Diabetes prevalence, incidence, complications and mortality among Alaska Native people 1985–2006

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ABSTRACT

Objectives. To examine trends in diabetes prevalence, incidence, complications and mortality between 1985 and 2006 among Alaska Native people.

Study design. We used data from the population-based Alaska Native Diabetes Registry, which includes all people who receive care in the Alaska Tribal Health System.

Methods. We compared the periods of 1986–1990 and 2002–2006 for diabetes-related amputations, renal replacement and mortality using Poisson regression. Complications and mortality data were examined for trends using Poisson regression. Survival analyses for those diagnosed since 31 December 1985 were performed using the Cox proportional hazard model.

Results. Age-adjusted diabetes prevalence increased from 17.3 in 1985 to 47.6/1,000 in 2006. The number of Alaska Native people living in Alaska with diabetes increased from 610 in 1985 to 3,386 in 2006. Diabetes incidence rates have also increased. Comparing age-adjusted rates for the 5-year periods 1986–1990 and 2002–2006, amputations decreased from 5.3 to 2.6/1,000, renal replacement decreased from 3.3 to 1.2/1,000 and mortality decreased from 41.7 to 33.2/1,000. Yearly analyses showed a downward trend for amputations, renal replacement and mortality rates. Survival analyses showed a significantly higher hazard ratio for any amputations, major amputations and renal replacement for the earlier time period compared to the most recent time period.

Conclusions. An increase in risk factors, awareness, funding and case-finding may be contributing to the increase in prevalence and incidence of diagnosed diabetes. While diabetes prevalence and incidence are increasing among Alaska Native people, our results suggest that even in remote, rural areas, complications and mortality can be reduced.

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Keywords: Alaska Native, diabetes, prevalence, incidence, amputations, renal replacement, mortality
INTRODUCTION

The increasing prevalence of diabetes in the Alaska Native population has been well documented (1–4). In response, the Alaska Native Diabetes Program has provided diabetes specialty services and training for health care providers since the 1980s. In 1997, the United States Congress created legislation addressing the epidemic of diabetes among American Indian and Alaska Native people. The funding for the Special Diabetes Program for Indians (SDPI) led to diabetes program development and expansion among tribal health organizations in Alaska.

Care for Alaska Native people was initially provided under the auspices of the Indian Health Service (IHS). It then shifted to tribal management in the 1980s. The Alaska Tribal Health System (ATHS) is a network of clinics and hospitals that provides primary and secondary care in remote, rural areas, and primary, secondary and tertiary care in the urban areas of Alaska (5). Electronic medical records have been in existence since 1979 (1). Progressive improvements in hemoglobin A1c, blood pressure and lipids were associated with public health initiatives in diabetes care and prevention (6). Amputation and renal replacement rates have been found to be lower than those in other populations, but rates vary widely among the major ethnic groups within Alaska (3,4,7). The purpose of this report is to examine trends in prevalence, incidence and mortality of diabetes, and incidence of amputations, renal replacement and mortality among Alaska Native people with diabetes.

MATERIAL AND METHODS

Incidence and prevalence of diabetes
Counts of people with diabetes
(numerators for prevalence and incidence)

The Alaska Native Diabetes registry was started in 1985 (1). All Alaska Native people known to have diabetes living in Alaska on 31 December 1985 were entered into the registry. Diagnosis dates of the original 610 diabetes cases were not documented. Cases were ascertained by searching patient visits in the electronic medical record for ICD-9 codes for diabetes, gestational diabetes and any abnormal glucose (Appendix I). Cases and date of diagnosis (starting 1 January 1986) were then verified with laboratory evidence, using standard diagnostic criteria at the time of diagnosis (8,9). They were then further classified into type 1, type 2, steroid-induced or unspecified type, based on clinical data at the time of diagnosis. If the clinical course of events demonstrated that a change in the classification of diabetes was warranted, the type of diabetes was changed in the registry. Prevalent cases of diabetes were defined as Alaska Native people with diabetes, living in Alaska at the end of each year. Incidence was defined as the number of new cases diagnosed each year among Alaska Native people living in Alaska at diagnosis. American Indians belonging to tribes from the continental United States were included in the registry but were excluded from this analysis. Many of them move in and out of state or get care in the private sector. For this reason, longitudinal information is not complete.
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**Alaska Native population (denominators for prevalence and incidence of diabetes)**

We used the IHS estimated population, which is calculated based on the most recent census and is adjusted for numbers of births and deaths provided by the National Center for Health Statistics population estimates (10). For intercensal years we used the age, gender and ethnic distribution of the most recent census applied to the IHS estimate for each year.

Regions are defined according to IHS service unit boundaries (1) for consistency over time. Major ethnic groups are used as they have been in prior reports and in the medical records. The term “Eskimo” includes the Yup’ik, Cup’ik, Inupiaq and Siberian (St. Lawrence Island) Eskimo people. These populations are from the south-west, north-west and northern coastal regions of Alaska. The term “Indian” includes the Tsimshian, Tlingit and Haida of south-eastern Alaska, and Athabascan Indian people from the interior. The term “Aleut” includes Aleut and Alutiiq people from the Aleutian and Pribilof Islands, coastal south-central Alaska and the Kodiak region. Percent change in prevalence of diabetes was calculated by subtracting the earlier rate from the later rate, dividing this difference by the earlier rate then multiplying it by 100. Incidence and prevalence of diabetes were age-adjusted to the standard U.S. 2000 population.

**Lower extremity amputations (LEA), renal replacement and mortality**

Cases were ascertained by searching for relevant ICD-9 codes (Appendix I) in the computerized medical record system, followed by a manual review of electronic and/or paper charts to verify that case definitions were met. All LEA not clearly attributable to trauma or another non-diabetes related condition were included in the analysis. All leg amputations above the ankle were defined as major amputations. LEA procedures occurring on the same leg during the same hospitalization or within 30 days after discharge were counted as 1 event. Renal replacement was defined as the initiation of long-term dialysis or transplant for end-stage renal failure due to diabetes. Deaths of patients from renal failure who did not undergo renal replacement were ascertained through the State of Alaska vital statistics records. All were reviewed to determine whether or not the renal failure was secondary to diabetes. The most recent death information available (date of death and underlying cause of death) from the State of Alaska Department of Vital Statistics as of July 2008 was used for analysis. The ICD-9 and ICD-10 codes used for analysis of death cause data are in Appendix I. Denominators (person-years of diabetes) for LEA, renal replacement and mortality (Appendix II) were calculated based on the mean number of diabetes patients in the registry in each calendar year (3).

