Audit of diabetes-related lower extremity amputations in the Northern Region of New Zealand 2013–2016

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ABSTRACT

AIMS: To characterise diabetes-related lower extremity amputations (DRLEA) and prior contact with specialist podiatrists in Northern New Zealand.

METHODS: Using administrative data, DRLEA ≥35 years were identified for the Northern Region (July 2013 to June 2016). For those domiciled in Metro Auckland (July 2015 to June 2016), additional clinical data described amputation cause, diabetes-related co-morbidities and podiatry contact.

RESULTS: There were 862 DRLEA for 488 people, including 25% (*n*=214) major amputations. Age-standardised amputation rates were three times higher for males than females (41.1 vs 13.6 per 100,000 population [95% confidence interval (CI): 37.3–44.9 vs 11.6–15.6 per 100,000] respectively). Amputation rates varied by ethnicity, being 2.8 and 1.5 times higher respectively for Māori and Pacific peoples than non-Māori, non-Pacific peoples. Mortality was high at 1-, 3- and 6-months post-admission (7.9%, 12.4 % and 18.3% respectively). There was high prevalence of peripheral vascular disease (78.8%), neuropathy (75.6%), retinopathy (73.6%) and nephropathy (58%). In the 3 months prior to first DRLEA admission, 65% were not seen by specialist podiatry.

CONCLUSIONS: Our study confirms higher DRLEA admission rates for Māori and males. We identified elevated rates among Pacific populations and observed suboptimal utilisation of specialist podiatry services.

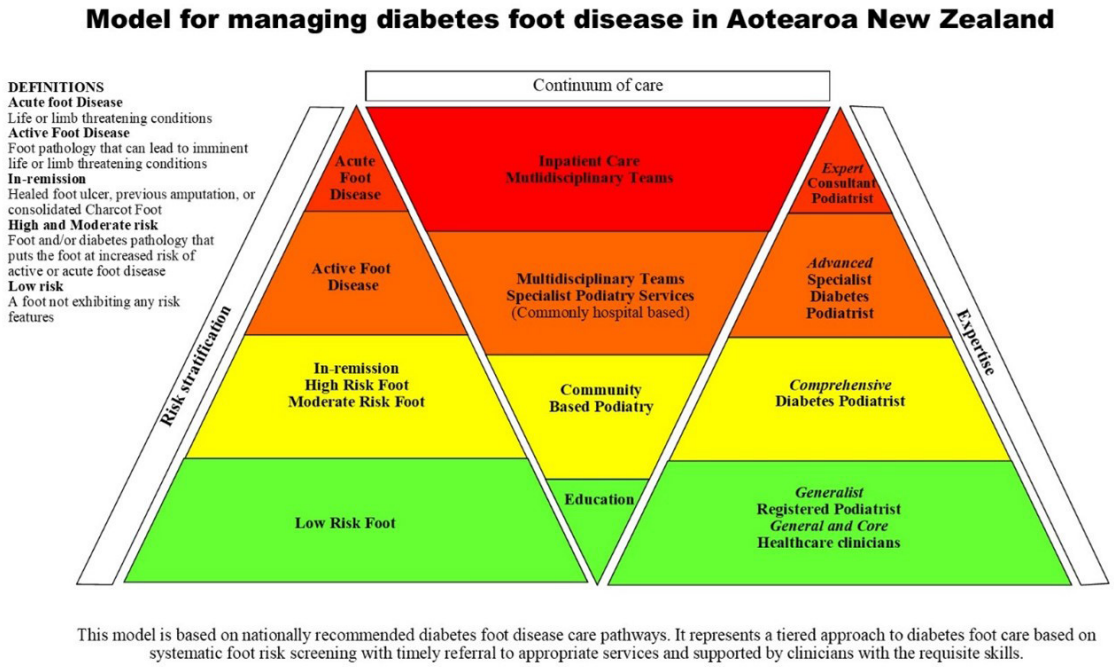
Diabetes is the leading cause of non-traumatic lower extremity amputation, both internationally[1] and in Aotearoa New Zealand.[2,3] Diabetes-related lower extremity amputations (DRLEA) are associated with demographic, socio-political and lifestyle factors, as well as broader microvascular and macrovascular complications.[4,5] Peripheral neuropathy, peripheral arterial disease (PAD) and a history of previous diabetes foot ulcers (DFU) or DRLEA are significant risk factors.[6] The majority of DRLEA are preceded by a DFU, with foot trauma being the predominate trigger for DFU.[5,7] In people with diabetes, the lifetime incidence of a DFU is estimated at 19% to 34%, of which 20% result in DRLEA.[1] Diabetes foot disease (DFD) contributes significantly to the global disability burden[1] and is associated with a 5-year mortality rate higher than for most types of cancers.[8,9]

