

# **Quality of Diabetes Care Among the Canadian Regular Forces: A Retrospective Cohort Study**

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Thesis submitted to the Faculty of Graduate and Postdoctoral Studies in partial fulfillment of the requirements for the MSc. degree in Epidemiology

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## **Abstract**

The objective of the thesis was to evaluate the quality of diabetes care in the Canadian Forces by determining the extent to which physicians adhere to recommendations outlined in the 2008 Canadian Diabetes Association (CDA) clinical practice guidelines. In addition, the effect of patient age, sex, rank and size of base on quality of care was assessed and the accuracy of a diagnosis of diabetes in an extract of the electronic medical record (EMR) was evaluated. Fourteen bases within the Canadian Forces were selected for investigation, representing roughly half of the Canadian Forces population. Cases of diabetes were ascertained based on laboratory criteria following a chart review. Twenty-one CDA guideline recommendations were considered. The Canadian Forces demonstrated greater than 75% adherence with each of 9 recommendations, 50-75% adherence with each of 7 recommendations and less than 50% adherence with each of 5 recommendations. The overall adherence with all applicable recommendations per patient was 60.3% (SE 0.66). Age, sex, rank and size of base were not important factors influencing guideline adherence. The sensitivity of a diabetes diagnosis in an extract of the EMR was 84.5%, the specificity was 99.8%, the positive predictive value was 85.1% and the negative predictive value was 99.8%. This is similar to the performance of provincial and national diabetes registries. The quality of diabetes care in the Canadian Forces compared favourably with that of the civilian population within Canada and internationally. The creation of a diabetes registry is expected to lead to further improvements in diabetes care.

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**Abbreviations:**

ACE, Angiotensin Converting Enzyme  
ACEi, Angiotensin Converting Enzyme inhibitor  
ACR, Albumin-Creatinine Ratio  
ADA, American Diabetes Association  
ARB, Angiotensin Receptor Blocker  
BP, Blood Pressure  
CCHS, Canadian Community Health Survey  
CDA, Canadian Diabetes Association  
CDC, Center for Disease Control and Prevention  
CF, Canadian Forces  
CI, Confidence Interval  
CIHI, Canadian Institute for Health Information  
DND, Department of National Defence  
eGFR, estimated Glomerular Filtration Rate  
EKG - Electrocardiogram  
EMR, Electronic Medical Record  
FN, False Negative  
FP, False Positive  
HbA1c, Hemoglobin A1c  
HDL, High-Density Lipoprotein  
LDL, Low-Density Lipoprotein  
N, Number (total)  
NDSS, National Diabetes Surveillance System  
NPV, Negative Predictive Value  
ODD, Ontario Diabetes Database  
PHAC, Public Health Agency of Canada  
PPV, Positive Predictive Value  
SD, Standard Deviation  
TC:HDL, Total Cholesterol to High-Density Lipoprotein Ratio  
TN, True Negative  
TP, True Positive  
USPSTF, United States Preventive Services Task Force

# Quality of Diabetes Care Among the Canadian Regular Forces: A Retrospective Cohort Study

## 1. Background

### *1.1 Burden of Disease*

The prevalence of diabetes is increasing globally with rates projected to double between the year 2000 and the year 2030 (Wild 2004). The rising numbers are due in part to population growth, an aging population and increasing levels of obesity and physical inactivity (Wild 2004). In 2008/2009, it was estimated that there were 2.4 million Canadians with diabetes, representing 6.8% of the population (Public Health Agency of Canada 2011). About 90% of these people have type 2 diabetes (Canadian Diabetes Association 2008). Cardiovascular disease represents a leading cause of morbidity and mortality among individuals with diabetes (Miettinen 1998). There is a two to fourfold increased risk of cardiovascular events among people with diabetes compared to those without diabetes, an increase that persists even after accounting for other traditional risk factors (Haffner 1998). As many as 68% of people with diabetes over the age of 65 die from coronary heart disease and up to 16% die from stroke (Pignone 2010). Overall, survival is reduced by as many as 15 years in those with type 1 diabetes and by 5 to 10 years in those with type 2 diabetes (Canadian Diabetes Association 2008). Diabetes is the sixth leading cause of death in Canada (Statistics Canada 2011). Other serious complications include eye disease, kidney disease, foot ulcers and amputations. The annual cost of diabetes to the Canadian health care system is projected to exceed \$19 billion by 2020 (Canadian Diabetes Association 2008).

## *1.2 Pathogenesis, Screening and Diagnosis*

In terms of the pathogenesis of diabetes, type 1 diabetes is due to a deficiency of insulin secretion as a result of the autoimmune destruction of pancreatic beta cells, while type 2 diabetes is due to a combination of resistance to the effects of insulin and a progressive decrease in insulin production.

The Canadian Diabetes Association (CDA) recommends screening for diabetes using a fasting plasma glucose level starting at the age of 40 and, then, every 3 years thereafter (CDA 2008).

The US Preventive Services Task Force (USPSTF) recommends screening asymptomatic adults at any age who have a blood pressure greater than 135/80 (USPSTF 2008). They do not state an optimal screening interval, deferring to the American Diabetes Association, which recommends, based on expert opinion, a screening interval of no more than 3 years in asymptomatic adults beginning at 45 years of age and a screening interval of no more than 3 years in those who are younger than 45, but who have certain risk factors (ADA 2011). The Canadian Task Force on Preventive Health Care will release its screening guidelines sometime in 2012.

A diagnosis of diabetes is made when plasma glucose measurements exceed a defined threshold on two separate occasions (e.g., a) fasting plasma glucose  $\geq 7.0$  mmol/l, b) random plasma glucose  $\geq 11.1$  mmol/l in the presence of classic symptoms of diabetes such as excessive urination, excessive fluid consumption and/or unexplained weight loss or c) 2-hour plasma glucose  $\geq 11.1$  mmol/l after a 75 g oral glucose tolerance test) (CDA, 2008).

### ***1.3 Prevalence of Diabetes in the Canadian Forces***

A survey conducted in 2008/2009 suggested that the prevalence of diabetes in the Canadian Forces is less than 2%, which is below the prevalence observed in the general population (Canadian Forces Health Services 2009). The lower numbers are in part due to the fact that the Canadian Forces screen out people with a history of diabetes at the recruitment stage and the population is younger than the at-risk general population. However, the number of personnel with diabetes is expected to rise with steadily increasing rates of obesity. Indeed, self-reported rates of obesity among the Regular Forces increased from 21% in 2004 to 24% just 4 years later (Canadian Forces Health Services 2009). Excess weight is the most important predictor of type 2 diabetes (Hosseini 2007, Hu 2001). Estimates of diabetes incidence and prevalence in the Canadian Forces, aside from self-reported data, are not available at this time. The introduction of an electronic medical record (EMR) has provided the opportunity to create a diabetes registry more readily. This would not only help clarify the prevalence of diabetes in the Canadian Forces, but facilitate assessments of the quality of diabetes care and the impact of quality improvement strategies.

### ***1.4 Importance of Quality of Care in the Canadian Forces***

The mission of the Canadian Forces Health Services Group is to “provide high quality health services to Canada’s fighting forces wherever they may serve” (Canadian Forces Health Services). Within their statement of mission, vision and values, they mention the importance of maintaining professional excellence and accountability (Canadian Forces Health Services). A critical issue that was identified was to develop and deliver “programs and services by a quality

assurance framework and a rigorous performance measurement model in order to optimize the care and health of our patients” (Canadian Forces Health Services). This is also true for chronic conditions such as diabetes, which affects what may be a growing segment of the Canadian Forces.

### ***1.5 Performance Indicators and Clinical Practice Guidelines***

A number of organizations in the U.S. and the UK have developed performance indicators to assess the quality of diabetes care. The U.S., the UK and Australia have provided cash incentives to primary care physicians who meet these performance standards in order to encourage optimal diabetes care. The UK’s Quality and Outcomes Framework is an example. Pay for performance initiatives have also been introduced in Canada. Ontario, for example, has provided financial incentives to physicians for childhood immunizations, influenza vaccines, fecal occult blood testing, Pap smears and mammograms (Bell 2007).

In 2008, the Canadian Diabetes Association (CDA) published clinical practice guidelines for the prevention and management of diabetes in Canada (CDA 2008). These guidelines form a convenient and effective resource to assess the quality of care provided to the Regular Forces. The recommendations proposed in the guidelines are based on the best available evidence as well as expert opinion on best practice. They share much in common with the American Diabetes Association (ADA) clinical practice guidelines and the UK’s National Institute for Health and Clinical Excellence (NICE) clinical practice guidelines, although there are notable differences as well (ADA 2011; NICE 2009). For example, the ADA lists a Hemoglobin A1c (HbA1c)  $\geq 6.5\%$

among their diagnostic criteria for diabetes. Despite having a lower sensitivity for diagnosis than fasting glucose levels, the ADA considered the HbA1c test to be more practical and convenient with wider acceptability and applicability. Another example of a notable difference in guidelines is the NICE's recommendation that blood pressure be controlled to under 140/80 for most patients with type 2 diabetes, whereas the CDA recommends a blood pressure of less than 130/80 for all patients. Despite these differences, Canadian physicians would be expected to be most familiar with the CDA guidelines, which should therefore set the standard of care in this country.

### ***1.6 Definition of Clinical Practice Guidelines***

Clinical practice guidelines have been defined as “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” (Field 1990). They are not intended to replace clinical judgment and must be weighed against a careful consideration of individual patient preferences and values. However, the ultimate goal of guidelines is to improve the quality of care, promoting practices that are effective based on the best available evidence and discouraging practices that are ineffective or harmful.

### ***1.7 Barriers to the Implementation of Clinical Practice Guidelines***

There is a large body of literature addressing potential barriers to the implementation of guidelines. Indeed, a U.S. study found that adherence with diabetes clinical practice guidelines and other measures of best practice was only 45.4% based on a review of 13 diabetes indicators

in a sample of 12 metropolitan areas (McGlynn 2003). Barriers may be due to physician-related factors, patient-related factors, guideline characteristics and/or system-level factors. In terms of physician-related barriers, lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, lack of outcome expectancy and inertia of previous practice have been proposed as being important (Cabana 1999). According to the Theory of Planned Behaviour, perceived social pressure on physicians to comply with guidelines may also be relevant (Azien 1991). In a review of systematic reviews, age and experience were cited as barriers to guideline adherence with younger and more inexperienced health care providers having a greater tendency to use guidelines (Francke 2008). In terms of guideline characteristics, relative advantage (does complying with guidelines offer advantages related to effectiveness or cost-effectiveness), compatibility (is the guideline compatible with a physician's values and needs), complexity (is the guideline complex to integrate into routine practice), trialability (are the guideline recommendations easy to try out), and observability (can physicians observe colleagues who have incorporated the guidelines easily) may all affect the adoption of guidelines (Francke 2010; Gurses 2010, Rogers 1995). Barriers involving the system include task characteristics (for example, stocking of medical supplies), tools and technologies (for example, availability of checklists), the physical environment (for example, physical layout or noise level), and organizational characteristics (for example culture, resources and leadership) (Gurses 2010). Limited staff, time, personal resources, high workload and lack of support from peers and superiors were also cited as specific systemic barriers to guideline implementation (Francke 2008).

### ***1.8 Factors Associated with Improved Quality of Care***

A variety of factors have been demonstrated to facilitate the implementation of clinical practice guidelines and improve the quality of care.

1) **Creation of Diabetes Registries:** There is evidence that the establishment of a diabetes registry can be an important step to improving processes of care and patient outcomes (Coppell 2011, O'Mullane 2010). Based on evaluations conducted over the course of this study, it is hoped that a diabetes registry can be created within the Canadian Forces

2) **Audit and Feedback:** Feedback can be defined as “any summary of clinical performance of health care over a specified period of time” (Guldborg 2009). In general, audit and feedback produced modest effects in terms of promoting guideline adherence and improving care (Grimshaw 2006). An update of a Cochrane review concluded that “audit and feedback can be effective in improving professional practice”, citing small to moderate effects (Jamtvedt 2006). The authors further stated that the effects of feedback were likely to be larger when adherence to the recommended practice is low. Another systematic review examining the effects of feedback to general practitioners about diabetes care found that many, but not all processes of care improved (Guldborg 2009). Two of the ten studies reviewed used electronic feedback. At the end of the current study, the results of the planned quality of care assessment will be fed back to primary care physicians within the Canadian Forces Health Services with the goal of improving care.

3) **Reminders and Electronic Clinical Decision Support Tools.** A systematic review showed that active measures such as reminders and feedback were more effective than passive measures such as educational campaigns (Grimshaw 2010). The effectiveness of both manual and electronic clinical reminders is supported by a number of published studies and reviews (Col 2005, Dexter 2001, Grimshaw 2004, Grimshaw 2003, Hunt 1998, Johnston 1994, Ornswein 1991, Shea 2011, Shea 1996). The effectiveness of reminders on processes of care is likely to be moderate (Grimshaw 2006). There is some evidence to suggest that computer-based reminders may be more effective than manual reminders (Cannon 2000). In the diabetes literature, electronic medical records with clinical decision support tools have been shown to improve care, particularly processes of care (Cebul 2011, Holbrook 2009, O'Connor 2005). Unfortunately, clinical decision support tools do not exist within the current EMR software used in the Canadian Forces.

4) **Educational Outreach:** Face to face educational outreach visits by physicians or pharmacists supplemented by printed materials may result in modest benefits in improving the quality of care (Col 2005, Grimshaw 2004). However, this approach is costly.

5) **Knowledge:** There is evidence of a modest, statistically significant association between a health care provider's knowledge of evidence-based medicine and the quality of diabetes care delivered as measured by four diabetes indicators (Shuval 2010).

6) **Opinion leaders:** The use of opinion leaders shows small benefits (Boaz 2011, Grimshaw 2010). However, identifying suitable opinion leaders can be difficult.

7) **Flow Sheets:** An example of a diabetes care flow sheet is provided in the reference list (British Columbia Medical Association 2010). Flow sheets facilitate better documentation of care and serve as an important reminder system. There is substantial evidence that diabetes care flow sheets improve adherence to clinical practice guidelines and specifically improve processes of care (Hahn 2008, Moharram 2008, Roff 1999); the evidence is less convincing for improvements in intermediate outcomes. Process of care measures are more directly under a physician's control, whereas intermediate outcomes can be influenced by biological factors such as disease aggressiveness and patient-related factors such as nonadherence. Diabetes care flow sheets are used by only a minority of primary care physicians in the Canadian Forces.

8) **Financial Incentives:** The goal of financial incentives is to encourage the delivery of evidence-based standards of care. In Australia, financial incentives were shown to increase the probability of HbA1c testing by 20% (Scott 2009). The introduction of financial incentives in the UK through the Quality and Outcomes Framework was associated with accelerated improvements in the quality of diabetes care, particularly processes of care, which are more under a physician's control, even after accounting for trends in improvement over time prior to the introduction of financial incentives (Alshamsan 2010, Oluwatowoju 2010). However, a recent Cochrane review concluded that "there is insufficient evidence to support or not support the use of financial incentives to improve the quality of primary health care" after reviewing

seven studies not all of which were diabetes-related (Scott 2011). To date, no pay for performance measures exist in the Canadian Forces.

9) **Volume-Outcome Relationships:** There is an extensive literature documenting the association between higher patient volume and better health outcomes in surgery and medicine (Birkmeyer 2002, Durairaj 2005, Druss 2004, Halm 2002). This relationship extends to the primary care of diabetes, particularly for processes of care. One study found a modest effect of larger practice size on process of care measures (Millett 2007). Another study reinforced this finding, observing that physicians who have a higher volume of patients with diabetes were more likely to perform important processes of care (Holmboe 2006). Finally, a study conducted in Taiwan showed mixed results with physicians in larger practices demonstrating increased lipid profile testing, but decreased HbA1c testing and poorer rates of reaching a target HbA1c of < 7% (Wang 2009). The different bases in the Canadian Forces serve varying numbers of personnel. There may be parallels between the above-mentioned volume-outcome relationships and the relationship of size of base to quality of care.

10) **Frequency of Contact:** A recent meta-analysis suggested that a high frequency of contact was a key feature of multi-faceted programs intended to improve the quality of diabetes care (Pimouguet 2011). Indeed, disease management programs with a high frequency of contact were associated with significant reductions in HbA1c levels compared to usual care or programs with a low frequency of contact (Pimouguet 2011).

11) **Visit Duration:** In a nationally representative sample of primary care physicians in the U.S., a modest relationship was observed between increased visit duration between 1997 and 2005 and improved quality of care including diabetes-related care (Chen 2009). However, there may be other confounding factors involved.

12) **Practice Setting:** In the Canadian Forces, some bases are located in more rural or isolated communities with poorer access to high-quality continuing medical education compared to urban communities, especially those with a medical school in the city. In this regard, it would be informative to know whether setting of practice influences patient outcomes. In a national sample of adults with diabetes, there was no significant difference in quality of care given to rural or urban residents (Strom 2011).

13) **Specialists:** Specialists would be expected to provide more guideline-consistent care than primary care physicians. Indeed in an observational study, the average number of International Diabetes Federation recommendations that were followed was significantly higher among endocrinologists than primary care physicians with significantly better blood glucose control under specialist care (Rodriguez 2011). Endocrinologists and internal medicine specialists are occasionally consulted by primary care physicians in the Canadian Forces.

14) **Nurse Practitioners:** It is interesting that one study that investigated the impact of nurse practitioners found that practices that included nurse practitioners provided better diabetes care than practices with physicians only (Ohman-Strickland 2008). In the Canadian Forces, primary care is provided by physician assistants, nurse practitioners and physicians.