**Statistical analysis**

For trends over time, amputations, renal replacement and mortality rates were analyzed using Poisson regression by the earliest (1986–1990) and most recent (2002–2006) five-year periods and yearly (1986–2006), adjusting for age. For presentation, amputations, renal replacement and mortality rates were age-adjusted to the Alaska Native diabetes population at midpoint (1995) because the age distribution of the population with diabetes has shifted somewhat to younger age groups since 1985.
For analyses of the effect of duration of diabetes on complication and mortality rates, we used 2 methods: a hierarchical model and survival analysis. Since documentation of date of diagnosis was initiated in 1986, we were able to classify patients by duration of diabetes into <5, 5–9 and 10+ years beginning in 1996. Therefore, for the time period 1996–2006, we were able to include duration of diabetes in the analyses.

Hierarchical model
The hierarchical model included duration of diabetes (<5, 5–9, 10+ years), time period (1996–1998, 1999–2001 and 2002–2006) and age. The time periods were chosen based on program changes that could be expected to affect rates of complications and mortality. The time period 1996–1998 was prior to the large federal increase in funds for diabetes prevention and care provided to the ATHS. During 1999–2001, programs increased staff and augmented clinical and case-finding activities. Since 2002 programs have been stable. The age categories for amputations and renal replacement were <55 and ≥55. Denominators (person–years of diabetes) are presented in Appendix III. For mortality, 4 age categories (<45, 45–64, 65–74 and 75+) were used for analysis. Interactions were included as necessary.

Survival analysis
For all cases with diagnosis dates (diagnosed since 31 December 1985), survival analyses of time from diagnosis until complication or death were performed using the Cox proportional hazards model, adjusted for age and sex. Time was defined as diagnosis date to time of event (amputation, renal replacement, death from diabetic renal disease or death from any cause). Time periods were defined as 1986–1995, 1996–1998, 1999–2001 and 2002–2006.

The statistical analysis packages SAS version 9.1 and Stata were used for data analyses. Results were considered to be significant at p<0.05 (11,12).

RESULTS

Prevalence
Diabetes prevalence increased across all ethnicities and regions from 1985 to 2006 (Table I). The increase in prevalence in males (231%) was about 1.7 times that of females (139%). The largest increase in prevalence was in the predominantly Eskimo regions. Compared to 1985, the proportion of patients in each age group between 15 and 55 has increased (Table II). The All Alaska Native prevalence for the years 1992 and 1999 were 20.35 and 31.28/1,000. Starting in the latter half of the 1990s, we observed a steeper trend in the increase in prevalence.

Incidence
Diabetes incidence among Alaska Native people overall has been steadily increasing since 1986 (Fig. 1 and Table III). The largest increase occurred in 1999–2001 during a period of increased diabetes funding which likely led to an increase in case-finding activity. The highest incidence is found in the same ethnic groups and regions that have the highest prevalence. There is a suggestion of an increase in the incidence of type 1 diabetes. In 1986–1990, 5 cases were diagnosed (0.08/10,000) and in 2002–2006 there were 36 cases diagnosed (0.44/10,000) age-adjusted to the standard U.S. 2000 population.
Table I. Diabetes prevalence per 1,000 Alaska Native people by major ethnic group and region for 1985 and 2006, age-adjusted to the 2000 standard U.S. population.

| Region          | Predominant Ethnicity, geography | Number of cases, 1985 | Population 1985 | Prevalence 1985 | Number of cases, 2006 | Population 2006 | Prevalence 2006 | Percent change |
|-----------------|----------------------------------|-----------------------|-----------------|----------------|-----------------------|-----------------|----------------|----------------|
| All-Alaska      | All-Native                       | 610                   | 73798           | 17.3           | 3386                  | 120488          | 47.6           | 175%           |
|                 | Eskimo                           | 179                   | 39308           | 9.6            | 1211                  | 60075           | 34.3           | 256%           |
|                 | Indian                           | 292                   | 25176           | 24.2           | 1429                  | 46665           | 52.4           | 116%           |
|                 | Aleut                            | 139                   | 9314            | 30.2           | 745                   | 13748           | 89.8           | 198%           |
|                 | Male                             | 239                   | 37464           | 13.4           | 1482                  | 60537           | 44.3           | 231%           |
|                 | Female                           | 371                   | 36334           | 21.3           | 1904                  | 59951           | 50.8           | 139%           |
| Region 1        | South-east                       | 21                    | 1107            | 36.2           | 103                   | 1289            | 109.5          | 202%           |
| Region 2        | South-east                       | 154                   | 10052           | 29.5           | 629                   | 14357           | 63.6           | 116%           |
| Region 3        | South-central                    | 193                   | 19998           | 22.6           | 1402                  | 41883           | 57.8           | 156%           |
| Region 4        | Interior                         | 78                    | 8522            | 18.7           | 379                   | 13198           | 55.3           | 196%           |
| Region 5        | North-west                       | 47                    | 5221            | 18.0           | 170                   | 7601            | 44.7           | 149%           |
| Region 6        | South-west                       | 23                    | 4184            | 12.0           | 148                   | 5684            | 40.4           | 236%           |
| Region 7        | North-west                       | 23                    | 5787            | 7.7            | 154                   | 7989            | 32.2           | 317%           |
| Region 8        | North coast                      | 23                    | 3021            | 15.1           | 81                    | 4981            | 29.9           | 97%            |
| Region 9        | South-west                       | 48                    | 15906           | 5.8            | 320                   | 23506           | 23.9           | 309%           |

a One Alaska Native person was of unknown specific ethnicity.
b See reference (3).

