9)	186 (54.4)	156 (45.6)
LEA after Dx	14 (6.9)	30 (5.0)	13 (4.3)	17 (5.7)
Toe	2 (1.0)	8 (1.3)	5(1.7)	3 (1.0)
Through foot	1 (0.5)	1 (0.2)	0 (0)	1 (0.3)
BK or AK, unilateral	6 (2.9)	17 (2.8)	6 (2.0)	11 (3.7)
BK or AK, bilateral	5 (2.5)	4 (0.7)	2 (0.7)	2 (0.7)
ESRD after Dx	14 (6.9)	18 (3.0)	10 (3.3)	8 (2.7)
Renal replacement	12 (5.9)	11 (1.8)	9 (3.0)	2 (0.7)
Death, no renal replacement	2 (1.0)	7 (1.2)	1 (0.3)	6 (2.0)
Stroke after Dx	44 (21.6)	108 (18.0)	55 (18.2)	53 (17.8)
MI after Dx	36 (17.6)	103 (17.1)	58 (19.1)	45 (15.1)

Table 2. Summaries of audit data, 464 Alaska Native people with non-type 1 diabetes, diagnosed 1986–1992.

Variable	Mean*	Med*	Q25	Q75	n	missing
Age at Dx	54.4	54.6	45.5	63.6	464	0
Number of audits	5.67	5	3	8	464	0
Follow up time	18.9	20.8	15.6	22.8	464	0
Audit age	64.8	66	56.4	74	464	0
BMI	33.3	32.5	29	36.5	440	24
HBA1C	7.85	7.45	6.8	8.7	437	27
Triglyceride	200	174	125	248	440	24
Total cholesterol	197	192	170	218	450	14
HDL cholesterol	49.1	47	38.5	57	340	124
LDL cholesterol	99.3	97	80	113	355	109
Systolic mean blood pressure	136	134	127	143	461	3
Diastolic Mean blood pressure	73.2	73	68	78	461	3

*Values are means and medians of median values obtained for each person on one or more audits

Association of audited parameters with complications and death

Death

Among all 601 people diagnosed with DM in 1986–1992, 303 (50.4%) survived at least 20 years beyond diagnosis (Table 1). The mean and median ages at death among the 591 people with non-type 1 DM were 73.65 and 75 years. A model that included ethnicity, gender, and age at diagnosis of DM, showed that among the 591 people with non-type 1 DM, greater age (HR 1.078, $p < 0.01$) and male sex (HR 1.486, $p < 0.01$) were associated with a greater hazard of death before the end of the study period (end of 2012).

Among the 591 people with non-type 1 DM, those who were not audited (127) had a 3.6 ($p < 0.01$) times higher hazard of death compared to people who were audited, when adjusted for age at diagnosis and gender Figure 1.