15) **Patient Education:** Diabetes self-management is an important component of diabetes care. Therefore patient education could be a factor in promoting adherence to with practice standards, particularly with respect to standards for target intermediate outcomes. A meta-analysis showed that patient education led to better blood glucose control as indicated by a reduction in HbA1c of 0.32 percent. The components of patient education that explained much of the variance in glycemic control included face-to-face interaction and exercise content (Ellis 2004). A 1% reduction in HbA1c levels is expected to lead to a 25%-37% reduction in microvascular complications, a 14% decrease in myocardial infarctions and a 21% reduction in diabetes mortality, indicating the importance of even modest reductions in HbA1c levels (Stratton 2000, The Diabetes Control and Complications Trial Research Group 1993, UK Prospective Diabetes Study (UKPDS) Group 1998). In the Canadian Forces, patient education occurs variably through primary care visits, dietician referrals and referrals to specialized diabetes clinics and diabetes education centers.

16) **Multi-faceted Interventions:** The use of multiple strategies has been found to improve guideline adherence and the quality of care over single interventions (Boaz 2011, Francke 2008).

### ***1.9 Quality of Diabetes Care in Canada and Internationally***

According to the 2007 Canadian Community Health Survey, which excluded members of the Canadian Forces, 81% of Canadians with diabetes received a Hemoglobin A1C test within the

last 12 months, 74% had a urine test for protein during the same time period, 66% had a dilated eye exam in the last 2 years and 51% had a foot exam in the last 12 months (CIHI 2009).

Overall, only 32% received all 4 recommended tests in the specified time frame (CIHI 2009). In terms of intermediate outcomes, the 2005 Diabetes in Canada Evaluation (DICE) study found that 49% had suboptimal Hemoglobin A1c levels ( $>7.0\%$ ) (Harris, 2005). These results suggest there are substantial gaps in the quality of care provided to people with diabetes in Canada.

An article was recently published that compared the quality of care in five countries that are part of the Organisation for Economic Co-operation and Development (OECD) including Canada, the U.S., the UK, Australia and New Zealand (Si 2010). Process of care measures such as rates of annual HbA1c testing, annual lipid profile testing, annual kidney function testing and annual or biennial eye examinations were reasonably high (see Table 1). In contrast, intermediate outcomes such as target HbA1c levels were less successfully reached. In a national survey in Taiwan, the percentage that had an HbA1c  $< 7\%$ , a blood pressure  $< 130/80$  mmHg and an LDL  $< 2.6$ mmol/l as per ADA guidelines were 32.4%, 30.9% and 35.3% respectively (Yu 2009). Clearly, there is room for improvement in diabetes care not only in Canada, but in other countries around the world.

**Table 1. International Estimates of the Quality of Diabetes Care**

<b>Recommendation</b>	<b>Canada*</b>	<b>US<sup>†</sup></b>	<b>UK<sup>†</sup></b>	<b>Australia<sup>†</sup></b>	<b>New Zealand<sup>†</sup></b>	<b>Taiwan<sup>#</sup></b>
<b>Annual HbA1c testing</b>	81% (2007 data)	61%-92%	83%	65%-93%	64%	-
<b>Annual lipid profile testing</b>	-	71%-85%	81%	50%-79%	64%	-
<b>Annual kidney function testing</b>	-	75%-85%	83%	18%-70%	64%	-
<b>Annual or Biennial Eye examinations</b>	66% (2007 data; biennial)	51%-68%	61%	32%-77% (biennial)	71% (biennial)	-
<b>HbA1c &lt; 7%</b>	51% <sup>θ</sup>	30%-49%	58% (HbA1c ≤7.5%)	38%-57%	73% (HbA1c <8.0%)	32.4%
<b>Blood pressure &lt; 130/80 mmHg</b>	-	-	-	-	-	30.9%
<b>LDL &lt; 2.6 mmol/L</b>	-	31% - 47%	-	-	-	35.3%

\*Reference: CIHI 2009

<sup>θ</sup> Reference: Harris 2005

<sup>†</sup> Reference: Si 2010

<sup>#</sup> Reference: Yu 2009

The purpose of this thesis is to monitor the quality of diabetes care given to members of the Canadian Regular Forces, understanding that serious complications may be prevented or minimized through adherence to recommended practices (Baigent 2005, Berl 2005, Brenner 2001, Gaede 2008, HPSCG 2002, Mayor 2011, Schrier 2002, Stratton 2000). Ensuring excellence in managing diabetes is one of several priorities of the Canadian Forces Health Services and the recent introduction of the EMR has provided a unique opportunity to study this subject more efficiently and effectively.

## 1.10 Objectives

The overall goal of the thesis is to investigate the quality of diabetes care in the Canadian Forces.

The specific objectives of the thesis are to:

1. Evaluate the quality of care provided to members of the Regular Forces who have diabetes by determining the extent to which health care providers adhere with recommendations outlined in the 2008 CDA clinical practice guidelines through a retrospective chart review over a period of more than 3 years.
2. Determine the effects of patient age, patient gender, patient rank and size of base on quality of care.
3. Investigate the accuracy of a diagnosis of diabetes in the EMR. This will help determine whether developing a diabetes registry in the Canadian Forces based on diagnostic information contained in the EMR is feasible.

### Objective 1: Evaluating quality of care.

Both processes of care and intermediate outcomes will be investigated based on adherence to recommendations from the Canadian Diabetes Association. Comparisons of the quality of diabetes care in the Canadian Forces will be made to the civilian population.

## Objective 2: Identification of patient and base factors associated with quality of care.

Although a number of factors have been shown to influence quality of care as indicated by a review of the literature, data on many of these factors were not available for the Canadian Forces and therefore were not considered in this thesis.

However, given the significant volume-outcome relationships that have been identified in the literature and the availability of data on base size, this thesis will investigate whether health care providers within larger bases show better adherence to recommended practices than health care providers in smaller bases. Larger bases would be expected to have a higher volume of patients with diabetes which likely correlates with increased awareness on the part of health care providers about the scientific literature on diabetes, including relevant clinical practice guidelines. In addition, larger bases may have a larger critical mass of health care providers to encourage acquisition of knowledge on the latest developments in medicine, translating to improvements in quality of care.

This thesis will also examine whether patient-related factors are associated with quality of care since patient adherence with a physician's advice are as important as a physician's awareness of clinical practice guideline recommendations. Therefore, the effect of patient age, gender and rank on guideline adherence will be evaluated. Patient rank can be considered a proxy for socioeconomic status given that higher rank (officers vs. non-commissioned members) is associated with higher education and income. In addition to a possible relationship of patient age,

gender and rank on adherence with a health care provider's advice, it is possible that physicians approach diabetes care differently in patients of different ages, gender or rank.

Physician-related factors such as physician age, gender, years of experience, and volume of patients with diabetes will not be assessed as this information was not readily available.

### Objective 3: Validation of a diagnosis of diabetes in the monthly assessment extract.

The feasibility of creating a diabetes registry based on the appearance of a diagnosis of diabetes in the EMR will be evaluated. Previous studies have shown that a physician diagnosis of diabetes is a highly accurate indicator for the presence of diabetes (Crane 2006, Hux 2002, Tu 2011, Zgibor 2007). However, errors in diagnostic (ICD-10) coding may produce false positives and incomplete documentation may result in false negatives. Using the EMR would, nevertheless, be a simple, convenient and effective way of creating a diabetes registry, provided that sensitivity, specificity, positive predictive value and negative predictive value are acceptable.

## **2. Methods**

In this retrospective cohort study, medical records of all eligible patients with diabetes were reviewed over a period of more than 3 years to accumulate data on adherence with the 2008 CDA clinical practice guidelines.

## ***2.1 Study Population.***

The study population consisted of members of the Regular Forces aged 18 to 60 with diabetes who were located in the 14 bases that incorporated progress notes into the EMR for 6 months or more as of December 19<sup>th</sup>, 2011. The 14 bases were Bagotville, Borden, Cold Lake, Comox, Edmonton, Esquimalt, Kingston, Moose Jaw, North Bay, Petawawa, Shilo, Suffield, Trenton and Winnipeg. There was a total of 32, 603 members of the Regular Forces in these bases, which represents roughly half of the overall Canadian Regular Forces population.

## ***2.2 Data Sources***

Three sources of data were used to identify people with diabetes, conduct an evaluation of the diagnostic accuracy of a diabetes diagnosis and assess quality of care.

1) Clinical diagnoses documented in the EMR within the physicians' progress notes or periodic health assessments were used to identify people with diabetes. Based on EMR data, an extract was generated that contained a list of patients with a diagnosis of diabetes (ICD-10 codes: E10-E14) for every relevant clinical encounter from as early as July 1, 2010 up to December 19<sup>th</sup>, 2011. This extract was known as the "monthly assessment extract". It should be noted that primary care providers are required to enter all relevant diagnoses for each clinic visit, not just the primary one which is the norm within provincial billing systems.

2) A pharmacy database was also used to identify people with diabetes. This database contained a list of personnel who were prescribed diabetes medication and/or glucose testing strips in the past year.

3) Finally, medical records (EMRs and older paper charts) were reviewed to determine whether laboratory criteria for diabetes were satisfied and to accumulate data on quality of care.

### ***2.3 Identifying Personnel with Diabetes***

Study participants were classified as having diabetes if they met the following criteria:

1) They had a diabetes diagnosis listed in the monthly assessment extract

OR

2) They were prescribed diabetes medication and/or glucose testing strips in the past year

AND

3) They had diagnostic glucose measurements on two separate occasions as per clinical practice guidelines (fasting glucose  $\geq 7.0$  mmol/l, random plasma glucose  $\geq 11.1$  mmol/l or 2-hour plasma glucose  $\geq 11.1$  mmol/l after a 75 g oral glucose tolerance test).

These three criteria were taken as the reference standard for assessing the accuracy of a diagnosis of diabetes listed in the monthly assessment extract.

## ***2.4 Outcome Measures***

The criteria used to assess quality of care were based on adherence to CDA guideline recommendations in two areas: processes of care, which refer to health care provider behaviours, and intermediate outcomes, which refer to laboratory values or blood pressure measurements.

## ***2.5 Process of Care Measures***

In terms of processes of care, it is recommended that patients with diabetes should have the following: a Hemoglobin A1c test at least every 6 months, an annual test for urine protein excretion (random urine albumin-creatinine ratio (ACR)), an annual kidney function test (serum creatinine converted to an estimated glomerular filtration rate (eGFR)), a blood pressure check at every visit, an annual foot exam with additional testing for peripheral neuropathy, a dilated eye exam every 1-2 years, a fasting lipid profile every 1-3 years and a baseline EKG in those over 40. An EKG should be repeated every 2 years in those who are at high risk for cardiovascular events (CDA, 2008). Patients at high risk for cardiovascular events are defined as males  $\geq 45$  years old and females  $\geq 50$  years old. Additional recommendations include an annual influenza vaccination, encouragement to stop smoking, the use of metformin as the initial oral anti-hyperglycemic agent and the prescription of an angiotensin-converting enzyme inhibitor (ACEi) or an angiotensin receptor blocker (ARB) for those with persistent albuminuria (ACR  $\geq 2.0$  mg/mmol in males or  $\geq 2.8$  mg/mmol in females), even in the absence of hypertension (CDA, 2008). According to the CDA clinical practice guidelines, an ACE inhibitor or ARB should also be prescribed for those at high risk of cardiovascular events (CDA, 2008).

Adherence with each of these recommendations was recorded by assigning a 0 (No adherence), 1 (Adherence) or 9 (Information not available/Recommendation not applicable).

In order to assess adherence with the recommendation for a hemoglobin A1c every 6 months, lab values up to 6 months prior to the date of the chart review were considered. For all annual tests, which are recommended at diagnosis and then annually, a time interval of up to 1 year prior to the date of the chart review was considered. The same applied for tests required every 1-2 or 1-3 years, except that a time interval of up to 2 years or 3 years from the date of the chart review respectively was considered. For the recommendation concerning blood pressure checks at every visit, a “0” was assigned if a blood pressure was not measured at a clinic visit even if the principal reason for the visit was not for diabetes care (eg., knee pain). For peripheral neuropathy testing, the use of a 10g monofilament or 128 Hz tuning fork must have been documented as recommended by clinical practice guidelines (CDA, 2008). “If “vibration sense” was documented, this qualified as appropriate peripheral neuropathy testing because only a tuning fork can be used to assess vibration sense. “Normal sensation”, “Neurological normal” or any of its variations was not accepted because sensation can be assessed by a variety of means other than by using a monofilament or tuning fork. A proper foot exam typically involves peripheral neuropathy testing, palpation for foot pulses and inspection for colour changes, skin lesions or structural abnormalities. If “feet normal” or any of its variations was documented, this was accepted as representing a foot exam. If peripheral neuropathy testing was done or foot sensation was documented, it was assumed that the patient had to have had his/her socks removed, giving the physician the opportunity to identify suspicious skin or structural abnormalities in the feet. The physician was given the benefit of the doubt in these cases and a “1” was assigned for foot

exam. For the recommendation concerning repeat EKGs in high risk individuals, those done within 2 years of the date of the chart review were noted for males  $\geq 47$  years and for females  $\geq 52$ . For patients over 40 who were not at high risk, EKGs done at any time in the past on the basis of a review of the EMR or preceding paper charts was accepted as complying with the recommendation for a baseline EKG. For male patients  $\geq 47$  years and female patients  $\geq 52$  who were considered high risk, a baseline EKG was accepted as having been done if an EKG was completed at any time before 2 years from the date of the chart review because of the difficulty of establishing the exact date of diagnosis of diabetes in all patients. For high risk males  $< 47$  and high risk females  $< 52$  with diabetes, only a baseline EKG was required; a repeat EKG was not necessary. A stress test was accepted as a substitute for an ordinary EKG. The recommendation for an annual flu shot was assigned a “1” if it was given in the current or previous flu season since the current flu season was not over at the time of the chart review. In smokers, if smoking cessation advice/counseling was documented, smoking cessation therapy was prescribed or a referral to a smoking cessation program was made (“Butt Out”), a “1” was assigned. The recommendation for the use of metformin as the initial anti-hyperglycemic agent was assigned a “9” if only insulin was prescribed or if the patient was diet-controlled. If any oral anti-hyperglycemic was prescribed and metformin was not one of them, a “0” was assigned. Testing for the urine total protein-to-creatinine ratio was accepted a substitute for the urine ACR. If 2 of the last 3 ACRs were elevated as defined above and 1 of the elevated values occurred in the last year prior to the date of the chart review, a “1” or “0” was assigned depending on whether or not an ACE inhibitor or ARB was prescribed. Otherwise, a “9” was assigned.

## ***2.6 Intermediate Outcomes***

In terms of intermediate outcomes, Hemoglobin A1c levels should be  $\leq 7.0\%$ , blood pressure should be  $< 130/80$  mmHg and, in those at high risk for cardiovascular events, low-density lipoprotein (LDL) should be  $\leq 2.0$  mmol/l with a secondary target being a total cholesterol:high density lipoprotein (TC:HDL) ratio of less than 4.0 (CDA, 2008). In patients with an on-treatment LDL level of 2.0 to 2.5 mmol/l, clinical judgment should be used to decide if additional therapy is necessary (CDA, 2008) . In those at moderate risk for cardiovascular events, cholesterol lowering treatment should be initiated if LDL is greater than 3.5 mmol/l and the TC:HDL ratio is greater than or equal to 5.0 (Genest, 2009).

As with the process of care measures, these intermediate outcomes were assigned a 0, 1 or 9 as appropriate for each patient.

For the recommendation of a Hemoglobin A1c  $\leq 7.0\%$ , the last recorded value in the last year was considered. If no values were documented in the last year, a “9” was assigned. For patients at high risk, a “1” was assigned if the LDL was  $\leq 2.5$  and if the TC:HDL ratio was  $< 4.0$ . For patients at moderate risk, a “1” was assigned if the LDL was  $< 3.5$  and if the TC:HDL ratio was  $< 5.0$ . For the recommendation concerning blood pressure, the average of the last 3 documented blood pressures was calculated to assess adherence. If less than 3 measurements were available, the average of the available blood pressures were calculated. The CDA guidelines do not provide any guidance on how to assess adherence with the blood pressure recommendation. It is not clear, for example, if only 1 or the average of 2 or more blood pressures above 130/80 mmHg is

needed to be considered undesirable or if 2 or more consecutive blood pressures must be above 130/80 mmHg to be considered high, warranting more aggressive management. Given the controversy regarding appropriate blood pressures in people with diabetes, an alternative to the recommendation of a blood pressure <130/80 mmHg was considered. There is some evidence that intensive blood pressure control is not beneficial in diabetics and may even be harmful such that the traditional threshold for diagnosing hypertension (140/90) be used (Arguedas 2009, Cooper-DeHoff 2010, Cushman 2010, Sui 2011). Therefore, an alternate variable was included where a “1” was assigned if the average blood pressure was <140/90 mmHg.

## ***2.7 Summary of Outcome Measures***

For each patient with diabetes, adherence with the all applicable CDA clinical practice guideline recommendations (exact number depends on risk level, smoking status and lab results) was assessed. Unfortunately, there is no widely used composite index for assessing the quality of diabetes care and weighting each of the CDA guideline recommendations according to importance would be arbitrary. Therefore, adherence with each guideline recommendation was analyzed separately. In addition, an overall indicator of compliance with the entire panel of applicable recommendations was determined for each patient. This was calculated for each patient as the proportion of all relevant guideline recommendations for which the patient was adherent.

It should be noted that where it is stated in the guidelines that following a specific recommendation should be “considered”, the health care provider was not penalized for not following the recommendation as it is open to clinical judgment.