Table II. Age distribution of the Alaska Native population, diabetes cases and prevalence rates per 1,000, for 1985 and 2006.

| Age group (years) | Estimated population | Number of cases | Proportion of cases (%) | Age-specific rate/1,000 |
|-------------------|----------------------|-----------------|-------------------------|-------------------------|
|                   | 1985                 | 2006            | 1985                    | 2006                    | 1985                 | 2006 |
| All-Native        | 73798                | 120488          | 610                     | 3386                    | 120488               | 47.6 |
|                   |                      |                 |                         |                         |                      | 175% |
| 0–14              | 24961                | 41058           | 5                       | 28                      | 0.8                  | 0.2  |
| 15–24             | 17551                | 20489           | 6                       | 59                      | 1.0                  | 0.3  |
| 25–34             | 11526                | 15877           | 24                      | 178                     | 3.9                  | 2.1  |
| 35–44             | 7300                 | 17736           | 60                      | 398                     | 9.8                  | 2.2  |
| 45–54             | 5564                 | 12223           | 123                     | 716                     | 20.2                 | 2.2  |
| 55–64             | 3579                 | 6685            | 170                     | 829                     | 27.9                 | 47.5 |
| 65+               | 3317                 | 6420            | 222                     | 1178                    | 36.4                 | 66.9 |
| Totals            | 73798                | 120488          | 610                     | 3386                    | 100                  | 100 |

Table III. Diabetes incidence/10,000 Alaska Native people by regions and time periods.

| Region           | 1986–1990 | 1991–1998 | 1999–2001 | 2002–2006 |
|------------------|-----------|-----------|-----------|-----------|
| All Alaska Native| 16.5      | 22.2      | 30.5      | 32.7      |
| Region 1         | 47.2      | 42.5      | 56.1      | 47.7      |
| Region 2         | 26.0      | 32.4      | 41.0      | 40.6      |
| Region 3         | 16.3      | 25.0      | 35.1      | 40.2      |
| Region 4         | 16.6      | 28.2      | 25.7      | 37.6      |
| Region 5         | 19.0      | 18.3      | 34.3      | 36.0      |
| Region 6         | 13.1      | 19.5      | 30.4      | 31.2      |
| Region 7         | 9.7       | 14.5      | 26.1      | 27.2      |
| Region 8         | 9.6       | 19.7      | 18.7      | 18.2      |
| Region 9         | 12.3      | 10.4      | 19.2      | 16.1      |

a Age-adjusted to the standard U.S. 2000 population (rate/10,000).
Amputations
Over the 21-year period, 82 people had a total of 130 amputations. Amputation rates among All Alaska Native people with diabetes decreased significantly from the 1986–1990 time period (5.3/1,000 persons/year) to the 2002–2006 time period (2.6/1000) (p=0.012) (Table IV). The change over time remained significant when controlling for ethnicity (p=0.017) and for gender (p=0.007). No interactions between gender and time or ethnicity and time were observed. Aleuts in both time periods had the highest rates. In the first time period, the Eskimo (p=0.012) and Indian groups (p=0.021) had significantly lower amputation rates compared to Aleut people. In the second time period, only the Eskimo people (p=0.015) had significantly lower rates of amputations compared to Aleut people. Males had higher rates than females in both time periods, but experienced a significant decrease. There was a significant decrease in major amputations comparing the time period 1986–1990 (3.7/1000) to the time period 2002–2006 (1.6/1000). When amputation rates were analyzed yearly for trends over the 21-year period, the same groups (All Alaska Native people with diabetes, the Aleut people and males) had significant decreases.

The longer a patient has had diabetes, the greater the risk is for amputations. There was a significant interaction between age group and time period when duration of diabetes was included in the model. Therefore we analyzed 2 age groups separately (<55 and ≥55) (Table V). Using Poisson regression, for people under 55 years of age there was no significant trend over the 3 time periods (p=0.118). For those 55 years of age or older, the rate of amputations decreased significantly from the 1996–1998 time period to the 2002–2006 time period; the trend over the 3 time periods was significant (p=<0.0001) even when adjusted for duration of diabetes. Survival analysis adjusted for age and sex showed that the probability of having any amputation (hazard ratio [HR] 3.04 p=0.028) or major amputation (HR 2.63 p=0.033) was significantly higher for the time period 1996–1998 compared to 2002–2006.
**Renal replacement**

Over the 21-year period, 53 people started dialysis or had a transplant, representing the sum of renal replacement treatment. Renal replacement rates among All Alaska Native people with diabetes decreased from the 1986–1990 time period (3.3/1000) to the 2002–2006 time period (1.2/1000) (p=0.011) (Table VI). The change over time was significant when controlling for ethnicity (p=0.016) and gender (p=0.012). No interactions between gender and time or ethnicity and time were observed. In the first time period, Indian rates appeared higher compared to Eskimo (p=0.335) and Aleut (p=0.435) rates. However, the Indian people experienced a significant decrease and, in the second time period, had a lower rate than Aleut people (p=0.369). Females had a higher rate than males in the first period, but experienced a significant decrease over time. When we examined rates for trend over the 21-year period, there was a significant downward trend for All Alaska Native people (p=0.038). The downward trend for the Indian people (p=0.053) and females (p=0.054) fell just short of significance.

Over the 21-year period, 13 people died of renal failure secondary to diabetes without undergoing renal replacement. For All Alaska Native people with diabetes, rates of renal replacement and renal deaths combined decreased from the time period 1986–1990.

| Table IV. Amputation rates/1,000 among Alaska Native people with diabetes in 1986–1990 and 2002–2006*. |
|---------------------------------------------------------------|
| **1986–1990** | **2002–2006** | **p value** |
|----------------|----------------|-------------|
| **Amputations** | **Cases** | **Rate** | **Cases** | **Rate** | **p value** |
| All Alaska Native | 19 | 5.3 | 36 | 2.6 | 0.012 |
| Eskimo | 2 | 1.6 | 7 | 1.4 | 0.674 |
| Indian | 7 | 4.1 | 16 | 2.5 | 0.291 |
| Aleut | 10 | 12.3 | 13 | 4.7 | 0.024 |
| Male | 11 | 8.2 | 23 | 3.9 | 0.038 |
| Female | 8 | 3.7 | 13 | 1.6 | 0.076 |
| **Major Amputations** | | | | | |
| All Alaska Native | 13 | 3.7 | 21 | 1.6 | 0.023 |
| **Minor Amputations** | | | | | |
| All Alaska Native | 6 | 1.7 | 15 | 1.0 | 0.355 |

* Denominators are presented in Appendix II.

b Age-adjusted to the 1995 Alaska Native diabetic population.

c Poisson regression adjusted for age comparing the 2 time periods.

| Table V. Amputation rates/1,000 among Alaska Native people with diabetes by duration of diabetes, time period and age group*. |
|---------------------------------------------------------------|
| **1996–1998** | **1999–2001** | **2002–2006** |
|----------------|----------------|----------------|
| **Amputations** | **Cases** | **Rate** | **Cases** | **Rate** | **Cases** | **Rate** |
| <55 | | | | | | |
| <5 years | 1 | 1.1 | 0 | 0 | 2 | 0.6 |
| 5–9 years | 0 | 0 | 0 | 0 | 2 | 1.3 |
| ≥55 | | | | | | |
| <5 years | 3 | 2.7 | 1 | 0.7 | 4 | 1.4 |
| 5–9 years | 6 | 8.4 | 4 | 3.9 | 4 | 1.6 |
| 10+ years | 22 | 20.9 | 6 | 4.9 | 13 | 4.4 |

* Denominators are presented in Appendix III.
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(4.3/1000) to 2002–2006 (1.4/1,000) (p=0.002) (Table VI). As for renal replacement alone, the decrease was significant when controlling for ethnicity (p=0.002) and gender (p=0.002). Inclusion of deaths secondary to diabetic renal failure in the analyses confirmed that the Indian group and females had the highest rates in the time period 1986–1990 but both had significant decreases over time. Considering renal deaths, the Eskimo people also experienced a significant decrease over time. When we examined rates for trends over the 21-year period, there were significant downward trends for All Alaska Native people (p=0.002), the Eskimo population (p=0.008), the Indian population (p=0.022) and females (p=0.003).