With timely access to diabetes foot protection services and rapid referral of DFU to specialist foot services, encouragingly, many DFU and their potential sequalae can be avoided.[7,10] It is recognised that clinician adherence to clinical guidance and pathways can be suboptimal,[11,12] but early recognition of DFU is important as referral delays for first expert assessment have been associated with more severe ulcerations, additional and longer hospitalisations and more revascularisations and DRLEA.[13]

In New Zealand, well-organised diabetes foot protection services are recognised as an essential component of DFU and DRLEA prevention.[14] The services are predominately podiatrist-led and are commonly organised as depicted in Figure 1. It is expected that people with diabetes will be routinely screened for risk of foot ulceration and will access services in accordance with recommended pathways.[15] Diabetes foot services in the Northern Region are organised as depicted and adhere to nationally recommended pathways.

Despite a focus on optimising diabetes foot care,[16] DRLEA numbers continue to increase and there are variations in rates by age, gender, ethnicity and region.[2,3,17] We wanted to understand more about the characteristics of amputations in the Northern Region of New Zealand. The audit was undertaken as part of a

Figure 1: Model for managing diabetes foot disease in New Zealand.



Adapted from Garret M, Beeler E, Haggart P, et al. Competency Framework for Podiatrists and Healthcare Clinicians Working in Diabetes Lower Limb Care in Aotearoa/New Zealand [Internet]. New Zealand Society for the Study of Diabetes. 2020. pp. 8. Adapted with permission.
NB: The transverse lines between the triangles do not align, reflecting the potential overlap between risk and care intervention, as well as clinician expertise.

quality improvement project on behalf of the four Northern Region district health boards (DHBs) and the Northern Region Alliance Podiatry Network.

Aims

We sought to characterise DRLEA by age, gender, deprivation and ethnicity. For a subcohort we also aimed to further describe the causes of DRLEA and attendance at specialist podiatry services prior to amputation.

Methods

Study design

This was an observational descriptive study designed to audit the DRLEA in the Northern Region of New Zealand.

Setting

The Northern Region consists of four DHB areas: Northland (NDHB), plus three Metro Auckland DHBs—Auckland (ADHB), Waitematā (WDHB) and Counties Manukau (CMDHB).

Study population

People living in the Northern Region who underwent a DRLEA between July 2013 to June 2016 inclusive were identified from the National Minimum Dataset (NMDS) using *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification 8th Edition* (ICD-10-AM) diagnostic and procedure codes.

People who had DRLEA in a Northern Region hospital who were domiciled to a DHB outside the Northern Region, or who had a DRLEA in a private hospital, were not included. People domiciled in the Metro Auckland area but who had a DRLEA in a public hospital elsewhere in New Zealand were included in the demographic analyses but excluded from the clinical care and service utilisation

analyses due to the unavailability of relevant clinical records.

Data sources

Information on DRLEA type, hospital admission demographics and date of death were obtained from the New Zealand Ministry of Health. For DRLEA that occurred in Metro Auckland July 2015 to June 2016, additional clinical and specialist podiatry service utilisation details were obtained from electronic hospital clinical records. Data collection was undertaken by diabetes services specialist podiatrists and medical registrars using a template developed by the authors and podiatry service team leaders. Collected data were randomly reviewed by the authors to ensure accuracy. Incomplete recording of critical events in one location resulted in the authors reviewing all clinical records from that location.

Statistics New Zealand's DHB projected population data and the New Zealand Virtual Diabetes Register 2016 estimates were used to calculate resident and diabetic population amputation rates respectively.