## ***2.8 Analysis***

### ***2.9. Sample Size Calculations***

As a conservative estimate for the quality of care assessment in objective 1, a sample of 385 patients with diabetes needed to be investigated to obtain an estimated proportion of those who adhere to a given CDA guideline recommendation that was within 5% of the true population proportion (D’Agostino, 2006). The estimate assumed an adherence rate of 50% to maximize the sample size required. The calculated sample size also assumed that a random sample was taken. However, in this study, a complete census of all eligible patients was taken as the target sample size of 385 was roughly the anticipated size of the population with diabetes

### ***2.10 Inter-rater Agreement***

One abstractor extracted the data from the medical records into an excel file. Demographic information including age, sex, rank and base location was collected. With reference to the 1<sup>st</sup> objective of assessing the quality of diabetes care, a second abstractor reviewed a random sample of 10% of the charts to determine the inter-rater reliability for 10 of the most important guideline recommendations using the kappa statistic: 1) HbA1c every 6 months; 2)  $HbA1c \leq 7.0\%$ ; 3)  $BP < 130/80$  mmHg; 4) High risk patients:  $LDL \leq 2.5$  mmol/l; 5) High risk patients: TC: HDL ratio  $< 4.0$ ; 6) Moderate risk patients:  $LDL < 3.5$  mmol/l; 7) Moderate risk patients: TC:HDL

ratio < 5.0; 8) Annual flu shot; 9) Annual or biennial eye exam; 10) Annual peripheral neuropathy testing. If the kappa value was not acceptable (<0.70), a further set of 10% of the charts was reviewed by the second abstractor until acceptable agreement between raters was reached (i.e. a kappa value exceeding 0.70)

### ***2.11 Objective 1: Univariate and Bivariable Analysis***

For the 1<sup>st</sup> objective, univariate analysis (frequencies, proportions) was conducted to determine the overall adherence with each of the individual CDA guideline recommendations with 95% confidence intervals around estimated proportions. In addition, the mean patient-specific adherence with the entire panel of applicable recommendations was calculated with 95% confidence intervals.

Note that due to time constraints in accessing paper charts, the recommendation for a baseline EKG was not verified in 10 patients. These cases did not contribute to the univariate analysis.

Bivariable analysis was conducted using chi square tests, Fisher's exact tests or t-tests, as appropriate, to describe and test the simple association between each outcome measure and each predictor variable (age (continuous), gender (dichotomous), rank (dichotomous) and base size (continuous)).

## ***2.12 Objective 2: Logistic Regression Modelling***

The effect of patient age, patient gender, patient rank and size of base on adherence to three guideline recommendations was evaluated using multiple logistic regression. One process of care outcome was examined in the regression analysis (i.e., HbA1C testing every 6 months) and two intermediate outcome were examined (i.e., BP <130/80 mmHg, HbA1c  $\leq$ 7.0%). These specific outcomes were selected on the basis of their importance in diabetes care, although it is recognized that decisions about importance are somewhat arbitrary.

Age and size of base were analysed as continuous measures and rank (officers vs non-commissioned members) and gender were dichotomous.

As there were only four independent variables of interest, and there was an interest in determining the independent effect of all four independent variables, a stepwise model fitting algorithm was not used (i.e., all 4 variables were entered into the model at one time).

Empirical logit plots were used to investigate the functional form of the associations with the continuous predictors (age and base size) and appropriate transformations were considered in determining the final logistic regression models.

Model fit was assessed using the Hosmer-Lemeshow goodness of fit test and the area under the ROC curve.

No potential effect modifiers were defined a priori and therefore interactions were not evaluated.

Using a commonly accepted rule of thumb of 10 events per variable, a sample size of 385 patients was felt to be sufficient to conduct the regression analysis (Peduzzi, 1996).

### ***2.13 Objective 3: Feasibility of creating a diabetes registry based on a diabetes diagnosis in the monthly assessment extract***

The feasibility of creating a diabetes registry in the Canadian Forces was assessed by determining the validity of a diabetes diagnosis listed in the monthly assessment extract. This diagnosis was compared to a reference standard of patients in the monthly assessment extract or pharmacy database with plasma glucose levels in the diabetes range on two separate occasions as defined previously in the section entitled, “Identifying Personnel with Diabetes”.

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated.

Since the laboratory records of all 32, 603 members of the Canadian Forces at the 14 selected bases could not be screened, an assumption was made that patients who were not listed in the monthly assessment extract or the pharmacy database did not have diabetes. As a sensitivity analysis for this assumption, the capture-recapture method was used to provide the best estimate of a “worst-case” scenario.

Patients in the monthly assessment extract with diagnostic glucose measurements on two separate occasions were labeled as true-positives (TP). After a thorough review of lab values in the EMR and older paper charts, those who did not meet this definition of diabetes were labeled as false positives (FP).

Patients with laboratory-confirmed diabetes who were listed in the pharmacy database but did not appear in the monthly assessment extract were labeled as false-negatives (FN).

The number of personnel without diabetes in the 14 selected bases was calculated as the difference between the total population size and the total number of patients with diabetes. The number of true negatives was then calculated knowing the number of false positives, thus completing the 2x2 table. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were subsequently determined.

To provide a “worst-case” scenario, the capture-recapture method was used. The capture-recapture method has been used by zoologists to estimate the size of wildlife populations. Essentially, a sample of animals is captured, marked and released. Then a second sample of animals is caught and the marked animals are said to be recaptured. Based on the size of the 2 samples and the number recaptured, the overall animal population size can be calculated using a simple formula. The capture-recapture method has also been used to estimate the prevalence of diabetes (Gill 2001). Based on the principles of capture-recapture, the overall prevalence of

diabetes in the 14 selected bases was calculated according to the Lincoln–Petersen method (Seber 1982, Verlato 2000). The formula used was  $N = M \times C / R$  where  $N$  = estimate of total number of patients with diabetes,  $M$  = total number of patients with diabetes captured and marked from the monthly assessment extract,  $C$  = total number of personnel captured from the pharmacy database and  $R$  = number of patients with diabetes captured by the monthly assessment extract that were then recaptured by the pharmacy database. The number of false negatives (FN) was calculated by subtracting the number of true positives from  $N$  (the estimated total number of patients with diabetes using the capture-recapture method) (see table 2). The number of true negatives was calculated knowing the number of false positives and the number of patients without diabetes (32, 603- $N$ ). The sensitivity, specificity, PPV and NPV based on this “worst-case” scenario were then determined.

**Table 2. Validation using the capture-recapture method**

<b>Diabetes diagnosis in the monthly assessment extract</b>	<b>Diabetes</b>		<b>Total</b>
	<b>Yes</b>	<b>No</b>	
<b>Yes</b>	TP	FP	TP+FP
<b>No</b>	FN	TN	FN+TN
<b>Total</b>	N	32603-N	32603

Note that due to time constraints, the older paper charts of 6 patients were not reviewed among those who did not have 2 diagnostic glucose measurements in the EMR laboratory records. In these patients, the diagnosis of diabetes was assumed to represent a false positive.

All statistical analyses were performed using Microsoft Excel 2003 and Stata software (version 11.0).

### ***2.14 Additional Notes***

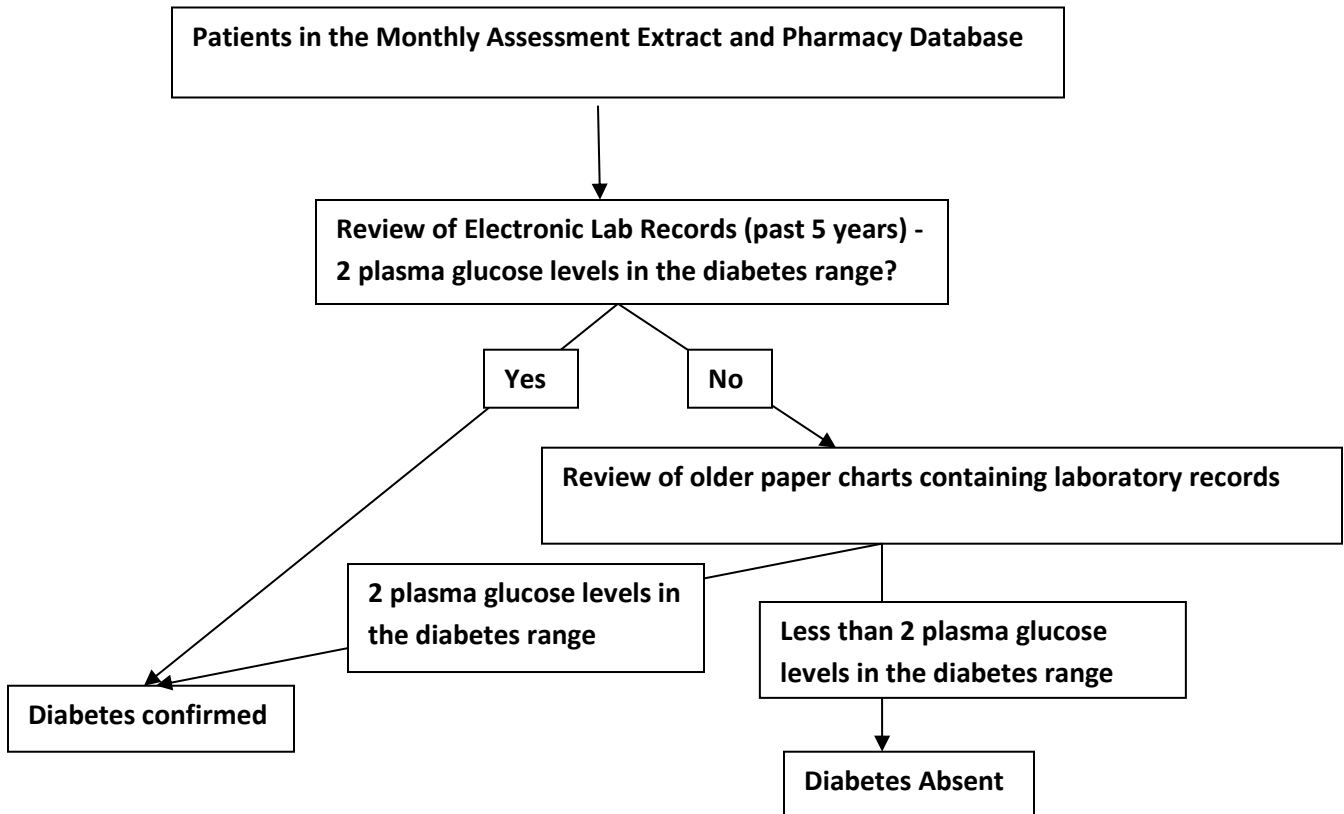
All health care for members of the Regular Forces, other than emergency after hours care, is provided by the Department of National Defense (DND). Therefore, the possibility that patients might receive care from outside clinics not affiliated with DND and have blood work done in outside labs is not a concern. Even when seen after hours in outside clinics, members of the Regular Forces are to report on those encounters to their local military medical clinic. Also note that the Canadian Forces do not accept applicants with pre-existing diabetes so all cases of diabetes among members of the Canadian Forces must have been diagnosed while in service.

For patients listed in the monthly assessment extract, lab records in the EMR were reviewed, which spanned a period of up to the last 5 years. Lab records in the older paper charts were reviewed if two diagnostic glucose levels were not found in the EMR.

Patients listed in the pharmacy database were followed up by first reviewing their EMR. Any patients who had diabetes by laboratory criteria were noted. Older paper charts were reviewed to search for additional lab values not contained in the EMR for any patient with only a single glucose level in the diabetes range. The older records were also reviewed for any patient with no diagnostic glucose levels, but who happened to have a diagnosis of diabetes listed in the progress

notes or periodic health assessments within the EMR, the latter of which spanned a period of up to the last 5 years. After reviewing these older records, any additional patients meeting the definition of diabetes were noted.

**Figure 1. Flow Chart of Case Ascertainment**



### ***2.15 Ethics Clearance***

Ethically, this project could be considered “low risk” since it involved a retrospective chart review with no direct patient contact. Individual consent was not obtained in light of the low risk nature of the study. To ensure security and confidentiality, only one abstractor, Dr. Amole Khadilkar, reviewed all of the medical records. A second abstractor, Dr. Jeff Whitehead, reviewed 10% of the medical records for the purpose of establishing inter-rater reliability. The

data was abstracted directly into a database on a Protected B computer on the Protected B network at the Department of National Defense (DND), which is a secure, password-protected network accessible only to authorized DND users. The personal information was rendered anonymous at the earliest possible opportunity. Upon completion of the chart review, the data was only available to the study investigators for analysis. All investigators with direct access to confidential data had signed privacy and confidentiality agreements. Data will only be released in aggregated form so as to avoid identifying any individual. Following the study, the data will be stored on a memory stick in a locked cabinet for a period of 10 years, after which the data will be deleted from the memory stick and the memory stick destroyed.

The aggregate data and study findings were used to support Amole Khadilkar's Master's thesis and will be used to create a summary report for dissemination within the Canadian Forces Health Services (CFHS). Publication of findings in a peer-reviewed journal will be considered. Before publishing a final research product, the CFHS reserves the right to review the final draft and methodology and to examine the research to verify that there has been no compromise of the personal information before the final research product is published. Papers or any other works which describe the results of the research undertaken will be written and/or presented in such a way that no individuals referred to in the records can be identified and no data linkages can be made between any personal information found in the records and personal information that is publicly available from other sources. There will be no exceptions to this rule without prior and specific written permission from the Director of Access to Information and Privacy (DAIP).

Dr. Doug Manuel, Assistant Professor in the Division of Epidemiology at the Ottawa Health Research Institute, acted as thesis supervisor and provided his expertise and overall guidance. Dr. Monica Taljaard, Assistant Professor in the Department of Epidemiology and Community Medicine at the University of Ottawa, acted as co-supervisor and provided statistical expertise. They did not have direct access to medical records or any personal identifying information. Only Department of National Defense (DND) Health Personnel working in the Epidemiology section of the Directorate of Force Health Protection who were specifically designated for this study had access to the datasets. They each had appropriate security clearance, including Dr. Amole Khadilkar, Public Health and Preventive Medicine Resident and Master's student, Dr. Jeff Whitehead, medical epidemiologist and co-supervisor, Dr. Maureen Carew, medical epidemiologist, and Mr. Robert Hawes, senior epidemiologist.

Before undertaking this study, approval was obtained from the Director of Access to Information and Privacy (DAIP) as well as Veritas, an independent review ethics board accredited by the Association for the Accreditation of Human Research Protection Programs (AAHRPP).

### **3. Results**

#### ***3.1 Characteristics of the study population***

There were 400 diabetes patients identified using the monthly assessment extract and the pharmacy database in the 14 bases selected for investigation, giving a total diabetes prevalence of 1.2% (95% CI: 1.1 to 1.3%). The characteristics of the study population are presented in Table 3. The population was predominately male and primarily consisted of non-commissioned members (lower rank). The proportion of officers (higher rank) with diabetes was substantially lower in this study (11.3%) than the overall proportion of officers in the Canadian Forces

irrespective of disease status (24.2%). Similarly, the proportion of females with diabetes in this study (4.3%) was lower than the overall proportion of females in the Canadian Forces (13.7%). The age of diabetes patients ranged from 23 to 60 years with a mean of 46.2 years (SD 6.3). Although two-thirds of the Canadian Forces are younger than 40 years, approximately 87% of the patients with diabetes in this study were 40 years or older. About a quarter of the patients were current smokers, putting them at increased risk for macrovascular and microvascular complications of diabetes (CDA 2008). 8% of the patients had type 2 diabetes managed by diet alone and another 8.3% had type 2 diabetes managed with insulin. Overall, only 2.3% had type 1 diabetes. The 14 bases selected for this study ranged in size from 166 to 5532 members with a mean of 3180 (SD: 1532).

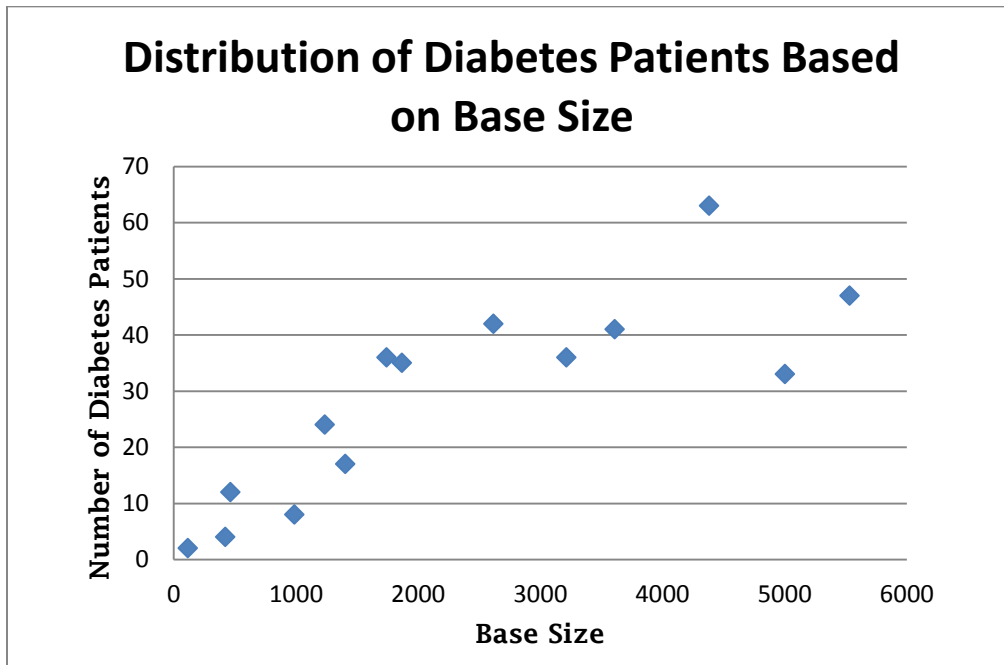
**Table 3. Characteristics of the study population**

	<b>Frequency (%) *</b>
<b>Gender</b>	
<b>Males</b>	383 (95.8%)
<b>Females</b>	17 (4.3%)
<b>Age</b>	
<b>Mean (SD)</b>	46.2 (6.3)
<b>Age &lt; 40 years</b>	53 (13.3%)
<b>Age 40-49 years</b>	218 (54.5%)
<b>Age 50-60 years</b>	129 (32.3%)
<b>Rank</b>	
<b>Officers</b>	45 (11.3%)
<b>Non-commissioned members</b>	355 (88.8%)
<b>Smoking status</b>	
<b>Smokers</b>	100 (25.4%)
<b>Non-smokers</b>	294 (74.6%)
<b>Type of diabetes</b>	
<b>Diet-controlled type 2 diabetes</b>	32 (8.0%)
<b>Type 2 diabetes on insulin</b>	33 (8.3%)
<b>Type 1 diabetes</b>	9 (2.3%)
<b>Base characteristics</b>	
<b>Mean base size (SD)</b>	3180 (1532)

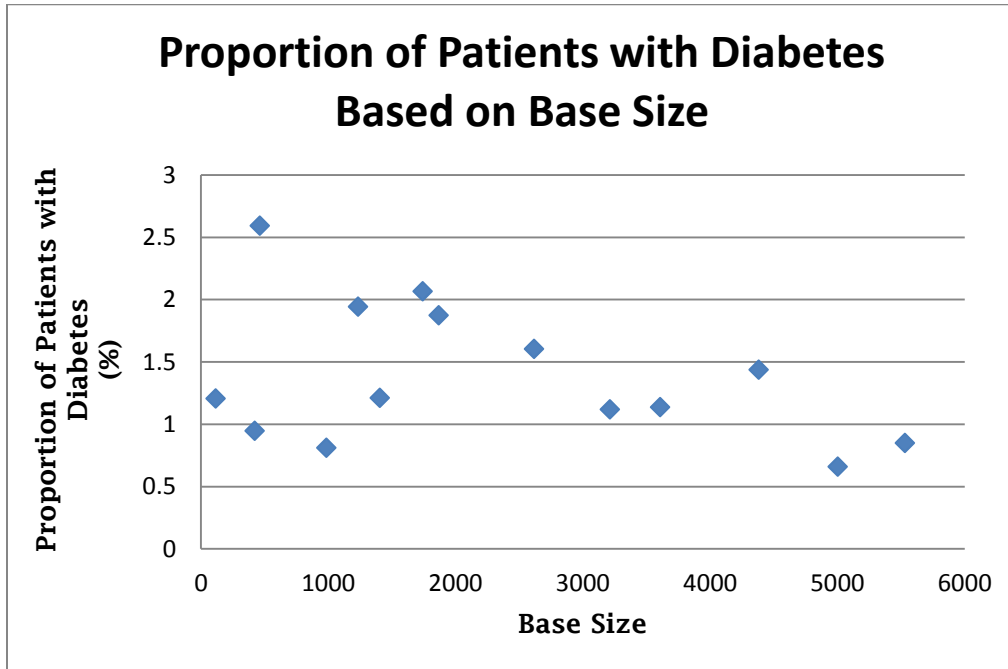
\*- Unless otherwise indicated

As expected, there generally was an increasing number of diabetes patients with increasing base size (see Figure 2). The proportion of patients with diabetes in each of the 14 bases ranged from 0.66% to 2.6% (see Figure 3).