Taking duration of diabetes into consideration for patients under 55 years of age, it was not possible to meaningfully compare time periods because there were so few cases of renal replacement or deaths from diabetes related renal disease in many categories (Table VII). Using Poisson regression for those 55 years of age and over, no significant time trends were observed for renal replacement alone or for replacement and deaths from renal disease combined. Survival analysis showed that the probability of renal replacement was significantly higher in the period 1999–2001 (HR 4.15 p=0.018) compared to 2002–2006. The probability of renal replacement or death from renal disease combined was higher for the period 1999–2001 compared to 2002–2006, although it did not reach statistical significance (HR 2.86 p=0.066).

Mortality

Mortality rates among All Alaska Native people with diabetes decreased from 41.7/1,000 in the time period 1986–1990 to 33.2/1,000 in the time period 2002–2006 (Table VIII). The mean age of death was 69.4 years for the period 1986–1990 and 71 years for the period 2002–2006. The change over time was significant when controlling for gender (p=0.011) and ethnicity (p=0.019). No interactions between time and gender or time and ethnicity were observed. The rates among the 3 major ethnic groups did not differ significantly among each other in either of the 2 time periods. Males had higher rates than females in both time periods and experienced a non-significant decrease between the 2 time periods. The rate among females decreased significantly between the 2 time periods. We examined mortality rates for trends over the 21-year period. There was a downward trend for All Alaska Native people (p=0.001) and females (p=0.014).

When adjusted for duration of diabetes and age, for the time periods 1996–1998, 1999–2001 and 2002–2006, mortality rates did not differ significantly among the 3 time periods (p=0.507). Survival analysis showed that there was no significant difference in hazard ratios among the time periods used in that analysis.

We examined the mortality data by cause of death. Comparing age-adjusted rates for time periods 1986–1990 and 2002–2006, deaths from ischemic heart disease (IHD) fell from 11.1 to 3.5/1,000 (p<0.0001) (Fig. 2), and deaths due to cerebrovascular accidents (CVA) decreased from 3.01 to 1.75/1,000, but the change was not significant (p=0.154). Indian people had the highest rate of death from ischemic heart disease (4.2/1,000 in the time period 2002–2006), followed by Aleut people (3.73/1,000) and Eskimo people (2.6/1,000). Eskimo people had the highest CVA death rates (2.2/1,000) in the time period 2002–2006, followed by Aleut people (1.75/1,000) and Indian people (1.45/1,000).
### Table VI. Renal replacement and renal death rate/1,000 among Alaska Native people with diabetes in 1986–1990 and 2002–2006.

| Renal replacement + Renal deaths | 1986–1990 | 2002–2006 | p value<sup>c</sup> |
|--------------------------------|-----------|-----------|------------------|
| All Alaska Native              | 11        | 15        | 0.011            |
| Eskimo                         | 2         | 1         | 0.091            |
| Indian                         | 7         | 8         | 0.026            |
| Aleut                          | 2         | 6         | 0.903            |
| Male                           | 3         | 6         | 0.310            |
| Female                         | 8         | 9         | 0.020            |

| Renal replacement + Renal deaths | 1986–1990 | 2002–2006 | p value<sup>c</sup> |
|--------------------------------|-----------|-----------|------------------|
| All Alaska Native              | 15        | 19        | 0.002            |
| Eskimo                         | 4         | 1         | 0.013            |
| Indian                         | 9         | 12        | 0.023            |
| Aleut                          | 2         | 6         | 0.899            |
| Male                           | 3         | 6         | 0.310            |
| Female                         | 12        | 13        | 0.003            |

<sup>a</sup> Denominators are presented in Appendix II.

<sup>b</sup> Age-adjusted to the 1995 Alaska Native diabetic population.

<sup>c</sup> Poisson regression adjusted for age comparing the 2 time periods.

### Table VII. Renal replacement and renal death rate/1,000 in Alaska Native people with diabetes by duration of diabetes, time period and age group.

| Renal replacement + Renal deaths | Duration of diabetes | 1996–1998 | 1999–2001 | 2002–2006 |
|--------------------------------|----------------------|-----------|-----------|-----------|
|                                | <5 years              | 0         | 0         | 2         |
|                                | 5–9 years             | 0         | 0         | 0         |
|                                | 10+ years             | 0         | 0         | 3         |
|                                | ≥55                   | 0         | 0         | 2         |
|                                | <5 years              | 0         | 0         | 2         |
|                                | 5–9 years             | 0         | 0         | 0         |
|                                | 10+ years             | 0         | 0         | 3         |
|                                | ≥55                   | 0         | 0         | 2         |
|                                | <5 years              | 0         | 0         | 2         |
|                                | 5–9 years             | 0         | 0         | 0         |
|                                | 10+ years             | 0         | 0         | 3         |
|                                | ≥55                   | 0         | 0         | 2         |
|                                | <5 years              | 0         | 0         | 2         |
|                                | 5–9 years             | 0         | 0         | 0         |
|                                | 10+ years             | 0         | 0         | 3         |
|                                | ≥55                   | 0         | 0         | 2         |

<sup>a</sup> Denominators are presented in Appendix III.

### Table VIII. Mortality rates in Alaska Native people with diabetes in 1986–1990 and 2002–2006.

| Mortality | 1986–1990 | 2002–2006 | p-value<sup>c</sup> |
|-----------|-----------|-----------|------------------|
| All Alaska Native | 156        | 467        | 0.019            |
| Eskimo    | 49        | 170        | 0.222            |
| Indian    | 76        | 200        | 0.094            |
| Aleut     | 31        | 97         | 0.338            |
| Male      | 61        | 221        | 0.205            |
| Female    | 95        | 246        | 0.022            |

<sup>a</sup> Denominators are presented in Appendix II.