Definitions

Diabetes was defined by any ICD-10-AM codes E10–E14. Occurrence of a DRLEA was determined using Ministry of Health reporting operation procedure codes. Retinopathy and neuropathy were deemed present if they were either ICD-10 coded in the NMDS or identified as present in the clinical notes audit. Amputation was defined as major, proximal to the ankle, or minor, occurring at or distal to the ankle. A diagnosis of PAD was defined as present if a clinical diagnosis of PAD, or a previous history of revascularisation procedures, or a reported ankle-brachial index of ≤0.9 or ≥1.3 or a toe-brachial index ≤0.70 was noted in the clinical record. Renal replacement therapy was defined as present when identified from the clinical record and diabetic nephropathy was defined by ICD-10-AM codes. Pre-amputation contact with a specialist podiatry service was defined as attendance within 3 months before the admission date, considering an average 12-week DFU healing time, to capture relevant specialist podiatry contacts.

Statistical methods

Age-standardised rates (ASR) of admission for DRLEA in people with diabetes were calculated for the Northern Region and Metro Auckland resident populations aged ≥35 by gender and ethnicity. Rates were standardised to New Zealand's population in 2015. A cutoff of ≥35 years was used to align with other DHB diabetes indicators. Average age at discharge and age-group specific admission rates were also calculated. Admissions were examined by domicile and deprivation, using the New Zealand Index of Deprivation 2013 (NZDep2013) quintile index of socio-economic deprivation as a proxy marker for socio-economic status.[18] ASR by NZDep2013 quintile were not calculated as projected estimates for DHB populations were not available at the time of data analysis. Mortality rates at 1, 3 and 6 months were calculated by admission using the date of last amputation procedure prior to date of death. Type of amputation and length of stay (LOS) were also analysed.

Additional analyses carried out for the Metro Auckland DHBs for the July 2015 to June 2016 cohort focussed on clinical risk factors associated with DRLEA, including PAD, neuropathy, retinopathy and diabetic nephropathy. Amputation cause, critical event leading to amputation and specialist podiatry attendance prior to amputation were also examined.

Being an audit, this project was considered low risk and reviewed under the expedited ethics pathway. Obtaining individual consent was waivered. To protect privacy, data were de-identified and allocated a unique identifier prior to data analysis and then aggregated. Ethics approval was granted from the Central Health and Disabilities Ethics Committee (reference 16/CEN/181/AM01).

Results

Northern Region cohort

There were 863 amputations performed on 488 people with a total of 635 admissions. Approximately 22% (*n*=107) of people experienced more than one admission over the 3-year period. The average LOS for DRLEA hospital admission was 18.2 days.

Minor amputations were most common, making up 75% (n=649) of DRLEA, and major amputations accounted for 25% (*n*=214). See Table 1.

The number of DRLEA admissions remained stable for the 3-year period (see Table 2 for numbers and demographic details). Mortality was high: in 7.9% (n=50) of admissions the person had died within 1 month of amputation, 12.4% (n=79) at 3 months and 18.3% (n=116) at 6 months.

The 3-year ASR for admissions for DRLEA in the resident Northern Region population ≥35 years

Table 1: Number of amputations by type for the Northern Region and Metro Auckland.

Code	Description	Northern Region	Metro Auckland
4433800	Amputation of toe	336	281
		38.9%	***38.9%***
4435800	Amputation of toe including metatarsal bone	268	231
		31.1%	***32%***
4436400	Midtarsal amputation	14	13
		1.6%	***1.8%***
4436401	Transmetatarsal amputation	31	27
		3.6%	***3.7%***
4436701 4436700	Disarticulation at knee Amputation above knee	102	80
		11.8%	***11.1%***
4436702	Amputation below knee	112	91
		13.0%	***12.6%***
Total		**863**	**724**

was 26.3 per 100,000 (95% confidence interval [CI] 24.2–28.3).

By gender the rate was three times higher in males than females at 41.1 per 100,000 resident population (95% CI 37.3–44.9 per 100,000) for males and 13.6 per 100,000 (95% CI 11.6–15.6 per 100,000) for females.

The mean age for DRLEA was 65 years. The 5-year age group specific rates per 100,000 population increased with age until 75–79 years. Concerningly, 6.8% (n=43) of DRLEA admissions occurred in individuals under the age of 45 years. The mean age of females on discharge post-DRLEA was 63.2 years compared to males at 65.7 years. Pacific people and Māori were a decade younger (mean age 59.9 and 60 years respectively) than the rest of the population (mean age 69.7 years).