**Figure 2.**



**Figure 3.**



***3.2 Feasibility of developing a diabetes registry based on a diabetes diagnosis in the monthly assessment extract***

The sensitivity of a diabetes diagnosis in the monthly assessment extract was 84.5% (95% CI: 81.0 to 88.0%), the specificity was 99.8% (95% CI: 99.8 to 99.9%), the positive predictive value was 85.1% (95% CI: 81.6 to 88.6%) and the negative predictive value was 99.8% (95% CI: 99.8 to 99.9%) (see table 4). Of the 59 false-positives, 19 patients (32.2%) had pre-diabetes and 40 patients (67.8%) had only one glucose level in the diabetes range instead of the required two. Pre-diabetes refers to fasting plasma glucose levels from 6.1 to 6.9 mmol/l or a plasma glucose level between 7.8 and 11.0 mmol/l two hours after a 75g oral glucose tolerance test. A single elevated glucose level may be due to laboratory error, unless confirmed by a repeat measurement on a separate occasion. In terms of false-negatives, there were 62 patients in the pharmacy database who had laboratory-confirmed diabetes that were not identified in the monthly

assessment extract. These cases generally had a diagnosis of diabetes reported in their medical records, but due to a software error, they did not appear in the monthly assessment extract.

As a “worst-case” scenario using the capture-recapture method, the corresponding sensitivity was 80.1% (95% CI: 76.9 to 84.4%), the specificity was 99.8% (95% CI: 99.8 to 99.9%), the positive predictive value was 85.1% (95% CI: 81.6 to 88.6%) and the negative predictive value was 99.7% (95% CI: 99.7 to 99.8%).

**Table 4. Validation of a diabetes diagnosis in the monthly assessment extract**

<b>Diabetes diagnosis in the monthly assessment extract</b>	<b>Diabetes</b>		<b>Total</b>
	<b>Yes</b>	<b>No</b>	
<b>Yes</b>	338	59	397
<b>No</b>	62	32144	32206
<b>Total</b>	400	32203	32603

### ***3.3 Inter-rater Agreement***

The level of agreement for the quality of care assessment, where 10% of the charts were reviewed by a second individual, was high (see table 6). There were some discrepancies related to the different dates of chart review between the two reviewers, but these had minor effects on the overall agreement.

**Table 5: Qualitative classification of kappa values as degree of agreement beyond chance \***

Kappa value	Degree of agreement beyond chance
0	None
0–0.2	Slight
0.2–0.4	Fair
0.4–0.6	Moderate
0.6–0.8	Substantial
0.8–1.0	Almost perfect

\* Reproduced from McGinn et al, 2004

**Table 6: Level of inter-rater agreement beyond chance**

Guideline Recommendation	Kappa Statistic (n=41)	95% CI
<b>Processes of Care</b>		
HbA1c every 6 months	0.75	0.44 to 1.0
Annual flu shot	0.85	0.54 to 1.0
Annual or biennial eye exam	0.89	0.75 to 1.0
Annual peripheral neuropathy testing	0.77	0.47 to 1.0
<b>Intermediate Outcomes</b>		
HbA1c $\leq$ 7.0 %	0.87	0.62 to 1.0
Blood pressure $<$ 130/80 mmHg	0.81	0.52 to 1.0
High risk patients: LDL $\leq$ 2.5 mmol/l	0.96	0.74 to 1.0
High risk patients: TC:HDL ratio $<$ 4.0 mmol/l	0.89	0.67 to 1.0
Moderate risk patients: LDL $<$ 3.5 mmol/l	0.95	0.66 to 1.0
Moderate risk patients: TC:HDL ratio $<$ 5.0 mmol/l	0.95	0.66 to 1.0

### ***3.4 Quality of Care Assessment***

The adherence rate for the 21 CDA guideline recommendations that were considered in this study are shown in table 7. Recommendations for which there was a greater than 75% adherence rate included HbA1c testing every 6 months, annual eGFR testing, eye exams every 1-2 years, smoking cessation advice, an LDL  $\leq$  3.5 mmol/l in patients at moderate cardiovascular risk, the prescription of an ACEi or ARB in patients with persistent microalbuminuria, a baseline EKG in patients over 40, lipid profile testing every 1-3 years and the use of Metformin as the initial oral

anti-hyperglycemic agent. There was low adherence (below 50%) for the annual influenza vaccination, for maintaining a blood pressure at less than 130/80, for getting an annual foot exam, for having annual peripheral neuropathy testing and for getting a blood pressure check at every physician visit. While the adherence for the recommendation to have a blood pressure less than 130/80 was quite low, the percentage of diabetes patients who had a blood pressure less than 140/90 was more reasonable at 77.1% (95% CI: 72.8 to 81.5%). The mean blood pressure of all 400 diabetes patients in this study was 131/81. 73.0% of the patient charts contained 2 or more blood pressure readings, 17.5% contained 1 reading and 9.5% contained no readings over a period of up to 2 years. Patients with no readings were excluded from the blood pressure analysis.

The mean overall adherence with all applicable CDA recommendations per patient was 60.3% (95% CI: 59.0 to 61.6%) with a range from 13.3% to 93.3%, which is less than optimal.

**Table 7. Adherence with the Canadian Diabetes Association clinical practice guideline recommendations among patients within the Canadian Regular Forces**

<b>Recommendation</b>	<b>Adherence (n=400)</b>	<b>95% CI</b>
<b>Processes of Care</b>		
Metformin should be the initial oral anti-hyperglycemic agent prescribed	357 (98.9%)	97.8 to 100.0%
Lipid profile every 1-3 years	387 (96.8%)	95.0 to 98.5%
Baseline EKG in patients over 40	324 (96.4%)	94.4 to 98.4%
ACEi or ARB prescription in patients with persistent microalbuminuria	40 (90.9%)	82.1 to 99.8%
Smoking cessation advice	100 (82.2%)	74.6 to 89.8%
Eye exam every 1-2 years	307 (77.1%)	73.0 to 81.3%
Annual eGFR	301 (75.6%)	71.4 to 79.9%
HbA1c every 6 months	301 (75.3%)	71.0 to 79.5%
ACEi or ARB prescription in patients at high risk	184 (71.3%)	65.8 to 76.9%
Annual ACR	269 (67.4%)	62.8 to 72.0%
Follow up EKG every 2 years in patients at high risk	147 (67.1%)	60.9 to 73.4%
Annual influenza vaccination	173 (43.4%)	38.5 to 48.2%
Annual foot exam	63 (15.9%)	12.3 to 19.5%
Annual peripheral neuropathy testing.	41 (10.3%)	7.3 to 13.3%
Blood pressure check at every visit	29 (7.3%)	4.7 to 9.8%
<b>Intermediate Outcomes</b>		
LDL $\leq$ 3.5 mmol/l (moderate risk)	116 (85.3%)	79.3 to 91.3%
TC:HDL $<$ 5.0 (moderate risk)	107 (74.8%)	67.6 to 82.0%
LDL $\leq$ 2.5 mmol/l (high risk)	182 (71.9%)	66.4 to 77.5%
TC:HDL $<$ 4.0 (high risk)	149 (57.5%)	51.5 to 63.6%
HbA1c $\leq$ 7.0%	200 (53.9%)	48.8 to 59.0%
Blood pressure $<$ 130/80	137 (37.7%)	32.7 to 42.8%

A comparison of the quality of diabetes care in this particular subset of the Canadian Forces was made to the quality of care in a subset of patients within Alberta's primary care networks and the best of international estimates (see table 8). Primary care networks (PCN) represent a multi-disciplinary collaborative model with a unique funding scheme where health professionals are paid on a traditional fee-for-service basis and an additional \$50 per patient is provided to the

PCN to support its ongoing activities. The PCN adherence rates were taken from a large cohort study involving 77,464 diabetes patients (Mann's 2012). Although there were some differences in the outcomes measured that limit comparability, the Canadian Forces generally showed better quality of care than Alberta's PCNs. The only exception was the recommendation for a HbA1c  $\leq$  7.0% which was equivalent in the two populations. Note that there were substantial age, sex and perhaps socioeconomic differences in the two populations with the mean age in the PCN study being 62.1 years (SD 15.1) and the proportion of females being 47%. Furthermore, the PCN study restricted their analysis of patients receiving Metformin or ACEi/ARBs to patients who were 66 years and older. With regard to international estimates, the Canadian Forces showed worse adherence for HbA1c testing, annual kidney function testing, and the annual foot exam. However, whereas only HbA1c testing in the last 6 months was considered in this study, HbA1c testing in the last year was considered in Australia and other countries (Si 2010); therefore, corresponding adherence rates would be expected to be higher in those countries. Furthermore, the Australian data that demonstrated higher adherence involved patients visiting specialist diabetes clinics, not primary care practices as was the case in the current study. A higher rate of annual foot exams was found in the Canadian Community Health Survey, which excluded members of the Canadian Forces, but this represents self-reported data which is subject to information bias (recall bias). The guideline adherence rate for the remaining recommendations was the same or better in the Canadian Forces compared to other countries. Again age, sex and perhaps socioeconomic differences between the populations need to be considered.

**Table 8. Comparison of the quality of care in a sample of diabetes patients within the Canadian Forces with a sample of diabetes patients within Alberta's primary care networks and with the best of international estimates (Point estimate with 95% confidence interval where available).**

<b>Recommendation</b>	<b>Canadian Regular Forces (n=400)</b>	<b>Alberta's Primary Care Networks (n=77464) *</b>	<b>Best of International estimates †</b>
<b>Processes of Care</b>			
Metformin should be the initial oral anti-hyperglycemic agent prescribed	98.9 (97.8 to 100.0)	84.3 (83.1 to 85.5)	-
Lipid profile testing every 1 to 3 years	96.8 (95.0 to 98.5)	63.5 (63.1 to 63.8) <sup>θ</sup>	71-85 (U.S.) <sup>θ</sup>
ACEi/ARB prescription in the presence of microalbuminuria	90.9 (82.1 to 99.8)	79.3 (78.2 to 80.3)	-
Eye exam every 1 to 2 years	77.1 (73.0 to 81.3)	32.7 (32.4 to 33.0) <sup>θ</sup>	32-77 (Australia) <sup>Ω</sup>
Annual kidney function testing	75.6 (71.4 to 79.9)	-	75-85 (U.S.)
HbA1c every 6 months	75.3 (71.0 to 79.5)	70.0 (69.7 to 70.3) <sup>θ</sup>	65-93 (Australia) <sup>θ</sup>
Annual ACR	67.4 (62.8 to 72.0)	44.7 (44.4 to 45.1)	-
Annual foot exam	15.9 (12.3 to 19.5)	-	51 (Canada)
<b>Intermediate outcomes</b>			
LDL ≤ 2.5 mmol/L	71.9 (66.4 to 77.5)	-	31-47 (U.S.) <sup>#</sup>
HbA1c ≤ 7.0%	53.9 (48.8 to 59.0)	53.2 (52.8 to 53.6)	38-57 (Australia)
Blood pressure <130/80	37.7 (32.7 to 42.8)	-	30.9 (Taiwan)

\*- Reference: Manns 2012

†- References: Si 2010, Yu 2009, CIHI 2009

<sup>θ</sup> - Annual estimate

<sup>Ω</sup> - Biennial estimate

<sup>#</sup> - LDL < 2.6 mmol/l

### ***3.5 Bivariable Analysis***

The results of the bivariable analysis are presented in tables 8-11. Gender was found to be significantly associated with adherence to 2 of 21 CDA guideline recommendations (see table 9, figure 3). With regard to the recommendation for HbA1c testing every 6 months, females showed a significantly worse adherence rate than males, while for the recommendation of maintaining a blood pressure less than 130/80, females showed significantly better adherence. There were no significant associations between rank, which is a proxy for socioeconomic status, and adherence with any of the 21 CDA guideline recommendations (see table 10, figure 4). Age was significantly associated with 3 recommendations including maintaining the blood pressure at less 130/80, getting an annual influenza vaccination and having an eye exam every 1-2 years (see table 11, figure 5). Generally for these recommendations, increasing age was associated with better adherence, except for the recommendation to maintain the blood pressure at less than 130/80, which worsened with age. Base size was significantly associated with 7 recommendations (see table 12, figure 6). For 3 of the recommendations, including annual lipid profile testing, annual ACR and  $LDL \leq 2.5$  mmol/l in patients at high cardiovascular risk, larger base size was associated with better adherence. However, for 4 recommendations, including the annual foot exam, annual peripheral neuropathy testing, eye exam every 1-2 years and annual influenza vaccination, adherence was better in the smaller bases.

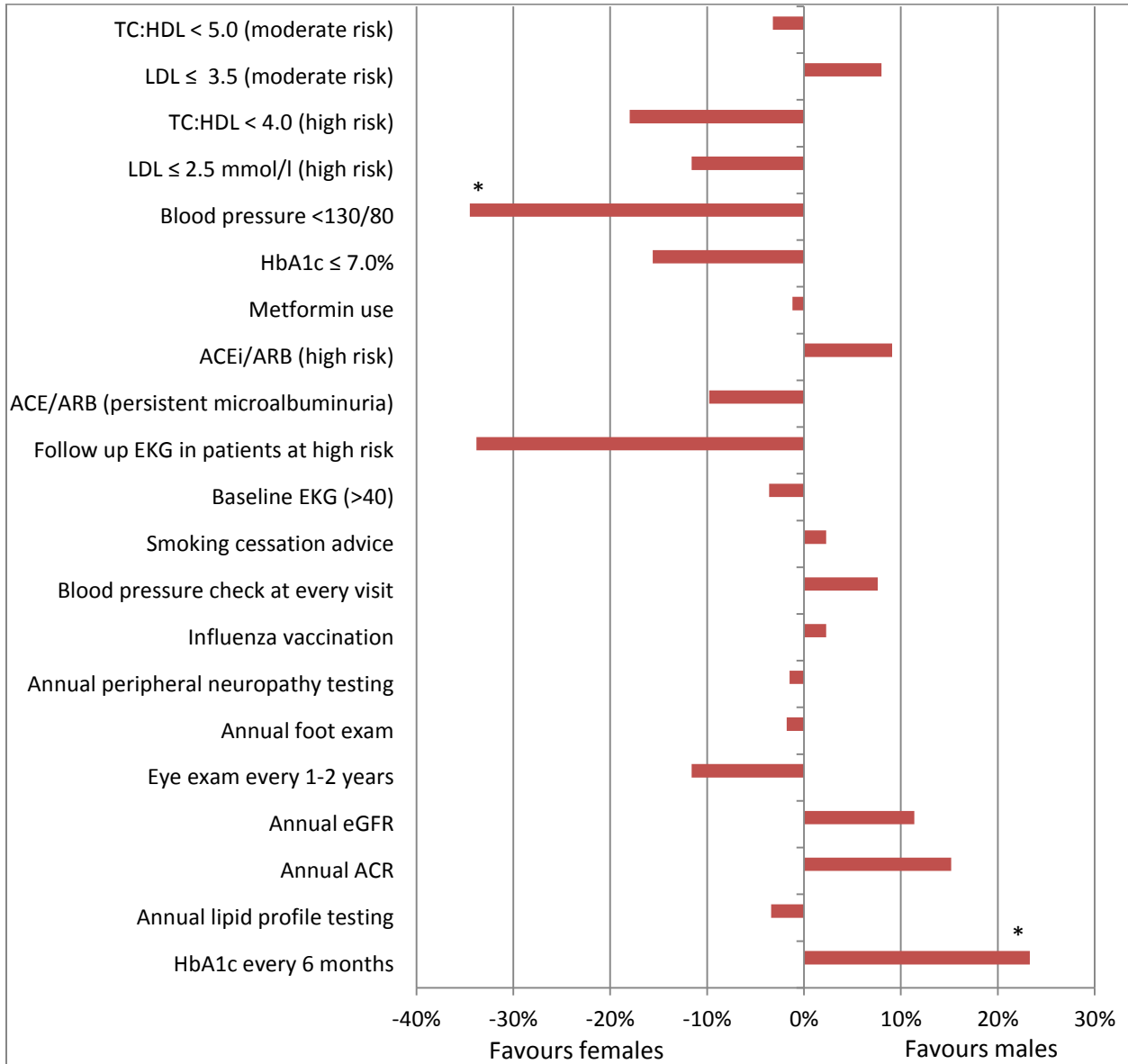
**Table 9. Bivariable tests of association between gender and adherence with Canadian Diabetes Association clinical practice guideline recommendations**