<sup>b</sup> Age-adjusted to the 1995 Alaska Native diabetic population.

<sup>c</sup> Poisson regression adjusted for age comparing the 2 time periods.
DISCUSSION

Prevalence and incidence of diabetes

The increase in prevalence has been steady in the 21 years of registry data collection and maintenance. While overall prevalence in 2006 (47.6/1,000) is less than the overall U.S. prevalence rate of 56/1,000 (age-adjusted to the standard U.S. 2000 population) (13), prevalence varies fivefold within the state from 23.9/1,000 to 109.5/1,000. The regions with the lowest prevalence rates, among a predominantly Eskimo population, showed the largest increase in prevalence. The decreased overall mortality rates and increased age at death probably contributed to the increase in prevalence rates.

In addition, the change in diagnostic criteria in 1997 (9) resulted in an approximately 9% increase in prevalence rates. The increase in the prevalence of 0–14 age group has been mainly due to type 1 diabetes (5 prevalent cases in 1985 and 25 prevalent cases in 2006).

Overall, the Alaska Native age-adjusted incidence in 2002–2006 (32.7/10,000) is lower compared to 75/10,000 for U.S. adults 19–79 years (14). It is possible that increased case-finding due to initiation of funding from SDPI contributed to the increase since 1999. The awareness of diabetes among both patients and providers may have increased during this period. This could have increased the likelihood that people would be tested in clinics.

Figure 2. Mortality rates/1,000 among Alaska Native people with diabetes in 1986–1990 and 2002–2006 by selected causes of death.

† Age adjusted to the 1995 Alaska Native Diabetes Population.

†† Includes heart disease and CVA.
and screening programs. While the incidence continued to increase in the 2002–2006 period, the rate of increase appears somewhat lower (Fig. 1). It is plausible that many of the people with unrecognized diabetes were diagnosed in 1999–2001, or perhaps a real decrease in diabetes incidence occurred because of prevention activities.

The increase in prevalence and incidence of type 2 diabetes seen in our population is likely due to changes in diet and lifestyle and an increase in body mass index (BMI). A study done in 1987–1988 showed that diabetes risk was lower among Alaska Native people who were physically active (e.g., cutting wood, hauling water) and who consumed seal oil or salmon daily (15,16). Several studies in the Alaska Native population have found that abnormal glucose tolerance is associated with overweight/obesity (2,17,18). Increasing fasting levels of insulin were found to be associated with higher BMI in Alaska Native residents of the Bering Straits region (19), indicating that insulin resistance is associated with increasing BMI in this population. Recent studies have shown that market or store-bought foods rather than traditional foods are the major sources of energy for Alaska Native people in north-western Alaska (20). A study in south-western Alaska found that for 14–19 year-olds, a smaller proportion of energy was supplied by traditional foods compared to older age groups (21).

**Amputations**

Recent data on amputation rates in diabetic populations are scarce. In 2002–2006, the overall Alaska Native amputation rate of 2.6/1,000 (Table IV) was 1.8/1,000 when age-adjusted to the standard U.S. 2000 population. This is lower than the all U.S. age-adjusted rate of 3.9/1,000 persons with diabetes in 2005 (22). Rates in the U.S. diabetic populations in the mid-to-late 1990s ranged from 3.7 to 15/1,000, but varied in age standardization and populations studied (23–25). The higher rate of amputations in males compared to females in our population has also been observed in Native American populations with diabetes (26–28). Historically, this also seems to be true for the all U.S. diabetic population (29). Many reports show an association between the development of a multidisciplinary foot care program and a reduction in amputation rates and/or risk factors (3,7,23,30). While our previous reports (3,7) showed reductions in amputation rates associated with enhanced foot care services, the SDPI program markedly increased access to podiatrist services and comprehensive foot exams and care, including surgical interventions. Several studies in diabetic populations show an association between LEA and smoking, systolic blood pressure, hemoglobin A1c, duration of diabetes and low values of high-density lipoproteins (HDL) (26–28,31–33). It is possible that improving metabolic control is contributing to our lower rate over time compared to other populations. Data from the Diabetes Standards of Care and Outcomes audit showed that mean HDL has increased; mean systolic and diastolic blood pressures, hemoglobin A1c, total cholesterol, low-density lipoproteins and triglycerides have steadily declined from 1994 to 2004 among Alaska Native people with diabetes (6). The lower amputation rates seen in our population may be due to an increase in the number of people with a shorter duration of diabetes. However, analyses including duration of diabetes still show a declining trend in amputations and may show the effects of foot
care program developments over time. We found that patients with 10+ years of diabetes under the age of 55 had higher rates of amputations compared to those over the age of 55. This suggests that diabetes in younger people may have a more deleterious effect. We need to provide intensive diabetes care in a multidisciplinary manner to our population that is at higher risk due to smoking, longer duration of diabetes at younger age and uncontrolled blood pressure or hyperglycemia, in addition to those with high-risk feet (ulcers, deformities, etc).

Renal replacement
The renal replacement rates in the Alaska Native diabetic population are lower compared to those found in other reports. Data from the U.S. Renal Data System showed that in 1996 the renal replacement rate due to diabetes in American Indian/Alaska Native people was 5.84/1,000 persons with diabetes, age-adjusted to the 1980 U.S. diabetic population (34). Data that included those who had initiated dialysis or died from diabetic nephropathy among Pima Indians from 1967–2002 showed that rates age-adjusted to the 1985 adult Pima general population increased until 1990 (approximately 14/1,000) and declined thereafter (approximately 9/1,000 by 1999–2002). This decrease was true even when duration of diabetes was taken into account (35). It is possible that our renal replacement and death rate has decreased due to improved control of blood sugar and blood pressure as well as increased use of renal-protective medications, as has been observed among Pima Indians, other south-west U.S. Indians and the Indian Health Service as a whole (6,35–37). Renal failure rates may appear lower if patients die of CVD prior to starting dialysis or if they die of diabetic renal failure (36). There is an association between early renal failure (albuminuria) and CVD events (38). However, our mortality rates from CVD have decreased, so this is probably not an explanation for our lower renal failure rates. In the report by Schraer et al. (1997), 8 out of 21 people (31%) with end-stage renal failure due to diabetes died without dialysis or transplant; between 1994 and 2006, we found 4 out of 44 people (9%) with end-stage renal failure died of diabetic renal failure without renal replacement. If people are finding dialysis more acceptable, our rates of dialysis secondary to diabetic renal failure may increase, while fewer people die of renal failure without initiating renal replacement. Increasing duration of diabetes is a risk factor for end-stage renal disease (39). It is worrisome that the number of patients who have had diabetes for 10+ years has tripled from 1996–1998 to 2002–2006. This may be predictive of future increases in the number of people requiring dialysis services.