There was also variation of amputation admission rates by ethnicity (Figure 2). The average ASR per 100,000 resident population aged 35 years and over was higher for Māori and Pacific people than non-Māori, non-Pacific people (75.9, 95% CI 63.8–88.1; 81.6, 95% CI 68.5–94.7; 16.1, 95% CI 14.3–17.8 respectively). The difference is also apparent in the rates for the estimated diabetes population, being 2.8 times higher for Māori (356.9, 95% CI 300–413.8) and 1.5 times higher for Pacific people (197.1, 95% CI 165.4–228.7) compared to non-Māori, non-Pacific people (127.8, 95% CI 113.9–141.6).

The number of people undergoing a DRLEA by NZDep2013 quintile was notably higher for those living in quintile 5 (the most deprived), with the number almost equal to the total numbers in the other four quintiles combined (311 and 319 respectively).

Metro Auckland cohort

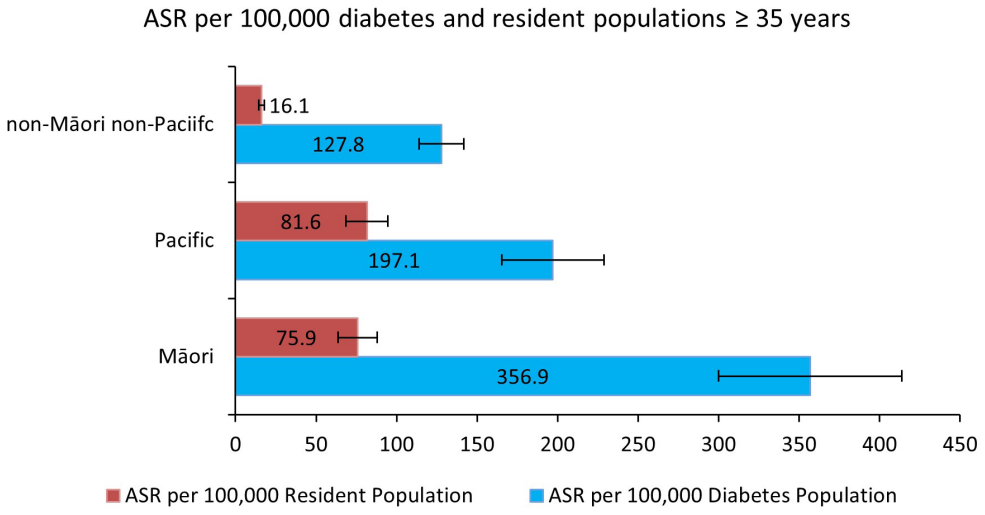
In the Metro Auckland 1-year July 2015–June 2016 cohort, there were 193 DRLEA-related admissions. Of these 27.5% (n=53) were female and 72.5% (n=140) were male. The prevalence of comorbidities was high, with retinopathy recorded in 73.6% (*n*=142) of admissions, neuropathy in 75.6% (*n*=146), PAD in 78.8% (*n*=152), diabetic nephropathy in 58% (*n*=112) and 21% (*n*=41) on renal replacement therapy.

Most amputations were multifactorial in cause, with underlying wounds/ulcers (n=147, 76.1%) and infections (n=111, 57.5%) documented in most cases. Foot ulcers, skin infection, ischaemia and osteomyelitis were noted as precursors to

Table 2: Demographic data—admissions for DRLEA for the Northern Region by year.

	2013–2014	2014–2015	2015–2016	Total	Proportion
Northern Region					
Total admissions	205	203	227	635	100%
Male	158	136	166	460	72.4%
Female	47	67	61	175	27.6%
Māori	53	57	45	155	24.4%
Pacific	48	43	60	151	23.8%
Asian	6	17	18	41	6.5%
European/Other	98	86	104	288	45.4%
Quintile 1	16	7	23	46	7.2%
Quintile 2	26	23	26	75	11.8%
Quintile 3	28	31	25	84	13.2%
Quintile 4	29	43	42	114	18.0%
Quintile 5	103	97	111	311	49.0%
Age <=44	10	20	23	43	6.8%
Age 45–64	84	71	95	250	39.4%
Age 65–74	59	52	65	176	27.7%
Age 75–84	43	46	44	133	20.9%
Age 85+	9	14	10	33	5.2%

Figure 2: Average age-standardised rate per 100,000 2015 DHB resident/diabetes populations aged 35 and over for admissions for DRLEA July 2013–June 2016 by ethnicity for the Northern Region.



amputation. The specific type of foot trauma or critical event leading to wounds/ulcers was inadequately documented, with a clear critical event ascertainable in only 34.7% (n=67) of admissions. Underlying critical events that were identified include: non-healing amputation site (n=14), trauma (n=10), footwear (n=9), pressure injury (n=8), abscess (n=5), toenail-related (n=4), burns (n=4), foreign body (n=4), broken or cracked skin (n=3), fall (n=3) and fracture (n=3).