<b>Recommendation</b>	<b>Male (n=383)</b>	<b>Female (n=17)</b>	<b>P-value</b>
<b>Processes of Care</b>			
HbA1c every 6 months	292 (76.2%)	9 (52.9%)	<b>0.029 *</b>
Annual lipid profile testing	370 (96.6%)	17 (100%)	1.000
Annual ACR	260 (68.1%)	9 (52.9%)	0.193
Annual eGFR	290 (76.1%)	11(64.7%)	0.284
Eye exam every 1-2 years	292 (76.6%)	15 (88.2%)	0.381
Annual foot exam	60 (15.8%)	3 (17.6%)	0.741
Annual peripheral neuropathy testing	39 (10.3%)	2 (11.8%)	0.691
Influenza vaccination	166 (43.5%)	7 (41.2%)	0.853
Blood pressure check at every visit	29 (7.6%)	0 (0%)	0.624
Smoking cessation advice	79 (82.3%)	4 (80.0%)	1.000
Baseline EKG (>40)	324 (96.4%)	15 (100%)	1.000
Follow up EKG in patients at high risk	141 (66.2%)	6 (100%)	0.181
ACE/ARB (persistent microalbuminuria)	37 (90.2%)	3 (100%)	1.000
ACEi/ARB (high risk)	179 (71.6%)	5 (62.5%)	0.693
Metformin use	341 (98.8%)	16 (100%)	1.000
<b>Intermediate Outcomes</b>			
HbA1c ≤ 7.0%	189 (53.2%)	11 (68.8%)	0.223
Blood pressure <130/80	125 (36.1%)	12 (70.6%)	<b>0.004 *</b>
LDL ≤ 2.5 mmol/l (high risk)	177 (71.7%)	5 (83.3%)	1.000
TC:HDL < 4.0 (high risk)	143 (57.0%)	6 (75.0%)	0.473
LDL ≤ 3.5 (moderate risk)	109 (85.8%)	7 (77.8%)	0.620
TC:HDL < 5.0 (moderate risk)	100 (74.6%)	7 (77.8%)	1.000

Note that the total number (n) was less than what was indicated in the column headings for some recommendations because data was either missing or not applicable

**\*- Statistically significant (P<0.05)**

**Figure 3. Percent differences in adherence between genders**



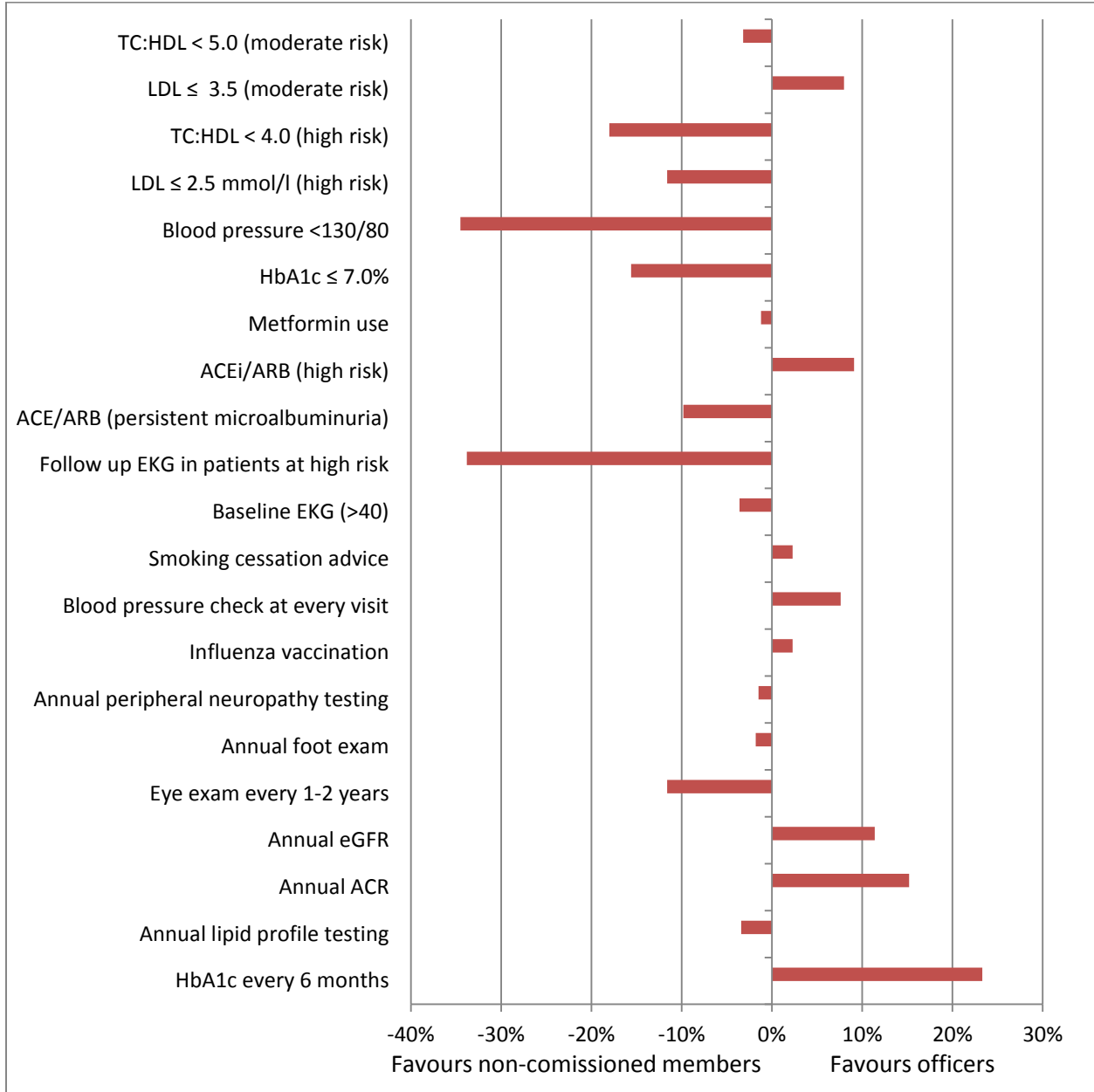
**\*- Statistically significant (p<0.05)**

**Table 10. Bivariable tests of association between rank and adherence with Canadian Diabetes Association clinical practice guideline recommendations**

<b>Recommendation</b>	<b>Officers (n=45)</b>	<b>Non-commissioned members (n=255)</b>	<b>P-value</b>
<b>Processes of Care</b>			
HbA1c every 6 months	30 (66.7%)	271 (76.3%)	0.157
Annual lipid profile testing	44 (97.8%)	343 (96.6%)	1.000
Annual ACR	28 (62.2%)	241 (68.1%)	0.430
Annual eGFR	33 (73.3%)	268 (75.9%)	0.703
Eye exam every 1-2 years	35 (77.8%)	272 (77.1%)	0.913
Annual foot exam	10 (22.2%)	53 (15.1%)	0.219
Annual peripheral neuropathy testing	8 (17.8%)	33 (9.4%)	0.081
Influenza vaccination	21 (46.7%)	152 (42.9%)	0.634
Blood pressure check at every visit	1 (2.2%)	28 (7.9%)	0.229
Smoking cessation advice	5 (62.5%)	78 (83.9%)	0.149
Baseline EKG (>40)	36 (97.3%)	288 (96.3%)	1.000
Follow up EKG in patients at high risk	20 (62.5%)	127 (67.9%)	0.547
ACE/ARB (persistent microalbuminuria)	4 (100%)	36 (90.0%)	1.000
ACEi/ARB (high risk)	21 (67.7%)	163 (71.8%)	0.639
Metformin use	43 (97.7%)	314 (99.1%)	0.407
<b>Intermediate Outcomes</b>			
HbA1c $\leq$ 7.0%	26 (61.9%)	174 (52.9%)	0.270
Blood pressure <130/80	19 (43.2%)	118 (37.0%)	0.427
LDL $\leq$ 2.5 mmol/l (high risk)	28 (77.8%)	154 (71.0%)	0.400
TC:HDL < 4.0 (high risk)	25 (71.4%)	124 (55.4%)	0.074
LDL $\leq$ 3.5 (moderate risk)	8 (80.0%)	108(85.7%)	0.641
TC:HDL < 5.0 (moderate risk)	9 (90.0%)	98 (73.7%)	0.452

Note that the total number (n) was less than what was indicated in the column headings for some recommendations because data was either missing or not applicable

**Figure 4. Percent differences in adherence between ranks**

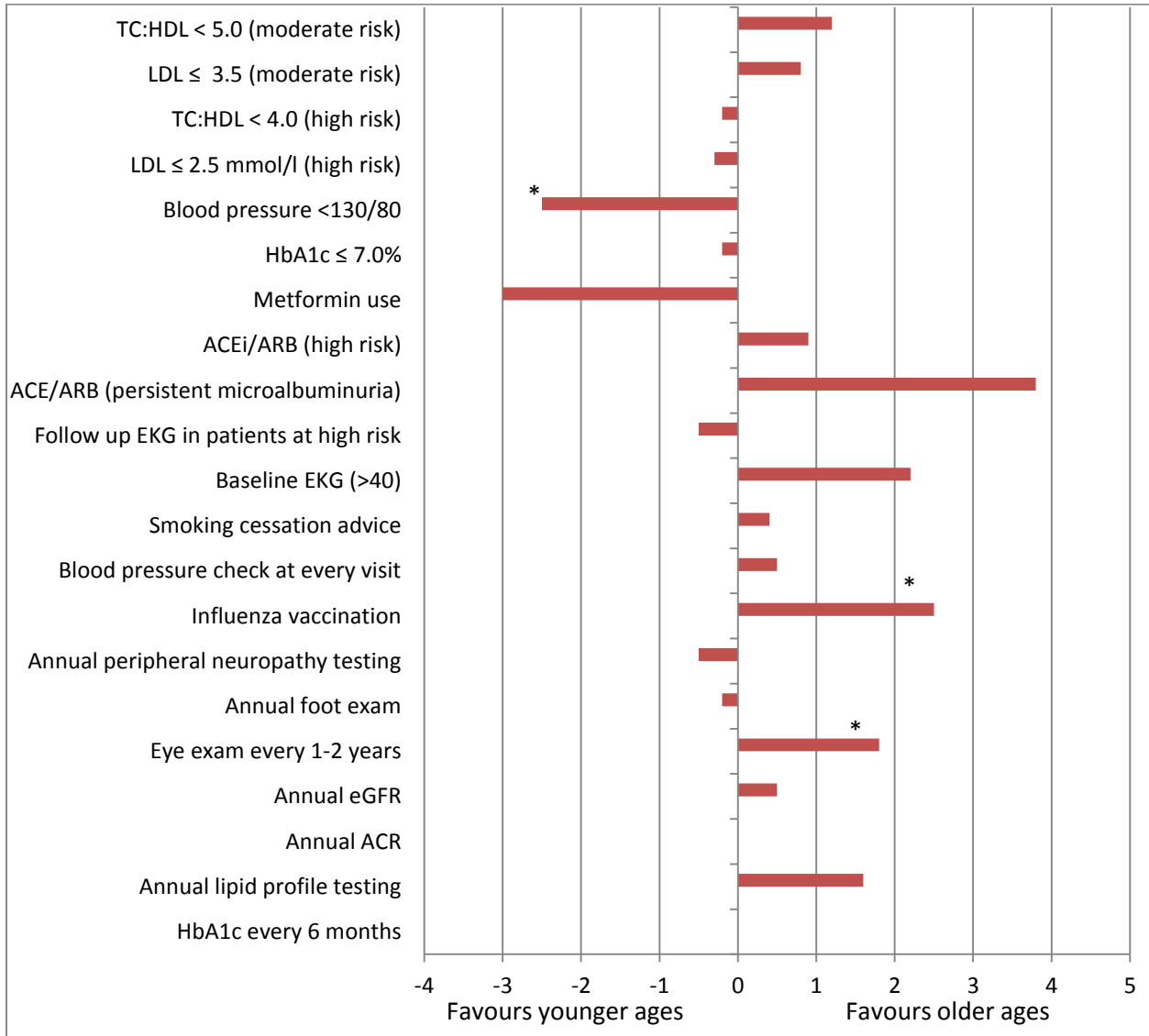


**Table 11. Bivariable tests of association between age and adherence with Canadian Diabetes Association clinical practice guideline recommendations**

Recommendation	Adherence		P-value
	Yes	No	
	Mean Age (SD)	Mean Age (SD)	
<b>Processes of Care</b>			
HbA1c every 6 months	46.2 (6.4)	46.2 (5.9)	0.939
Annual lipid profile testing	46.2 (6.1)	44.6 (10.0)	0.363
Annual ACR	46.2 (6.1)	46.2 (6.4)	0.931
Annual eGFR	46.4 (6.0)	45.9 (6.5)	0.469
Eye exam every 1-2 years	46.7 (6.0)	44.9 (6.3)	<b>0.017 *</b>
Annual foot exam	46.0 (6.4)	46.2 (6.2)	0.770
Annual peripheral neuropathy testing	45.8 (6.9)	46.3 (6.1)	0.618
Influenza vaccination	47.6 (6.2)	45.1 (6.1)	<b>&lt;0.001 *</b>
Blood pressure check at every visit	46.6 (6.4)	46.1 (6.3)	0.733
Smoking cessation advice	45.6 (6.1)	45.2 (6.5)	0.804
Baseline EKG (>40)	47.8(4.6)	45.6 (5.7)	0.111
Follow up EKG in patients at high risk	50.4 (3.3)	50.9 (3.4)	0.323
ACEi/ARB (persistent microalbuminuria)	47.1(6.1)	43.3 (6.5)	0.242
ACEi/ARB (high risk)	50.0 (3.5)	49.1 (4.0)	0.083
Metformin use	46.3 (6.3)	49.3 (5.6)	0.356
<b>Intermediate Outcomes</b>			
HbA1c ≤ 7.0%	46.2 (6.1)	46.4 (6.5)	0.859
Blood pressure <130/80	44.9 (6.6)	47.4 (5.6)	<b>&lt;0.001 *</b>
LDL ≤ 2.5 mmol/l (high risk)	49.6 (3.5)	49.9 (4.2)	0.600
TC:HDL < 4.0 (high risk)	49.7 (3.7)	49.5 (3.7)	0.646
LDL ≤ 3.5 (moderate risk)	40.0 (4.5)	39.2 (3.8)	0.501
TC:HDL < 5.0 (moderate risk)	40.2 (4.3)	39.0 (4.6)	0.155

\* Statistically significant (P<0.05)

**Figure 5. Adherence based on age (differences in years)**



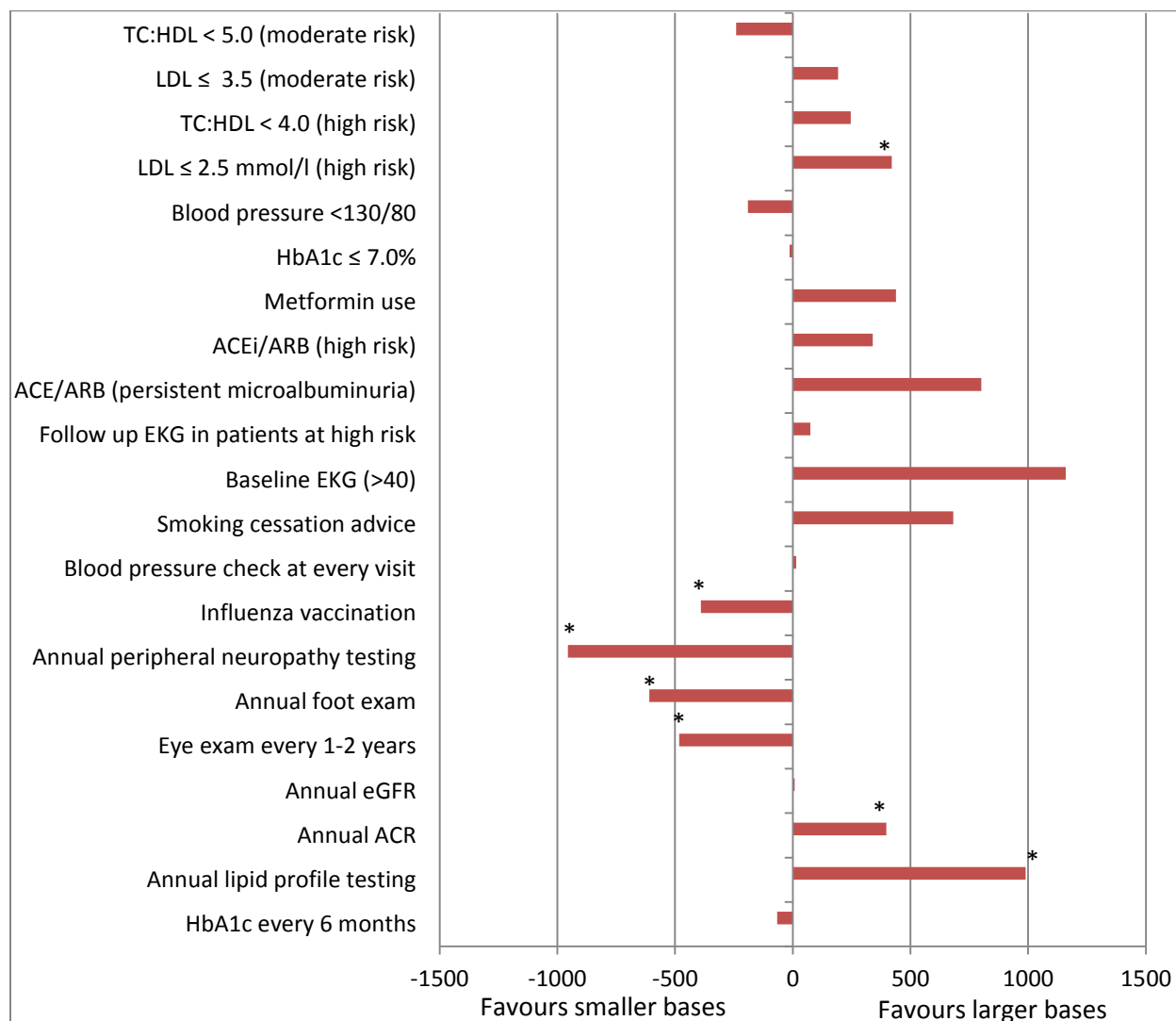
**\* Statistically significant (P<0.05)**