Mortality
Death rates among Alaska Native people with diabetes age-adjusted to the U.S. 2000 population were 31.6/1,000 in 1986–1990 and 16.7/1,000 in 2002–2006, a 49% decrease. Other studies have noted recent mortality rates from 13.3/1,000 to 47.5/1,000 age-adjusted to the North American non-diabetic populations and decreases of 11% to 48% from earlier periods (40–44). In contrast, Hoehner et al. found no significant change in all-cause mortality between 1965 and 1998 among Pima Indians with diabetes (45). It must be noted in the above studies, the demographics of the populations studied, standards used for age-adjustment, time periods, definition of diabetes
and whether or not duration of diabetes was considered, varied widely.

Others have postulated that better diabetes care, which is associated with improvements in several parameters including a decrease in total cholesterol, low density lipoproteins, hemoglobin A1c and blood pressure, may have resulted in a decrease in death rates (40,42). We have also noted improved lipids, blood pressure and hemoglobin A1c in our population (6). Also, the use of a registry since 1985 has helped us to keep track of and provide optimal care to patients with diabetes and this may be associated with a decrease in death rates. A report from the Danish Diabetes Register showed a 40% decrease in mortality among diabetes patients in the 3 years after inclusion in the registry (46). We found no significant trends for mortality between 1996 and 2006 when duration of diabetes was included. However, the 10-year period may not have been long enough to observe a trend since mortality rates are the result of multiple factors over a long period of time.

Cause of death coding from the State of Alaska Department of Vital Statistics has changed from ICD-9 to ICD-10, starting in 1999. A review of the comparability ratios performed by the State of Alaska showed that for the most common causes of death, the ratio was close to 1 (47). Therefore, we conclude that the changes in our age-adjusted rates by death cause are not due to a change in the coding scheme. While it appears that the cancer death rate increased from the earlier to the latter time period, the change was small (6.8/1,000 to 7.1/1,000). Although death rates due to cardiovascular disease have decreased, it remains the major cause of death among Alaska Native people with diabetes.

**Limitations**

Several population counts of Alaska Native people could be used as denominators. One is the IHS user population. This refers to the number of people who have used the IHS/tribal system to receive care at least once in the preceding 3 years. However, this may underestimate age and gender groups that have lower user rates. The IHS estimated population is census-based, and therefore we have chosen to use it as the denominator for prevalence and incidence of diabetes. All population counts include American Indians of non-Alaskan origin; they cannot be accurately separated from the Alaska Native population in the census. Our prevalence and incidence rates would have been somewhat lower if we had used the user population. They would have been somewhat higher if we had been able to exclude the American Indian population from the census data. Unfortunately, Alaska Native patients with diagnosed diabetes and/or amputations or renal replacement receiving care entirely outside of ATHS may have been missed by our methods. However, in 6 of the 9 regions, ATHS provides the only primary and follow-up care locally available. Patients using this system are not personally billed for services or medications. Comparison of the counts of people using the system to census data indicates that this system is used by a vast majority of Alaska Native people. The use of a computerized medical record system ensures any visit to a clinic or a pharmacy for diabetes services will lead to case review for the registry.

We considered the possibility that our lower amputation and renal replacement rates were due to earlier mortality in the Alaska Native diabetic population. However, we found that
the age distributions of the Alaska Native diabetic population and the U.S. diabetic population are very similar. Therefore we conclude that our lower rates are not due to early mortality, which could have reduced the number of older, higher-risk people. We could not address the effect of duration of diabetes for patients initially entered in 1985 since date of diagnosis was not documented when the registry was initiated. It is likely that the increasing numbers of newly diagnosed diabetes cases contributed to our apparent decreases in complications and mortality. However, the fact that the decreases in amputations and renal replacement were significant when controlled for duration of diabetes among patients diagnosed since 1985 suggests that improved care played an important role.

Conclusions and future directions
In the context of a health system with a unified electronic medical record, no personal bills for health care visits and medications due to the obligation of the federal government to provide health care to Native Americans as part of treaty agreements (48), additional funding through SDPI for diabetes care and prevention, availability of a multidisciplinary foot program and the use of a statewide, population-based registry, we conclude that amputations and renal replacement rates can improve even in remote, rural areas in Alaska. Although diabetes prevalence is increasing, it is still below the U.S. rate in some regions within the ATHS. We know that risk factors such as obesity (2,49) and Metabolic Syndrome (50) exist in our population. Research findings from ongoing projects in several Alaska Native population groups may provide more clues as to why the incidence of diabetes is lower in certain groups. Such information could be important in primary prevention of diabetes and associated risk factors. Primary prevention of diabetes is a priority in this population. More programs similar to the Diabetes Prevention Program are needed, which provide tools for intensive lifestyle and behaviour changes. Our preliminary observations on the incidence of type 1 diabetes may reflect a worldwide trend and a variety of risk factors (51).

Although Alaska Native complication rates are lower compared to other populations, the increase in the number of patients with longer duration of diabetes and younger age at diagnosis (Appendix III) is of concern. The provision of care to an increasing number of persons with diabetes complications will be challenging. Therefore, it is important to decrease the proportion of patients with diabetes who have albuminuria, uncontrolled blood pressure, blood sugar and cholesterol. Reports on mortality, renal replacement and amputations among Indigenous people with diabetes are limited, and vary by region and ethnicity. There is a need for using uniform definitions and methodologies for such reports (52). We encourage an international collaborative to report on the experience of Indigenous populations affected by diabetes with regards to complications and mortality. This information may help in designing effective, culturally attuned interventions.

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REFERENCES

1. Schraer CD, Lanier AP, Boyko EJ, Godhes D, Murphy N. Prevalence of diabetes mellitus in Alaskan Eskimos, Indians, and Aleuts. Diabetes Care 1988;11(9):693–700.

2. Murphy NJ, Schraer CD, Bulkow LR, Boyko EJ, Lanier AP. Diabetes mellitus in Alaskan Yup’ik Eskimos and Athabascan Indians after 25 years. Diabetes Care 1992; 15(10):1390–1392.