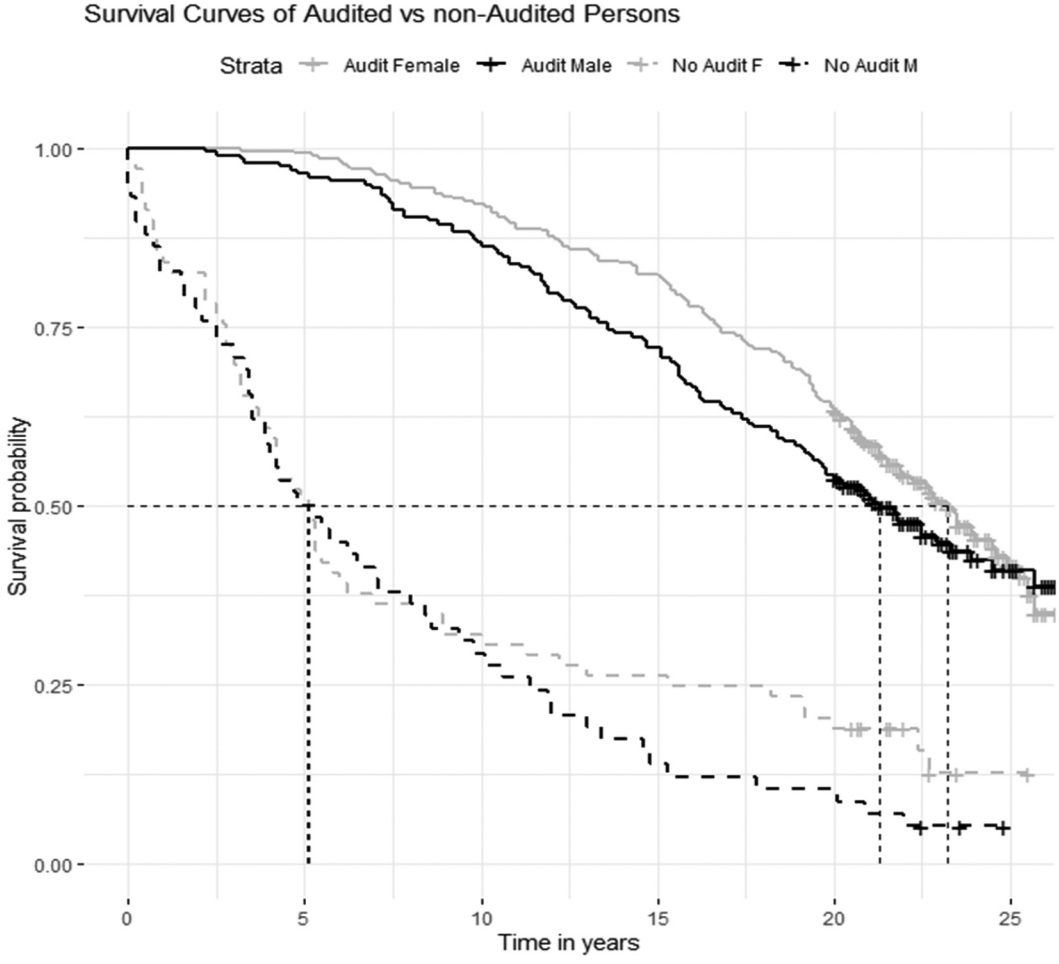

Figure 1. Survival curves, audited versus not audited, Alaska Native people with non-type 1 diabetes.

Univariate analyses of time until death found the following significant or nearly significant associations: male sex, HR 1.24, $p = 0.04$; prescription of at least one diabetes medication HR 4.7, $p < 0.01$; each additional medication increased hazard 1.85 times, $p < 0.01$; lower median BMI (1 point decrease) HR 1.04, $p = 0.01$; higher median cholesterol (10 point increase) HR 1.06, $p < 0.01$; higher median LDL cholesterol (10 point increase), HR 1.06, $p = 0.03$; higher median systolic blood pressure (10 point increase) HR 1.1, $p = 0.05$; higher median triglycerides (10-point increase) HR1.1, $p = 0.06$. Ethnicity and higher median HbA1C were not significantly associated with hazard of death within the study period.

Multivariable analysis found several significant associations (Table 3).

LEA

Univariate analyses of time until LEA found the following significant associations: male sex HR 6.03, $p < 0.01$; median HbA1C (1 point increase) HR 1.39, $p < 0.01$; median triglyceride (10-point increase) HR 1.04, $p = 0.04$. We found little evidence of increased risk with increasing age at diagnosis, ethnicity, use of at least one diabetes medication, median systolic BP, median total cholesterol, or median LDL. Lower median BMI was marginally associated with higher risk (1 point decrease) HR 1.08, $p = 0.08$.

Multivariable analysis found several significant associations (Table 4).

ESRD

Records for all 17 of the individuals with non-type 1 diabetes were randomly selected for audit. We found no significant associations with any risk factors in univariate or multivariable analyses.

Stroke (CVA)

Among the 601 people diagnosed in 1986–1992, 108 (18.0%) experienced at least one CVA after the diagnosis of DM and before 1 January 2013. Seventeen people (2.8%) had more than one CVA event after diagnosis. Among 126 events after diagnosis of DM, 94 (74.6%) were confirmed while 32 were of lesser degrees of certainty. Limiting the analyses to events with a high degree of certainty did not change the results. Sixteen people experienced CVA prior to the diagnosis of DM, including one who had an event pre-and post-diagnosis. One person who experienced one CVA after diagnosis had type 1 diabetes and was excluded from analysis. Among the 107 individuals with non-type 1 diabetes who experienced CVA after the diagnosis of DM, 89 were selected for at least one audit.