**Table 12. Bivariable tests of association between base size and adherence with Canadian Diabetes Association clinical practice guideline recommendations**

Recommendation	Adherence		P-value
	Yes	No	
	Mean Base Size (SD)	Mean Base Size (SD)	
<b>Processes of Care</b>			
HbA1c every 6 months	3164 (1535)	3230 (1533)	0.710
Annual lipid profile testing	3212 (1523)	2222 (1553)	<b>0.022 *</b>
Annual ACR	3304 (1567)	2906 (1419)	<b>0.015 *</b>
Annual eGFR	3172 (1500)	3164 (1623)	0.965
Eye exam every 1-2 years	3068 (1507)	3550 (1554)	<b>0.008 *</b>
Annual foot exam	2669 (1408)	3279 (1535)	<b>0.004 *</b>
Annual peripheral neuropathy testing	2327 (1396)	3282 (1514)	<b>&lt;0.001*</b>
Influenza vaccination	2963 (1589)	3354 (1468)	<b>0.012 *</b>
Blood pressure check at every visit	3194 (1441)	3179 (1541)	0.961
Smoking cessation advice	3541 (1532)	2859 (1468)	0.088
Baseline EKG (>40)	3207 (1468)	2047 (1755)	0.713
Follow up EKG in patients at high risk	3126 (1405)	3051 (1524)	0.717
ACEi/ARB (persistent microalbuminuria)	3759 (1452)	2958 (1518)	0.300
ACEi/ARB (high risk)	3085 (1426)	3425 (1499)	0.089
Metformin use	3203 (1523)	2765 (1960)	0.568
<b>Intermediate Outcomes</b>			
HbA1c $\leq$ 7.0%	3169 (1532)	3183 (1491)	0.931
Blood pressure <130/80	2961 (1457)	3151 (1531)	0.243
LDL $\leq$ 2.5 mmol/l (high risk)	3253 (1430)	2832 (1448)	<b>0.037 *</b>
TC:HDL < 4.0 (high risk)	3239 (1416)	2992 (1492)	0.177
LDL $\leq$ 3.5 (moderate risk)	3365 (1675)	3173 (1771)	0.640
TC:HDL < 5.0 (moderate risk)	3360 (1618)	3124 (1858)	0.466

\* Statistically significant (P<0.05)

**Figure 6. Adherence based on base size**



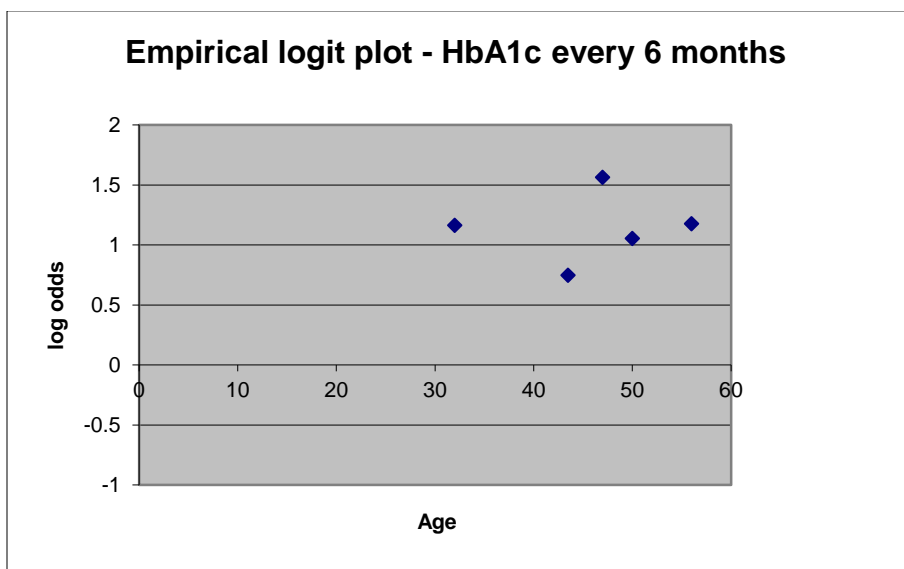
\* Statistically significant (P<0.05)

### 3.6 Logistic regression: Effect of sex, rank, age and base size on three key outcomes

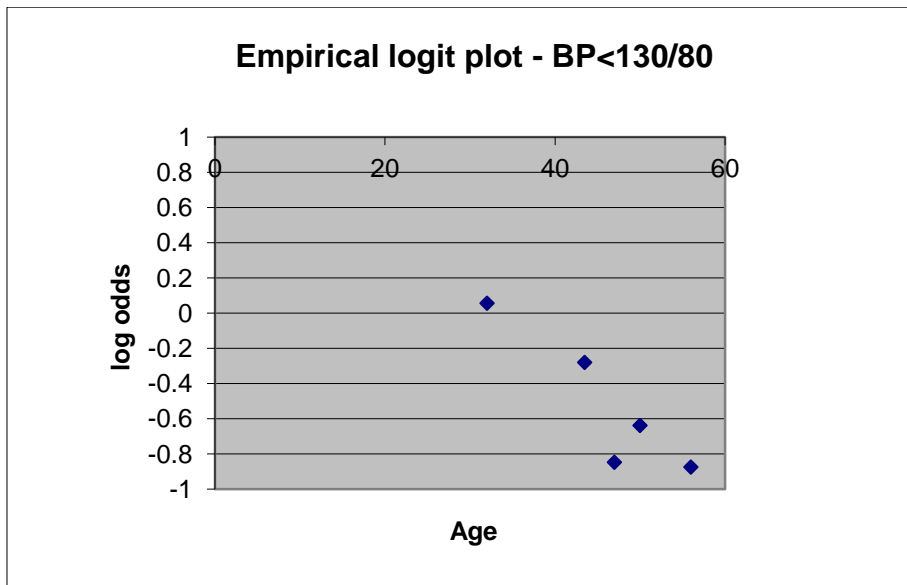
Three outcomes (HbA1c every 6 months, blood pressure < 130/80 and HbA1c ≤ 7.0%) were considered in logistic regression models that included 4 independent variables (sex, rank, age and base size). Sex and rank were analysed as dichotomous predictors, while age and base size were analysed as continuous. A stepwise fitting algorithm was not introduced because all 4

independent variables were of interest and were entered into the model at the same time. Using empirical logit plots, we investigated the functional form of the associations with age and base size (see Figures 7-12). Some of the associations deviated from a linear trend. Therefore square and quadratic transformations of the continuous predictors were considered, but they did not show statistically significance and were dropped from the final models (data not shown). The model fit as assessed by the Hosmer-Lemeshow goodness of fit test was adequate, though this test has limitations (see Appendix). The area under the ROC curve ranged from 0.5433 to 0.6378, indicating that the best model fit occurred for the outcome, blood pressure<130/80 (see Appendix). Diagnostics were conducted to look for outliers and influential points (see Appendix). The outliers were unremarkable. No data entry errors were detected and there were no implausible values. Removal of the identified outliers did not substantially change the conclusions. Potential effect modifiers were not defined a priori and therefore interactions were not evaluated.

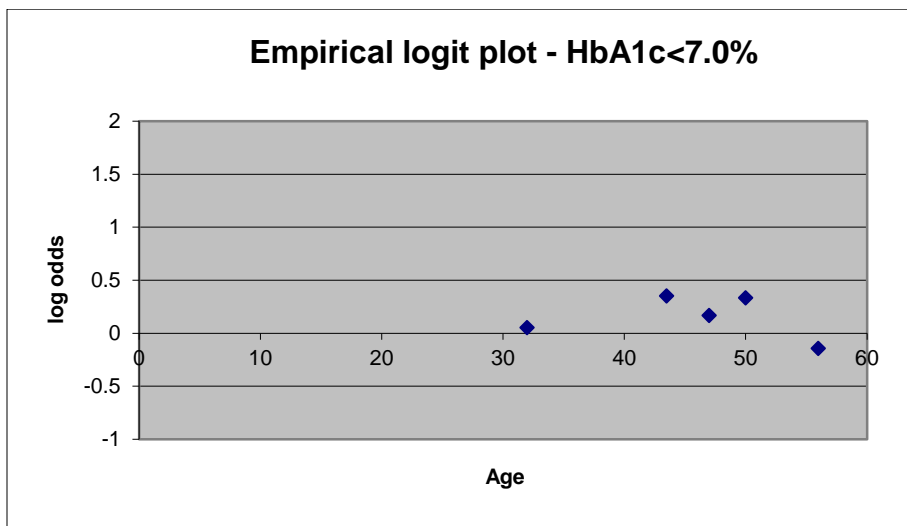
**Figure 7.**



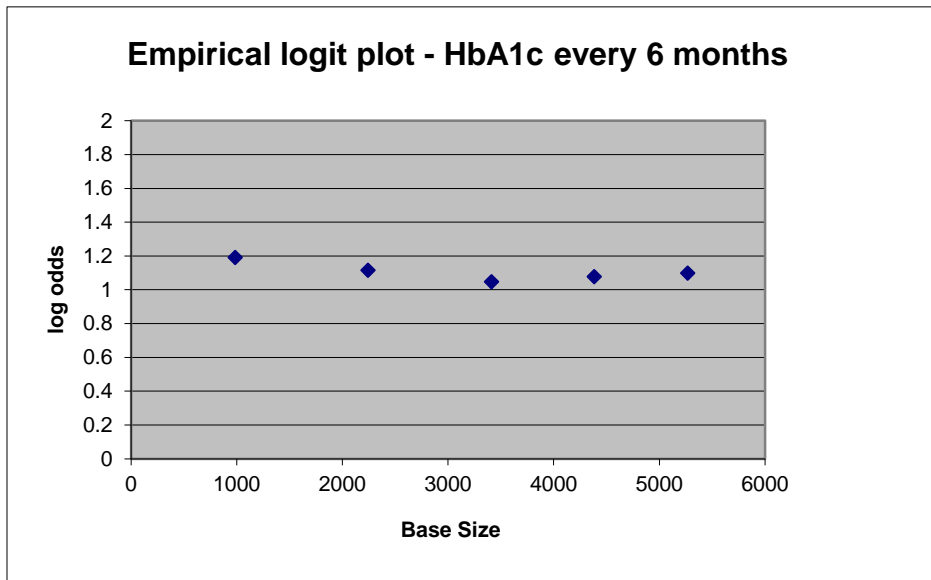
**Figure 8.**



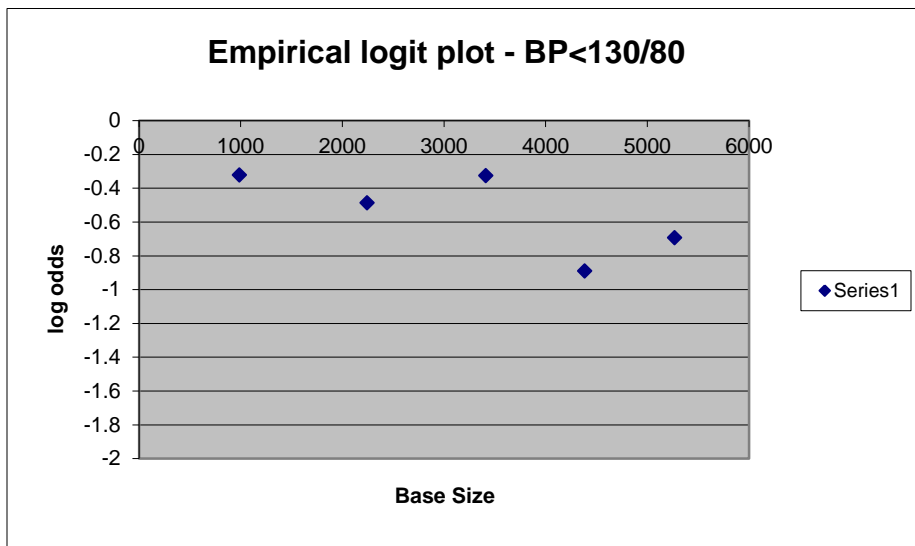
**Figure 9.**



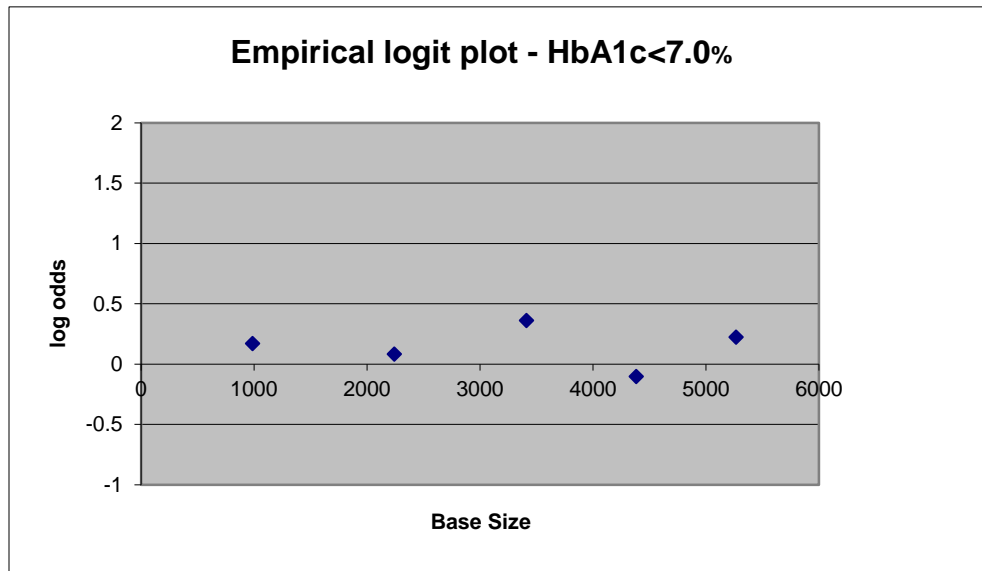
**Figure 10.**



**Figure 11.**



**Figure 12.**



For the outcome, HbA1c testing every 6 months, sex was the only statistically significant predictor with an odds ratio of 3.051 (95% CI: 1.134 to 8.214) (see table 13); male sex was associated with a 3-fold higher odds of adherence compared to the female sex.

**Table 13. Logistic regression model for HbA1c testing every 6 months**

Predictor	Odds ratio	95% CI	P-value
Age	0.999	0.962 to 1.036	0.941
Sex (reference: female)	3.051	1.134 to 8.214	<b>0.027 *</b>
Rank (reference: non-commissioned member)	0.585	0.297 to 1.152	0.121
Base Size	1.000	1.000 to 1.000	0.491

**\*-Statistically significant (p<0.05)**

For the outcome, blood pressure < 130/80, age and sex were statistically significant predictors with odds ratios of 0.933 (95% CI: 0.900 to 0.969) and 0.255 (95% CI: 0.086 to 0.754) respectively (see table 14). For every 10-year increase in age, there was a 50% decrease in the odds of adherence with the blood pressure recommendation. For males, the odds of adherence was 26% that of females.

**Table 14. Logistic regression model for blood pressure < 130/80**

<b>Predictor</b>	<b>Odds ratio</b>	<b>95% CI</b>	<b>P-value</b>
Age	0.933	0.900 to 0.969	< <b>0.001</b> *
Sex (reference: female)	0.255	0.086 to 0.754	<b>0.014</b> *
Rank (reference: non-commissioned member)	1.492	0.767 to 2.901	0.238
Base Size	1.000	1.000 to 1.000	0.309

**\*-Statistically significant (p<0.05)**

For the outcome, HbA1c ≤ 7.0%, there were no statistically significant predictors, suggesting that age, sex, rank and base size were not important factors affecting adherence with this recommendation (see table 15).

**Table 15. Logistic regression model for HbA1c ≤ 7.0%**

<b>Predictor</b>	<b>Odds ratio</b>	<b>95% CI</b>	<b>P-value</b>
Age	0.997	0.964 to 1.030	0.837
Sex (reference: female)	0.509	0.172 to 1.503	0.221
Rank (reference: non-commissioned member)	1.485	0.762 to 2.89	0.245
Base Size	1.000	1.000 to 1.000	0.916

**\*-Statistically significant (p<0.05)**

## **4. Discussion**

### **4.1 Prevalence of Diabetes**

The prevalence of diabetes in the 14 bases investigated in this study was estimated to be 1.2% (95% CI: 1.1 to 1.3%), which is substantially lower than the figure for Canada as a whole (6.8%) (Public Health Agency of Canada 2011). The discrepancy can be accounted for by the fact that the Canadian Forces screen out recruits with a history of diabetes and members are generally young with two-thirds of them being under 40 years. It is well-established that the prevalence of diabetes increases with age (CDC 2010). The discrepancy is not due to differences in obesity

rates, which are surprisingly similar in the Canadian Forces and the civilian population (Canadian Forces Health Services 2009, Statistics Canada - b 2011)

The fact that fewer officers and females had diabetes than would be expected from the proportion of officers and females in the Canadian Forces may be related to the lower rates of obesity in these two groups (Canadian Forces Health Services 2009). Indeed, obesity is a primary risk factor for type 2 diabetes (Hossein 2007, Hu 2001).