3. Schraer CD, Adler AI, Mayer AM, Halderson KR, Trimble BA. Diabetes complications and mortality among Alaska Natives: 8 years of observation. Diabetes Care 1997; 20(3):314–321.

4. Naylor JL, Schraer CD, Carpenter CA, Murphy NJ, Thiele MC, et al. The Alaska Native Diabetes mellitus program. Int J Circumpolar Health 2003;62(4):363–387.

5. Schraer CD, Mayer AM, Vogt AM, et al. The Alaska Native diabetes program. Int J Circumpolar Health 2001;60:487–494.

6. Ramesh M, Schraer CD, Schraer C, Mayer AM, Asay E, Koller K. Effect of social diabetes program for Indians funding on system changes in diabetes care and outcomes among American Indian/Alaska Native people 1994–2004. Int J Circumpolar Health 2008;67(2–3):203–212.

7. Schraer CD, Weaver D, Naylor JL, Provost E, Mayer AM. Reduction of amputation rates among Alaska Natives with diabetes following the development of a high-risk foot program. Int J Circumpolar Health 2003;63(Suppl 2):S114–S119.

8. World Health Organization Study Group. Diabetes mellitus. Geneva: World Health Org; 1985 (Tech. Rep. Ser. 727). 99 p.

9. Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diabetes Care 1997;20(7);1183–1197.

10. Indian Health Service (IHS). Statistical note, Number 1. Rockville: Indian Health Service; 1993. 5 p.

11. SAS Institute Inc. SAS 9.1.3. Cary, NC: SAS Institute Inc; 2002–2004.

12. StataCorp. 2005. Stata Statistical Software: Version 9.0. College Station, TX: StataCorp LP.

13. Centers for Disease Control. Crude and age-adjusted percentage of civilian, non-institutionalized population with diagnosed diabetes, United States, 1980–2006. Atlanta: CDC; 2008 [cited 2009 Feb 10]. Available from: http://www.cdc.gov/diabetes/prevalence/national/fgage.htm.

14. Centers for Disease Control. Crude and age-adjusted incidence of diagnosed diabetes per 1,000 population aged 18–79 years, United States, 1980–2007. CDC; 2007 [cited 2009 July 31]. Available from: http://www.cdc.gov/diabetes/statistics/incidence/incidence.htm.

15. Adler AI, Boyko EJ, Schraer CD, Murphy N. The negative association between traditional physical activities and the prevalence of glucose tolerance in Alaska Natives. Diabetic Med 1996;13(6):555–560.

16. Adler AI, Boyko EJ, Schraer CD, Murphy N. Lower prevalence of impaired glucose tolerance and diabetes associated with daily seal oil or salmon consumption among Alaska Natives. Diabetes Care 1994;17(12):1498–1501.

17. Murphy NJ, Schraer CD, Thiele MC, et al. Dietary change and obesity associated with glucose intolerance in Alaska Natives. J Am Diet Assoc 1995;95(6):676–682.

18. Ebbesson SO, Schraer CD, Risica PM, et al. Diabetes and impaired glucose tolerance in three Alaskan Eskimo populations. The Alaska-Siberia Project. Diabetes Care 1998;21(4):563–569.

19. Schraer CD, Risica PM, Ebbesson SO, Go OT, Howard BV, Mayer AM. Low fasting insulin levels in Eskimos compared to American Indians: are Eskimos less insulin resistant? Int J Circumpolar Health 1999;58(4):272–280.

20. Nobmann E, Ponce R, Matil C, et al. Dietary intakes vary with age among Eskimo adults of northwest Alaska in the GOCADAN Study, 2000–2003. J Nutr 2005; 135(4):856–862.

21. Bersamin A, Luick BR, Ruppert E, Stern JS, Zidenberg-Cherr S. Diet quality among Yup’ik Eskimos living in rural communities is low: the Center for Alaska Native Health Research pilot study. J Am Diet Assoc 2006; 106(7):1055–1063.

22. Centers for Disease Control. Crude and age-adjusted hospital discharge rates for nontraumatic lower extremity amputation per 1,000 diabetic population, United States, 1980 to 2005. Atlanta: CDC; 2007 [cited 2009 Aug 24]. Available from: http://www.cdc.gov/diabetes/statistics/lea/fig3.htm.

23. Rith-Najarian S, Dannels E, Aceton K. Preventing amputations from diabetes: The Indian Health Service experience. West Indian Med J 2001;50(Suppl 1):S41–S44.

24. Rieber GE, Boyko EJ, Smith DG. Lower extremity foot ulcers and amputations in diabetes. In: Diabetes in America. Washington, DC: U.S. Govt. Printing Office (NIH publ. No. 95-1468); 1995. p. 414.

25. Center for Disease Control. Hospital Discharge rates for non-traumatic lower extremity amputation by diabetes status – United States, 1997. MMWR 2001;50(43):954–958.

26. Nelson RG, Godhes DM, Everhart JE, et al. Lower-extremity amputations in NIDDM: 12-year follow-up study in Pima Indians. Diabetes Care 1988;11(1):8–16.

27. Lee JS, Lu M, Lee VS, Russell D, Bahr C, Lee ET. Lower-extremity amputation: incidence, risk factors, and mortality in the Oklahoma Indian Diabetes Study. Diabetes 1993;42(6):876–882.

28. Resnick HE, Carter EA, Sosenko JM, et al. Incidence of lower-extremity amputation in American Indians: the Strong Heart Study. Diabetes Care 2004;27(8):1885–1891.

29. Centers for Disease Control. Age-adjusted hospital discharge rates for nontraumatic lower extremity amputation per 1,000 diabetic population, by sex. United States, 1980–2005. Atlanta: CDC; 2007 [cited 2009 Sep 8]. Available from: http://www.cdc.gov/diabetes/statistics/lea/fig5.htm.