In 45% (*n*=87) of admissions the patient was seen by specialist podiatry services in the 3 months prior to amputation, decreasing to 35% (n=47) when examined by first admission within the 3-year study period. Age, ethnicity and gender did not appear to influence access to specialist podiatrist care.

Discussion

The study identified a consistent DRLEA admission rate over the observation period, with 75% being minor amputations. Approximately 20% experienced multiple admissions within the 3 years. Amputation admission rates increased with age, but occurrences were also noted in younger age groups. Males, Māori and Pacific people faced elevated admission rates for DRLEA. High numbers of DRLEA were observed with higher levels of deprivation. Furthermore, Māori and Pacific populations underwent amputations approximately a decade earlier than other groups. High mortality rates were observed at 1, 3 and 6 months. However, due to the limited cohort size, these rates may not be generalisable to the broader New Zealand population.

The prevalence of microvascular related comorbidities of retinopathy, neuropathy and diabetic nephropathy was high, as was PAD. It was often difficult to ascertain a primary cause of DRLEA; however, common precursors were evident with foot ulcers, skin infection, ischaemia and osteomyelitis being noted. Approximately 65% of people admitted had not been seen by specialist podiatry services leading up to their first amputation. People admitted for a subsequent amputation were more likely to have prior podiatry contact.

The steady rate for all DRLEA in this study differs from an OECD report that noted a greater than 25% decline in major amputations for 2000–2012 for some countries including New Zealand, with minor amputation rates starting to increase.[19] It will be interesting to see if future reporting on DRLEA from the OECD also shows a slowing or flattening of the rate of amputation.

This study revealed a high 1-month mortality rate of approximately one in 12, doubling to almost one in five at 6-months—a trend consistent with the broad range of 4% to 22% reported in a systematic review on hospital 30-day mortality rates for all amputations.[20] This finding potentially reflects the high comorbidity burden, aligning with other studies that link comorbidity and mortality in individuals undergoing lower limb amputation.[2,5,20] Yet a New Zealand study did not establish a clear link with comorbidity; instead, it identified age and Māori ethnicity as independent factors linked to increased risk.[21] Many other factors also influence mortality rates, including patient status, the level of amputation, health provider decisions and patient preference.[20] However, mortality rates in this study were not adjusted to report on the influence of these factors.

Our results indicating higher rates of DRLEA in males is in keeping with other New Zealand and international studies, but the reasons why remain unclear.[2,3,5,22,23] While differences may be due to differences in health-seeking behaviours, the proportions seen by podiatrists prior to DRLEA were similar. More likely reasons are the higher cardiovascular risk of for men, higher smoking rates[24] and potentially the type of occupation and associated footwear.

There is an established correlation between increasing age and heightened risk of DRLEA,[5] which this study reaffirms. Yet it was disconcerting that 6.8% of severe end-stage complications occurred in younger individuals, as this can signal poor diabetes outcomes and associated diminished quality of life, and potentially reduced life expectancy. The prevalence of type 2 diabetes is rising in teenagers and young adults and is more likely to affect Māori and Pacific populations.[25] This age group is also more likely to develop microvascular complications, including neuropathy, which is a significant risk factor for earlier DRLEA.[26]

Higher DRLEA admission rates for Māori and Pacific people are evident when examining rates against both the general and diabetes population. The higher rate in our audit of DRLEA for Pacific people differs from other New Zealand studies that found Pacific people had a lower rate than European/other ethnicities.[2,3] Undercounting of Pacific peoples in the denominator data sources would inflate these rates.[27] Ethnic disparities including higher DRLEA rates for Indigenous populations have also been found

in international studies, but the cause remains unclear.[4,28] It is postulated that ethnic disparities could be related to socio-economic factors and comorbidities; however, other New Zealand studies have demonstrated an enduring disparity after adjusting for these variables.[2,3] Distal effects of colonisation, institutional racism and cultural competency of clinicians may contribute to health inequalities.[29,30] This was unable to be evaluated in this study. As noted by others, there was a likely correlation between worsening deprivation levels and higher numbers of DRLEA, probably linked to the corresponding higher prevalence and burden of diabetes for those living in higher levels of socio-economic deprivation.[6]

Ulcers being present in 76.1% of DRLEA is consistent with other research.[5] However, documentation of the critical event of DFU was insufficient, recorded in only 34.7% of admissions. Foot trauma, a major contributor to DFU and DRLEA, was noted as an underlying cause in a third of cases, significantly lower than the expected 80%. The under-reporting of foot trauma may be due to prolonged DFU duration before amputation, affecting event recall. Accurate recording of critical events is crucial, not only for clinical understanding but also for accessing funding pathways for wound care and patient rehabilitation.