#### ***4.2 Validation of the monthly assessment extract***

Estimates of the sensitivity (84.5%), specificity (99.8%), positive predictive value (85.1%) and negative predictive value (99.8%) of a diabetes diagnosis listed in the monthly assessment extract were comparable to the performance of Canadian provincial and national diabetes registries, which used administrative data sources. For example, the National Diabetes Surveillance System (NDSS) reported a sensitivity of 70.8% and a positive predictive value of 79.6%, while the Ontario Diabetes Database (ODD) reported a sensitivity of 86%, a specificity of 97% and a positive predictive value of 80% (Hux 202, Southern 2010). Both the NDSS and ODD used an algorithm for case ascertainment that required two physician claims for diabetes within 2 years or one hospital discharge abstract containing a diabetes diagnosis. It is expected that the sensitivity of the monthly assessment extract would increase once a software error is corrected that caused diabetes patients associated with physicians who were no longer in active service to be missing from the extract. This software error led to many apparent false negatives that were eventually captured by the pharmacy database. The capture-recapture method was used to provide a worst-case scenario, where the sensitivity of a diabetes diagnosis in the monthly

assessment extract was estimated to be 80.1% (95% CI: 76.9 to 84.4%). Possible sources of false negatives in this worst case scenario may have included diabetes patients who did not visit physicians often (less frequently than every 6 months) or who were well-controlled by diet alone and received less intensive follow-up. The false positives identified in this study were certainly at risk of developing diabetes in the future, but they did not have true diabetes by laboratory criteria. Reminding physicians to carefully distinguish pre-diabetes from true diabetes when they document their assessments in the progress notes and avoid making a diagnosis of diabetes based on only one elevated glucose level may help increase the positive predictive value of the monthly assessment extract. A single elevated glucose level may be due to laboratory error, unless confirmed by a repeat measurement on a separate occasion. In summary, the performance of the monthly assessment extract appears to be acceptable such that creating a diabetes registry in the Canadian Forces is feasible especially once technical difficulties with the extract are resolved. It should be noted that there are diabetes registries in other countries that perform better than their Canadian counterparts using more elaborate case ascertainment strategies (Carstensen 2011, Morris 1997).

#### ***4.3 Quality of Care***

The quality of diabetes care in the Canadian Forces appeared favourable compared to that of the civilian population in Canada and countries around the world based on adherence rates with practices recommended by the CDA. It is not clear what aspects of the Canadian Forces Health Services lend themselves to better diabetes care. However, the Canadian Forces have a highly structured, publically funded health care system in which medications and medical devices are provided at no cost to members, removing financial barriers to treatment. In addition, rather than

paying health care providers on a fee-for-service basis, the Canadian Forces have salaried physicians who generally see fewer patients per day than physicians working in provincial health care systems and therefore have more time and resources to carry out better care. The occupational repercussions of poorly controlled diabetes may motivate CF members to adhere more closely to a physician's medical advice and engage in appropriate self-management. Finally, the use of the EMR likely facilitates better diabetes practice in the CF. Still, there is room for improvement given that there was an average adherence rate of only 60.3% with all applicable CDA guideline recommendations per patient.

Specific areas where there was low adherence (below 50%) included receiving an annual influenza vaccination, maintaining a blood pressure at less than 130/80, getting an annual foot exam, having annual peripheral neuropathy testing and getting a blood pressure check at every medical visit. Four of the five recommendations were based on grade D evidence which refers to consensus opinion (CDA 2008). The systolic blood pressure target of less than 130 was supported by level 3 evidence, which refers to nonrandomized clinical trials or cohort studies (CDA 2008). The diastolic blood pressure target of less than 80 was supported by level 2 evidence, which refers to randomized controlled trials or systematic reviews not meeting level 1 criteria (CDA 2008).

The influenza vaccination rate for diabetes patients in the Canadian Forces was 43.4% (95% CI: 38.5 to 48.2%), falling short of the 80% target established for adults with chronic medical conditions in Canada (PHAC 2006). The vaccination rate for Canadians aged 18 to 64 with chronic medical conditions in the civilian population was 38% in the 2005-2006 season, also

falling short of the target (PHAC 2006). People with diabetes are at increased risk of complications from influenza and should be encouraged to have regular vaccinations on an annual basis (Public Health Agency of Canada–c 2011).

While the adherence rate for the recommendation to have a blood pressure less than 130/80 was significantly higher in the Canadian Forces than in Taiwan, it was still quite low at 37.7 (95% CI: 32.7 to 42.8). There is some clinical trial evidence supporting the blood pressure target set by the CDA (Adler 2000, Hansson 1998, Orchard 2001, Schrier 2002, UK Prospective Diabetes Study Group-b 1998). The importance of maintaining a low blood pressure was further underlined by a recent study that found that blood pressure in excess of 120/80 was associated with a population attributable fraction for all-cause mortality and cardiovascular disease mortality of 30.4% and 40.6% respectively in the U.S. (Yang 2012). The difficulty of attaining blood pressure targets in patients with diabetes has been described extensively in the literature (Agha 2003, Coon 2002, Cotton 2006, Miller 2000). Reasons include physician satisfaction with progress, competing priorities during the patient visit, patient nonadherence, limited treatment options (high cost of medications/inadequate insurance, adverse side effects of medications, comorbidities) and clinical inertia (Cotton 2006). In spite of the CDA recommendations, there is some controversy about how to define appropriate blood pressures in people with diabetes in light of several recent studies suggesting that intensive blood pressure control is not beneficial and may even be harmful (Arguedas 2009, Cooper-DeHoff 2010, Cushman 2010, Sui 2011). For this reason, an alternative blood pressure target of less than 140/90 was assessed and successfully achieved in 77.1% (95% CI: 72.8 to 81.5%) of patients. The average blood pressure of all 400

patients with diabetes identified by the monthly assessment extract and the pharmacy database was 131/81.

Adherence with the recommendation for a blood pressure check at every visit was very poor. However, blood pressure measurements take time to perform properly and may detract from other priorities during a patient visit, especially if the principal reason for the visit is not related to diabetes care (eg., injury). Future updates of the CDA clinical practice guidelines should offer more flexibility with regards to this particular recommendation, especially given the current controversy concerning intensive blood pressure control in people with diabetes.

In addition to regular foot checks by patients themselves, foot exams and peripheral neuropathy testing by physicians are important for preventing serious foot ulcers from developing. However, these were performed quite poorly by physicians in the Canadian Forces. One reason documented in some of the charts was that 10g monofilaments were not available. A reasonable recommendation, then, would be to distribute 10g monofilaments to all physicians as their cost is relatively low. The value of using 10g monofilaments or 128 Hz tuning forks to test for peripheral neuropathy was supported by grade A, level 1 evidence in the CDA clinical practice guidelines (CDA 2008).

Although adherence with the recommendation for a  $HbA1c \leq 7.0\%$  was above 50% and similar to adherence rates in the civilian population in Canada and internationally, it was still less than adequate at 53.9%. There was grade A, level 1 evidence supporting this recommendation (CDA 2008). Physicians should be doing a better job at meeting this target, especially with the

availability of a wider selection of anti-hyperglycemic agents. However, clinical judgment is required to balance the benefits of reductions in HbA1c with the risks of hypoglycemia. Furthermore, patient adherence with lifestyle modifications may be an issue. A recent randomized controlled trial was published involving obese adults with a mean BMI of 36 who underwent intensive glycemetic control over a period of 12 months. Despite a target HbA1c of  $\leq$  6.0%, the average achieved HbA1c was 7.5% (Schauer 2012). This points to the difficulty of achieving HbA1c targets even in the context of a randomized controlled trial.

#### ***4.4 Strategies to improve care***

Creating a diabetes registry in the Canadian Forces will be an important step to improving quality of care (Coppell 2011, O'Mullane 2010). It appears that based on the performance of the monthly assessment extract, creating a registry will be feasible once technical difficulties are resolved and physicians are reminded about adhering to strict diabetes diagnostic criteria.

Feedback provided to health care providers about their performance should help improve diabetes care in the Canadian Forces, particularly in areas where performance was poor (Jamtvedt 2006). Importantly, the feedback given to physicians should provide encouragement about the areas where they excel.

Unfortunately, clinical decision support tools that provide electronic reminders at the point of care about appropriate tests and interventions do not exist within the EMR software used by physicians in the Canadian Forces. If they were available, they would certainly help improve the

quality of care (Col 2005, Dexter 2001, Grimshaw 2004, Grimshaw 2003, Hunt 1998, Johnston 1994, Ornshtein 1991, Shea 2011, Shea 1996).

During the chart review, only a minority of physicians were found to use diabetes care flow sheets, which have been shown to be beneficial ((Hahn 2008, Moharram 2008, Roff 1999). More widespread use of diabetes care flow sheets would improve the documentation of appropriate processes of care and intermediate outcomes and serve as a convenient reminder system, which the EMR software presently lacks.

Financial incentives to encourage optimal diabetes care have shown to be beneficial in the UK through the Quality and Outcomes Framework (Alshamsan 2010, Oluwatowoju 2010) and consideration could be given to using them in the Canadian Forces, although a recent Cochrane review concluded that “there is insufficient evidence to support or not support the use of financial incentives to improve the quality of primary health care” (Scott 2011). In this era of fiscal restraint due to increasing government debt and escalating health care costs, the possibility of implementing financial incentives in the Canadian Forces appears remote. However, at the very minimum, every physician office should be stocked with a 10 g monofilament, which carries a relatively low cost.

#### ***4.5 Association of age, gender, rank and base size with guideline adherence***

Remarkably there was no significant association between rank, which is a proxy for socioeconomic status, and adherence with any guideline recommendation. Perhaps, differences in socioeconomic status between officers and non-commissioned members were not large

enough for an association to be detected. The fact that medications are provided at no cost to patients and health care is free and accessible to all may somewhat obscure the effect of socioeconomic differences.

Gender was associated with only 2 of 21 CDA guideline recommendations including the recommendation for HbA1c testing every 6 months, where females showed a significantly worse adherence rate than males, and the recommendation for maintaining a blood pressure at less than 130/80, where females showed significantly better adherence. In the general population, the prevalence of hypertension in males and females is more or less similar (Kearney 2005, Public Health Agency of Canada-b 2010, Wolf-Maier 2003). However, obesity is a major risk factor for hypertension and the rates of obesity are lower in females compared to males in the Canadian Forces (Canadian Forces Health Services 2009, Narkiewicz 2006). Therefore adherence with the blood pressure recommendation would be expected to be higher in females. The reason for the lower rate of HbA1c testing in females is unclear.

There was a significant association between age and adherence with three recommendations including maintaining a blood pressure at less 130/80, which decreased with age, as well as getting an annual influenza vaccination and having an eye exam every 1-2 years, which both increased with age. The prevalence of hypertension is known to rise with age so it is not surprising that the blood pressure target is not met as frequently in older patients (Lloyd-Jones 2005). Physicians may be more concerned about influenza vaccinations and eye exams in older patients since complications of influenza are increased in older adults and the rate of significant

retinopathy increases with increasing duration of diabetes (Public Health Agency of Canada-c 2011, Thomas 2012).

An unexpected result was that although adherence with three CDA guideline recommendations was significantly better in larger bases, adherence with another four recommendations was significantly worse in larger bases. Potentially, higher health care provider:patient ratios in smaller bases may explain some of the unexpected results. It should be noted that in the majority of cases, base size had no significant effect on adherence rates.

The logistic regression analysis confirmed the bivariable analysis.

#### ***4.6 Limitations***

The sensitivity derived using the capture-recapture method should be interpreted with caution because the two sources used for determining the prevalence of diabetes were not independent (i.e., patients diagnosed with diabetes in the monthly assessment extract were more likely to be prescribed diabetes medication or glucose testing strips and appear in the pharmacy database).

When the two sources are positively dependent as was the case here, the capture-recapture method leads to an underestimate of the true diabetes prevalence (Chao 2001). In practice, however, it is difficult to find two independent sources (Verlato 2000).

Another limitation is the lack of a true gold standard for the validation of the monthly assessment extract. Unfortunately, there was no efficient method for screening the lab results of all 32 603 personnel, which would have made laboratory criteria the true gold standard.

It could be reasonably argued that the quality of care in the 14 bases selected for this study is not representative of the entire Canadian Forces. Still, as the eligible target population constituted almost 50% of the Canadian Regular Forces, the results are likely meaningful. Moreover, it is unlikely that bases that had incorporated progress notes into the EMR for 6 months or more differed substantially from bases that did not, as the EMR was rolled based on factors that were unlikely to be associated with quality of care such as geographic location and convenience.

Data entry errors are always possible, but kappa values were good indicating a high level of agreement between reviewers and a reduced chance of random errors.

There was a relatively large percentage of patients with no blood pressure readings or only 1 blood pressure reading. This may have skewed the findings. However, the overall adherence with the blood pressure target was poor in any case. Moreover, the CDA clinical practice guidelines provide no guidance on how to assess adherence with the blood pressure recommendation. Specifically, they do not clarify whether the average of two or more readings needs to be equal to or greater than 130/80 to warrant more aggressive management or whether two or more consecutive readings need to be  $\geq 130/80$  to warrant intensification of therapy.

For the recommendation for an annual influenza vaccination, the current season and the previous season were both considered since the current season was not over by the time of the chart

review (December 19<sup>th</sup>, 2011). While reasonable, this may have inflated the calculated vaccination rate, which was still below target.

For the bivariable analyses, no corrections were made for multiple testing; therefore these analyses should be considered exploratory.

In considering volume-outcome relationships in diabetes care, it is possible that base size may not have been the appropriate measure. Health care in each base is divided into clinical delivery units or CDUs that serve approximately 1500 patients each. Perhaps there may have been variation in the quality of care provided by the CDUs based on the number of diabetes patients served by the CDUs. This may be a subject for future research.

The logistic regression models would have been improved if provider level data were available. Multilevel regression could have been considered. Unfortunately, provider level data such as physician age, gender, years of experience and number of patients with diabetes was not available.

#### ***4.7 Conclusion***

In conclusion, based on adherence with CDA clinical practice guideline recommendations, the quality of diabetes care in the 14 bases investigated within the Canadian Forces was generally the same or better than the quality of care in the civilian population within Canada and other industrialized countries. However, there definitely is room for improvement as the mean adherence with all applicable CDA clinical practice guideline recommendations was only 60.3%

per patient. The creation of a diabetes registry will facilitate the investigation of the effect of future quality improvement strategies.

## **5. Acknowledgements.**

The author would like to acknowledge the excellent supervision provided by Dr. Doug Manuel, Dr. Monica Taljaard and Dr. Jeff Whitehead. Special thanks to Major (Dr.) Stephen Cooper for guidance on the use of the EMR, to Robert Hawes for compiling the monthly assessment extract, to Janice Ma for providing access to the pharmacy database, to Zelma Buckley for delivering the paper charts and to Laura Bogaert for assistance with Stata programming.