Univariate analyses of time until CVA found the following significant/suggestive associations: increasing age at diagnosis, HR 1.06, $p < 0.01$; median BMI (1 point increase), HR 0.96, $p = 0.02$; use of at least one diabetes medication, HR 2.2, $p = 0.04$; higher median systolic BP (10-point increase) HR 1.26, $p < 0.01$; difference in time to first stroke between ethnicities $p = 0.06$ (log rank test). We did not find significant associations for male sex, median HbA1C, median triglyceride, median total cholesterol, or median LDL.

Multivariable analysis found several significant associations (Table 5).

Table 3. Multivariable associations with death during the study period, Alaska Native people with diabetes diagnosed 1986–1992.

Characteristic	Hazard ratio (95% C.I.)	p	Odds ratio (2.50%-97.50%)	p
Age at Dx	1.10 (1.08–1.11)	<0.01	1.13 (1.10–1.16)	<0.01
Sex M	1.51 (1.11–2.05)	<0.01	1.34 (0.82–2.19)	0.20
Median BMI	0.98 (0.95–1.00)	0.08	0.96 (0.92–1.00)	0.09
Median HbA1C	1.32 (1.20–1.45)	<0.01	1.33 (1.12–1.59)	<0.01
Median cholesterol	1.00 (1.00–1.01)	0.02	1.00 (1.00–1.01)	0.08
At least one medication	3.60 (1.83–7.07)	<0.01	5.56 (2.54–13.37)	<0.01

Table 4. Multivariable associations with Lower Extremity Amputation (LEA) during the study period, Alaska Native people with diabetes diagnosed 1986–1992.

Characteristic	Hazard Ratio (95% C. I.)	p	Odds Ratio (2.50%-97.50%)	p
Median HbA1C	1.44 (1.13–1.83)	<0.01	1.35 (1.04–1.73)	0.02
Sex M	5.20 (1.90–14.27)	<0.01	4.75 (1.78–15.04)	<0.01
Median BMI	0.92 (0.85–1.00)	0.04	0.92 (0.84–1.00)	0.08
Median Triglycerides	1.02 (0.99–1.06)	0.12	1.03 (0.99–1.06)	0.16

Table 5. Multivariable associations with CVA during the study period, Alaska Native people with diabetes diagnosed 1986–1992.

Characteristic	Hazard Ratio (95% C. I.)	p	Odds Ratio (2.50%-97.50%)	p
Age at Dx	1.04 (1.02–1.07)	<0.01	1.03 (1.00–1.05)	0.03
Ethnicity group 2	0.87 (0.45–1.67)	0.67	0.82 (0.39–1.65)	0.59
Ethnicity group 3	1.68 (1.04–2.72)	0.03	1.77 (1.02–3.08)	0.04
Median Systolic BP	1.01 (0.99–1.03)	0.24	1.01 (0.99–1.04)	0.16
At least one medication	2.24 (1.42–3.52)	<0.01	2.14 (1.23–3.75)	<0.01
Median BMI	0.97 (0.93–1.01)	0.11	0.97 (0.93–1.01)	0.19

Myocardial infarction (MI)

Among the 601 people diagnosed in 1986–92, 103 (17.1%) experienced at least one MI after the diagnosis of diabetes and before 1 January 2013. No person who experienced MI had type 1 DM. Fifteen people (2.49%) had more than one MI event after diagnosis. Among the 118 MI events following the diagnosis of DM, 88 (74.6%) were confirmed, while 30 were of lesser degrees of certainty. Limiting the analyses to events with a high degree of certainty did not change the results. Fourteen people experienced MI prior to the diagnosis of DM but none had events both pre-and post-diagnosis. Among the 103 individuals who experienced MI after the diagnosis of DM, 86 were randomly selected for at least one audit.

Univariate analyses of time until MI found the following significant associations: Increasing age at diagnosis, HR 1.03, $p < 0.01$; male sex HR 1.91, $p < 0.01$; median total cholesterol (10-point decrease), HR 1.1, $p < 0.01$. We did not find significant associations for ethnicity, median BMI, median HbA1C, median triglyceride, at least one diabetes medication, median systolic BP, or median LDL.