Findings from this study indicate that people with diabetes-related foot complications may not be receiving timely access to specialist podiatry services, with only 35% of admissions being seen prior to first DRLEA admission. This finding is similar to another New Zealand study that reviewed care before and after admission for a DFU and reported only 33% were seen by specialist foot services.[11] The low number seen is cause for concern, indicating referral patterns and behaviours that are contrary to national recommendations of early referral to specialist foot services.[14,15] This may be a contributing factor to our high DRLEA rates compared to countries with similar healthcare systems, such as Australia and the United Kingdom.

Strengths and limitations

This study uses a well-curated national hospital discharge dataset, ensuring reliable documentation of amputations in New Zealand hospitals. Clinical note reviews were conducted by experienced clinicians using local electronic clinical records, with author oversight for accuracy. Identifiable data allowed verification of amputation procedures and comorbidities against the clinical record, enabling differentiation between single and multiple amputations in one person.

However, potential under-estimation of the total proportion of people having multiple admissions may exist due to exclusion of admissions outside the study period. The ASR by NZDep2013 quintile was not calculated due to unavailability of appropriate projections for DHB populations during the study analyses.

While the study examined all DRLEA, rates were calculated for those ≥35 years, introducing variation in age thresholds between studies. Approaches to calculate resident and diabetes populations also vary across countries and studies, making comparisons challenging.[19] We reported on admissions for DRLEA complicating direct comparisons with studies reporting numbers and rates.

Conclusion

This study adds to local knowledge regarding DRLEA in the Northern Region of New Zealand with the audit being undertaken to inform service development. Our findings of higher rates of DRLEA admission rates for Māori and males is consistent with other studies. The finding of high rates for Pacific people is new. Referral to expert podiatrist care for acute diabetes foot problems needs to be improved. The findings reinforce the need for further work to combat these health inequities and improve diabetes foot-related outcomes.

COMPETING INTERESTS
The authors declare no competing interests.

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Appendix

Appendix Table 1: Numbers of admissions and lower limber amputation (LLA) procedures in people with diabetes.

	2013–2014	2014–2015	2015–2016	Total
Northern Region				
Number of admissions for a LLA	205	203	227	635
Number of LLA procedures*	290	269	303	862
Metro Auckland				
Number of admissions for a LLA	162	168	193	523
Number of LLA procedures*	240	221	262	723

*Limited to the first 20 procedure codes per admission.

Appendix Table 2: Age-specific rates per 100,000 resident population for DRLEA for the Northern regions.

5-year age groups	Rates of DRLEA admissions per 100,000 population
35–39	1.5
40–44	8.3
45–49	10.3
50–54	16.2
55–59	22.0
60–64	36.2
65–69	47.9
70–74	47.0
75–79	78.9
80–84	78.9
85+	46.3

Table 3: Rates for admissions for DRLEA for the Northern Region and Metro Auckland.

	Northern Region	**Metro Auckland**
Resident population		
2013–2014	**26.4**	**23.5**
95% CI	*22.7–30*	*19.9–27.2*
2014–2015	**25**	**23.9**
95% CI	*21.5–28.5*	*20.2–27.5*
2015–2016	**27.4**	**26.8**
95% CI	*23.9–31*	*23.0–30.6*
Total	**26.3**	**24.9**
95% CI	*24.2–28.3*	*22.6–26.9*
Diabetic population		
2013–2014	**174.2**	**159.3**
95% CI	*150.3–198.1*	*134.7–183.9*
2014–2015	**179.3**	**169**
95% CI	*154.3–204.3*	*143.2–194.7*
2015–2016	**193.6**	**183.6**
95% CI	*168.3–218.9*	*157.5–209.6*
Total	**182.4**	**170.7**
95% CI	*168.1–196.6*	*156–185.4*