30. Litzelman DK, Slemenda CW, Langefeld CD, et al. Reduction of lower extremity clinical abnormalities in patients with non-insulin-dependent diabetes mellitus. A randomized, controlled trial. Ann Intern Med 1993;119(1):36–41.
31. Moss SE, Klein R, Klein BE. The prevalence and incidence of lower extremity amputation in a diabetic population. Arch Intern Med 1992;152(3):610–616.
32. Selby JV, Zhang D. Risk factors for lower extremity amputation in persons with diabetes. Diabetes Care 1995;18(4):509–516.
33. Reiber GE, Pecoraro RE, Koepsell TD. Risk factors for amputation in patients with diabetes mellitus. A case-control study. Ann Intern Med 1992;117(2):97–105.
34. Centers for Disease Control. End-stage renal disease attributed to diabetes among American Indians/Alaska Natives with Diabetes – United States, 1990–1996. MMWR 2000;49(42):959–962.
35. Pavkov M, Knowler W, Bennett P, Looker H, Krakoff J, Nelson R. Increasing incidence of proteinuria and declining incidence of end-stage renal disease in diabetic Pima Indians. Kidney Int 2006;70(1):1840–1846.
36. Burrows NR, Narva AS, Geiss LS, Engelgau MM, Acton KJ. End-stage renal disease due to diabetes among southwestern American Indians, 1990–2001. Diabetes Care 2005;28(5):1041–1044.
37. Narva AS. Reducing the burden of chronic kidney disease among American Indians. Adv Chronic Kidney Dis 2008;15(2):168–173.
38. Howard BV, Lee ET, Cowan LD, et al. Rising tide of cardiovascular disease among American Indians: the Strong Heart Study. Circulation 1999;99(18):2389–2395.
39. Nelson RG, Knowler WC, Pettitt DJ, Saad MF, Bennett PH. Diabetic kidney disease in Pima Indians. Diabetes Care 1993;16(1):335–341.
40. Tierney EF, Cadwell BL, Engelgau MM, et al. Declining mortality rate among American Indians with diabetes in North Dakota, 1997–2002. Diabetes Care 2004;27(11):2723–2725.
41. Booth GL, Kapral MK, Fung K, Tu JV. Recent trends in cardiovascular complications among men and women with and without diabetes. Diabetes Care 2006;29(1):32–37.
42. Gregg EW, Gu Q, Cheng YJ, Narayan KMG, Cowie CC. Mortality trends in men and women with diabetes, 1971 to 2000. Ann Int Med 2007;147(3):149–155.
43. Lipscombe LL, Hux JE. Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995–2005: a population-based study. Lancet 2007;369(9563):750–756.
44. Preis SR, Hwang SJ, Coady S, et al. Trends in all-cause and cardiovascular disease mortality among women and men with and without diabetes mellitus in the Framingham Heart Study, 1950 to 2005. Circulation 2009;119(13):1728–1735.
45. Hoehner CM, Williams DE, Sievers ML, Knower WC, Bennett PH, Nelson RG. Trends in heart disease death rates in diabetic and non-diabetic Pima Indians. J Diabetes Complications 2006;20(1):8–13.
46. Carstensen B, Kristensen JK, Ottosen P, Borch-Johnsen K; Steering Group of the National Diabetes Register. The Danish National Diabetes Register: trends in incidence, prevalence and mortality. Diabetologia 2008;51(12):2187–2196.
47. State of Alaska. 2003 Annual Report, Appendix C: Mortality. Alaska Bureau of Vital Statistics; 2003 [ cited 2009 Aug 31]. Available from: http://www.hss.state.ak.us/dph/bvs/PDFS/2003/annual_report/Appendix_C_web2003.pdf.
48. Indian Health Service Fact Sheets: Federal basis for health services. Rockville: HIS; 2009 [ cited 2009 Sep 25]. Available from: http://info.ihs.gov/BasisHlthSvcs.asp.
49. Risica PS, Schraer CD, Ebbesson S, Nobmann E, Cavalletto B. Overweight and obesity among Alaskan Eskimos of the Bering Strait region: The Alaska Siberia Project. Int J Obes Relat Metab Disord 2000;24(8):935–944.
50. Schumacher C, Ferucci ED, Lanier AP, et al. Metabolic syndrome: prevalence among American Indian and Alaska native people living in the southwestern United States and in Alaska, Metab Syndr Relat Disord 2008;6(4):267–273.
51. Soltesz G, Patterson CC, Dahlquist G; EURODIAB Study Group. Worldwide childhood type 1 diabetes incidence — what can we learn from epidemiology? Pediatr Diabetes 2007;8(Suppl 6):S6–S14.
52. Naqshbandi M, Harris SB, Esler JG, Antwi-Nsiah F. Global complication rates of type 2 diabetes in Indigenous peoples: A comprehensive review. Diabetes Res Clin Pract 2008;82(1):1–17.

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Appendix I.
ICD-9 codes used for ascertaining diabetes were 250.00-250.93, 357.2, 362.0-362.06, 366.41, 648.0-648.04, 648.80-648.84, 790.20-790.22, 790.29. ICD-9 codes used for ascertaining incidence of amputations were v49.70-v49.77, and operation codes of 84.10-84.19 and 84.3. For renal replacement, the ICD-9 codes used were v56.0-v56.8, v45.1, v42.0 and operation codes of 39.95-39.953, 54.98-54.983, 55.6-55.692.

ICD-9 and ICD-10 codes used for classifying death causes were as follows: circulatory: I00-I09 and 390-459; all heart diseases: I00-I09; I11, I20-I51, 390-398, 402,404, 410-419; IHD: I20-25; 410-414; 429.2; CVA: 160-69, 430-434, 436-438; diabetes: E10-14 and 250; neoplasms: C00-D48 and 140-239; digestive: K00-K93 and 520-579; respiratory: J00-J98 and 800-999; genitourinary: N00-N99 and 580-629; infectious diseases A00-B99, 001-139.

Appendix II. Denominators for amputations, renal replacement and mortality rates (for data in Tables IV, VI and VIII).

| Person-years of diabetes | 1986–1990 | 2002–2006 |
|--------------------------|-----------|-----------|
| All Alaska Native        | 3598.5    | 13981     |
| Eskimo                   | 1079.5    | 4836      |
| Indian                   | 1705      | 6134.5    |
| Aleut                    | 814       | 3009      |
| Male                     | 1406.5    | 5965.5    |
| Female                   | 2192      | 8015.5    |

Appendix III. Denominators for amputations, renal replacement and renal death rates, including duration of diabetes (for data in Tables V and VII).

| Duration of diabetes | 1996–1998 | 1999–2001 | 2002–2006 |
|----------------------|-----------|-----------|-----------|
| <55                  |           |           |           |
| <5 years             | 954.5     | 1371      | 3233.5    |
| 5–9 years            | 345       | 518       | 1546.5    |
| 10+ years            | 301.5     | 337.5     | 788       |
| ≥55                  |           |           |           |
| <5 years             | 1099.5    | 1446.5    | 2871.5    |
| 5–9 years            | 716.5     | 1026      | 2485      |
| 10+ years            | 1052      | 1234      | 2971      |