Multivariable analysis found several significant associations (Table 6).

Any of four complications

Univariate analyses of time until the first complication (LEA, ESRD, Stroke, MI) among patients audited found the following significant associations: Increasing age at diagnosis HR 1.04, $p < 0.01$; male sex HR 1.54, $p < 0.01$; median BMI (1 point increase) HR 0.96, $p < 0.01$; at least one medication, HR 2.3, $p = 0.01$.

We did not find significant associations for ethnicity, median HbA1C, median triglyceride, median systolic BP, median total cholesterol, or median LDL.

Multivariable analysis found several significant associations (Table 7).

Associations of audit parameters with age at diagnosis of DM

Age at diagnosis of DM was associated with several complications noted above. Among examined parameters, greater age at diagnosis was associated with lower HbA1C, lower BMI, lower total cholesterol, higher systolic BP, and higher age at audit.

Discussion

This report presents observations on the long-term survival, wellbeing, and complication experience of

Table 6. Multivariable associations with Myocardial infarction (MI) during the study period, Alaska Native people with diabetes diagnosed 1986–1992.

Characteristic	Hazard ratio (95% C.I.)	p	Odds Ratio (2.50%-97.50%)	p
Age at Dx	1.03 (1.01–1.05)	<0.01	1.01 (0.99–1.03)	0.41
Sex M	1.78 (1.14–2.80)	0.01	1.63 (0.99–2.68)	0.05
Median cholesterol	0.99 (0.98–1.00)	0.01	0.99 (0.98–1.00)	<0.01

Table 7. Multivariable associations with LEA, ESRD, Stroke, MI during the study period, Alaska Native people with diabetes diagnosed 1986–1992.

Characteristic	Hazard ratio (95% C.I.)	p	Odds Ratio (2.50%-97.50%)	p
Age at Dx	1.04 (1.02–1.05)	<0.01	1.02 (1.01–1.04)	<0.01
Sex M	1.53 (1.11–2.12)	<0.01	1.40 (0.93–2.10)	0.11
Median BMI	0.97 (0.95–1.00)	0.04	0.97 (0.94–1.00)	0.09
At least one medication	1.52 (1.11–2.09)	<0.01	1.43 (0.92–2.24)	0.12

805 Alaska Native people with DM in a "real world" setting. We found that over 50% of people with DM in each of two registry-based cohorts remained free of four major diabetes-related complications for the remainder of life or throughout the approximately 20-year study period. This can be the basis of encouragement for people with DM. We believe that the study results demonstrate two important points: 1) even in remote regions, reasonable levels of metabolic and blood pressure control were achieved in a tribally managed health care system, and 2) most people with DM can experience relatively good outcomes, with mean and median ages of death greater than the life expectancy of Alaska Native people born in 2014–2018 (70.4 years) [13]. We are not aware of comparable long-term studies in other populations.

We attempted to interpret our findings in the context of most recently recommended parameters for people with DM. Recommendations for lipids and HbA1C are individualised in current American Diabetes Association Standards of Care and in Indian Health Service guidelines. Recommended blood pressure is below 130/80 [1,14]; the median value in this study population (134/73) shows that approximately half the study population met these criteria.

Our finding that higher HbA1C was associated with LEA confirms previous observations [2]. Higher HbA1C was also associated with increased risk of death in multivariable analysis. The ACCORD study found an increased risk of death in an older population with more intensive glucose management compared to a standard-therapy group [15]. Our median HbA1C of 7.45 was close to the 7.5% in their standard therapy group, which experienced significantly lower mortality. Ghouse et al. found that the effect of HbA1C on all-cause mortality depended on the duration of diabetes. With short duration, strict control was associated with a lower risk of death, whereas in those with >5 years duration of diabetes, strict control was associated with an increased risk of death. Our values for mean and inter quartile range fall within the range of lowest risk for mortality [16].

Use of at least one diabetes medication was associated in multivariable analyses with death, stroke, and a composite of four complications: use of each additional medication was associated with higher hazard. The worse survival outcomes in the ACCORD study with intensively treated older people with DM, which could not be explained by the Study Group, led to a discontinuation of intensive therapy [15]. We speculate that our finding of medication associations with poor outcomes may be consistent with ACCORD findings. However, our findings may also reflect the fact that people with metabolic control that is more difficult to manage and/or more comorbidities may be treated with more medications. It must be noted that our patients were diagnosed prior to the use of more modern antiglycemic therapies such as the glucagon-like peptide-1 (GLP-1) agonists and sodium-glucose-cotransporter-2 (SGLT-2) inhibitors.

In multivariable analyses, higher total cholesterol was negatively associated with MI but was marginally associated with increased risk for death. A review of published cardiovascular risk data found that lower total cholesterol was associated with greater risk for death in several studies [17].

Lower BMI was associated in multivariable analyses with greater hazard of death, LEA, a composite of all four complications and with CVA in a univariate analysis. Several studies have found U-shaped curves with mortality being higher at low as well as high BMI [17–21], including a population of people with type 2 DM [22]. While our mean and median BMI of 33.3 and 32.5 were higher than those associated with the lowest mortality categories for some populations in the above-cited studies, they were comparable to the lowest mortality in others.

Higher age at diagnosis of DM was significantly associated in multivariable analyses with increased hazard for death, stroke, MI, and the composite of the four complications. Persons diagnosed at an older age were observed during a later period of life than were those diagnosed at younger ages. It is unclear if those who were diagnosed at an older age had been living with diabetes longer before diagnosis. If diabetes is identified in the beginning of the disease process, complications can be prevented or delayed with improvement in hyperglycaemia [23].

The rates of diabetes-related LEA, ESRD and CVA among Alaska Native people have been significantly different among the various populations in the past [3,6]. In this study, only the previously noted association of Group 3 ethnicity with CVA was found.

This study was subject to some limitations. A major limitation is that tobacco use was inconsistently coded from year to year in the audits, so tobacco data could not be analysed. Approximately 25% of the people audited did not have LDL reported. Therefore, the association of outcomes with LDL could not be evaluated. Records on a small group of people were not found or were judged to be inadequate. However, since our review focused on serious complications of diabetes, we believe that it is very unlikely that people experiencing these events would not have at least some mention of them in the records.

Conclusions

This study of Alaska Native people living with diabetes found that the care delivered by tribal health care programmes and the people themselves resulted in good metabolic and blood pressure control. Over 60% of those diagnosed in 1986–92 experienced none of four serious complications during their remaining lifetimes or 20 years following diagnosis. Our findings that lower BMI and use of at least one diabetes medication were associated with higher hazard for some deleterious outcomes may suggest that goals in care of elders should be carefully individualised. This includes evaluation of emphasis on weight loss, and consideration of which medications are effective and necessary for each individual person.

We believe there are several reasons for our ability to provide longitudinal data and support good outcomes. Maintenance of a registry over several decades and through many technologic changes reduced the risk that people with DM would be lost to follow-up. Date of diagnosis is a vital piece of information that needs to be encoded into registries. Surveillance of complications provides the ability to identify higher rates of complications in some populations so that specific targeted care can be provided. An example was the higher rate of amputation in some regions [6], which was addressed by targeted training in foot care and provision of specialised footwear. Consistency of coding of tobacco use over time in data systems is important.

Although a clinical referral system is important, local surveillance systems, patient and community education, and patient lists are vital. Local teams include nutrition specialists, nurses, primary care providers, and data managers. Throughout the existence of the registry, lists of patients were compared with local teams' findings. This further ensures that no person is lost to follow-up. Regional diabetes speciality clinics, including nutritionists and physical therapists experienced in diabetic foot care are held regularly to support local care teams. Support includes a course in diabetes management and prevention provided to Community Health Aides/Practitioners.

Optimal standards of care evolve over time, reflecting newer medications and new research findings. Ongoing review of care provided at local facilities and referral centres assures the updating of care provided is in accordance with new information.

In summary, maintenance of a registry, support from a multispecialty DM speciality team, and ongoing review of care based on established standards are all important components of effective DM care.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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