## **6. Appendix A: List of diabetes medications captured in pharmacy database**

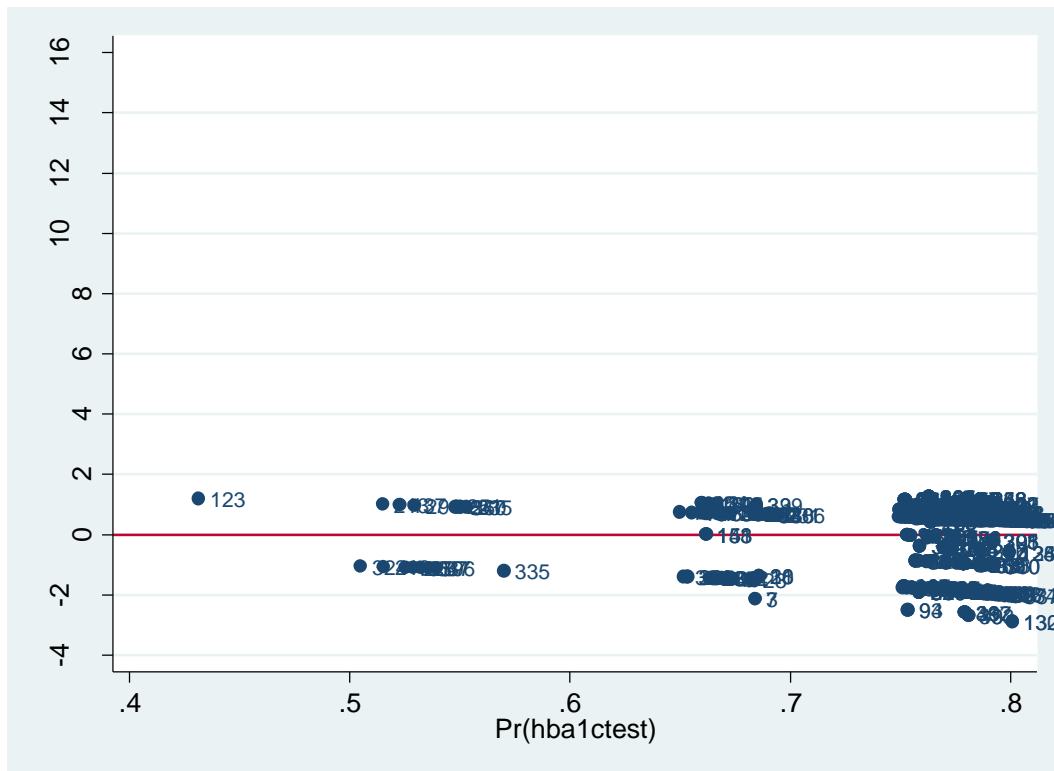
Fast acting insulin: insulin lispro (Humalog)  
Fast acting insulin: insulin aspart (Novorapid)  
Fast acting insulin: Humulin R  
Fast acting insulin: Novolin GE Toronto  
Intermediate-acting insulin: Humulin N  
Intermediate-acting insulin: Novolin GE NPH  
Combination fast-acting and intermediate-acting insulin (Humulin 30/70)  
Combination fast-acting and intermediate-acting insulin (Novolin GE 30/70)  
insulin glargine (Lantus)  
metformin (Glucophage)  
glibenclamide (Glyburide)  
gliclazide (Diamicron)  
glimepiride  
repaglinide (Gluconorm)  
acarbose (Glucobay)  
rosiglitazone (Avandia)  
pioglitazone (Actos)  
metformin and rosiglitazone (Avandamet)

The newer agents including sitagliptin (Januvia), saxagliptin (Onglyza), exenatide (Byetta) and liraglutide (Victoza) are used as add-on agents in combination with

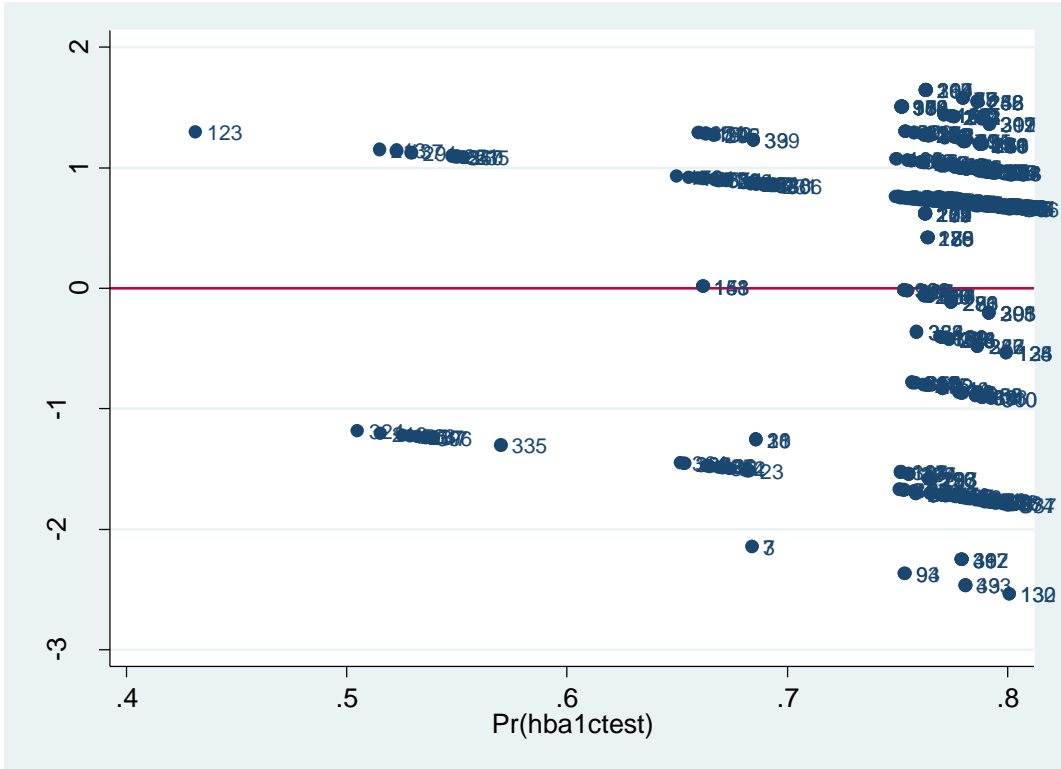
traditional diabetes medications and would be captured on the basis of the traditional medications

## 7. Appendix B: HbA1c testing every 6 months

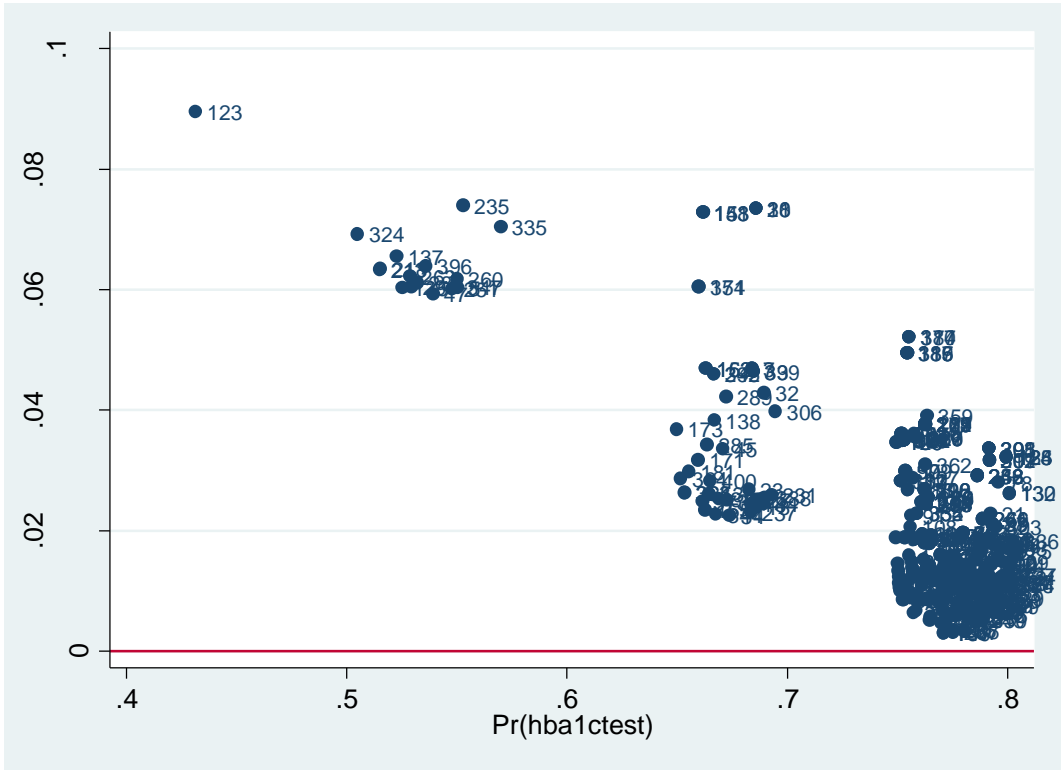
1. **Hosmer-Lemeshow goodness of fit test:** Chi square value: 2.18; P-value = 0.975. Indicates adequate fit
2. Area under ROC curve: 0.5601
3. **Plots of standardized Pearson residuals, deviance residuals and leverage.**



No obvious outliers from standardized Pearson residuals, except maybe observation 123, although it has a residual < 2



Again, no obvious outliers, except observation 123. A series of observations have a residual <-2 but they are difficult to identify because they overlap.

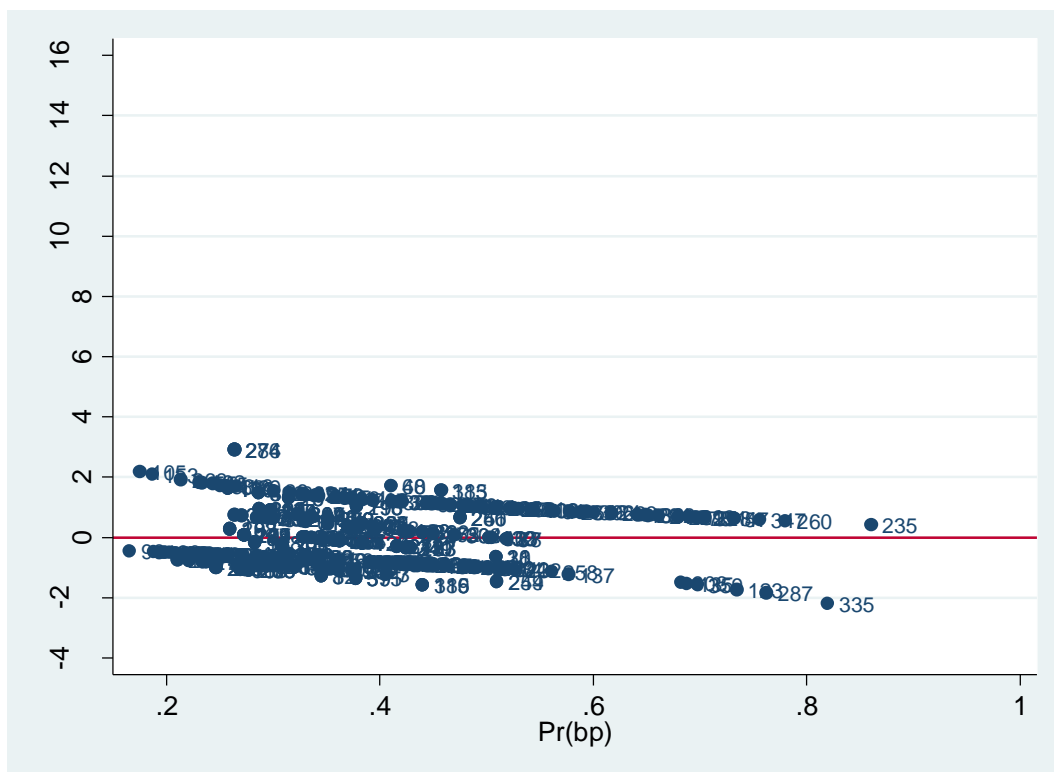


Observation number 123 has the most leverage and it may be an outlier. This observation number refers to an older female officer aged 51 residing in a small base who had HbA1c testing in the last 6 months.

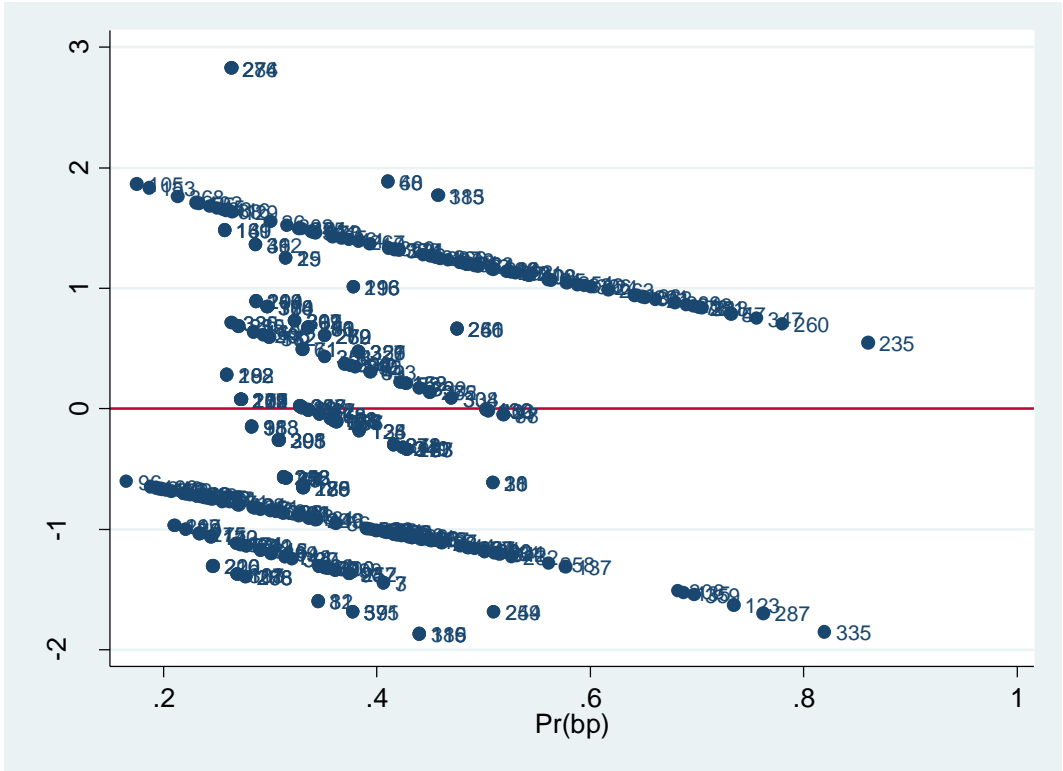
When this point was removed, it did not change any predictors from significant to non-significant or vice-versa.

## 8. Appendix C – blood pressure < 130/80

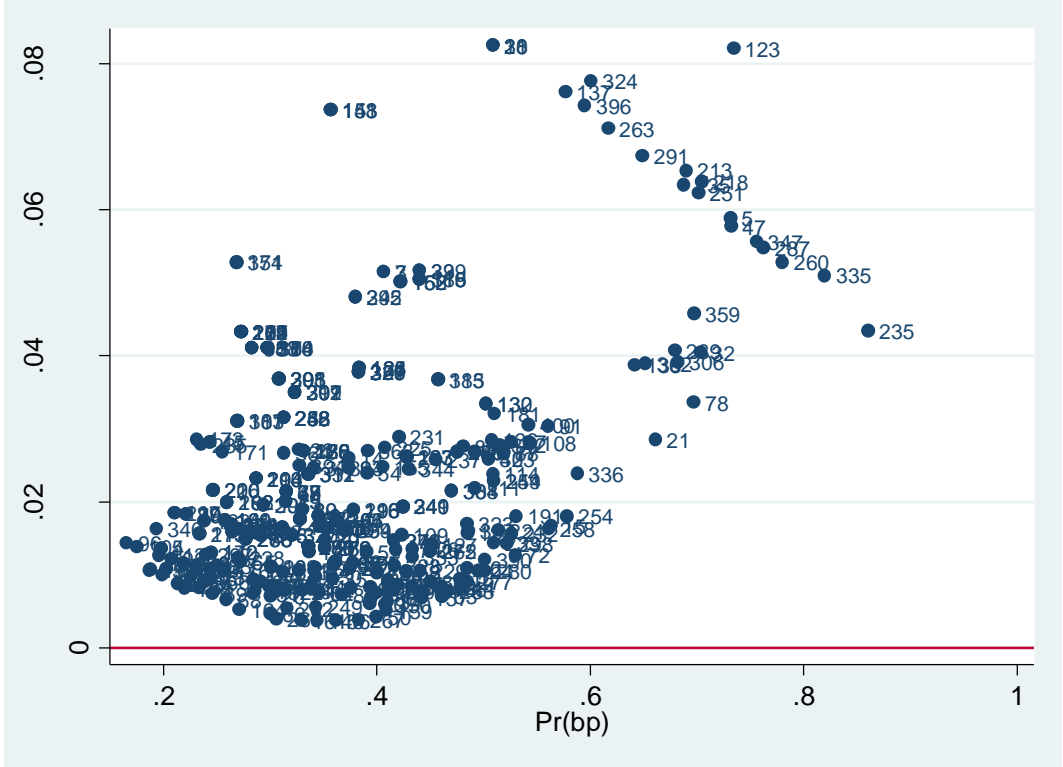
1. **Hosmer-Lemeshow goodness of fit test:** Chi-square value: 7.54; P-value = 0.480. Indicates adequate fit.
2. Area under ROC curve: 0.6378
3. **Plots of standardized deviance residuals, deviance residuals, leverage and Pregibond's dbeta**



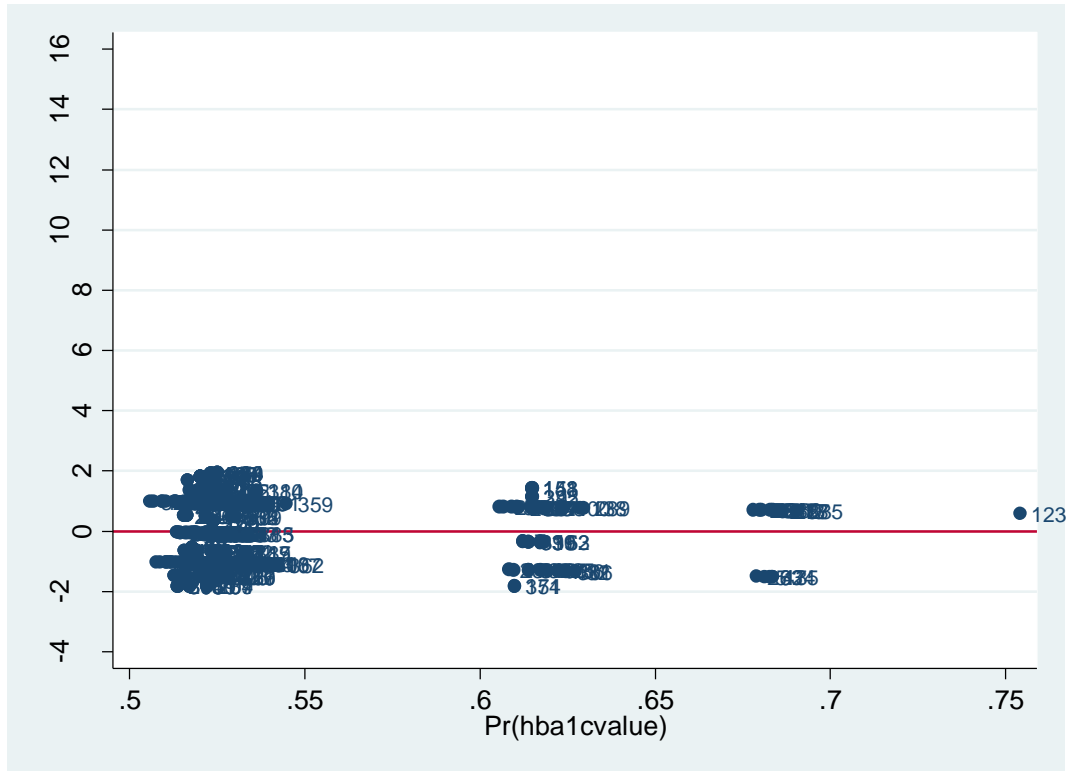
No obvious outliers, except point 335 is < -2 and two illegible points are > 2.



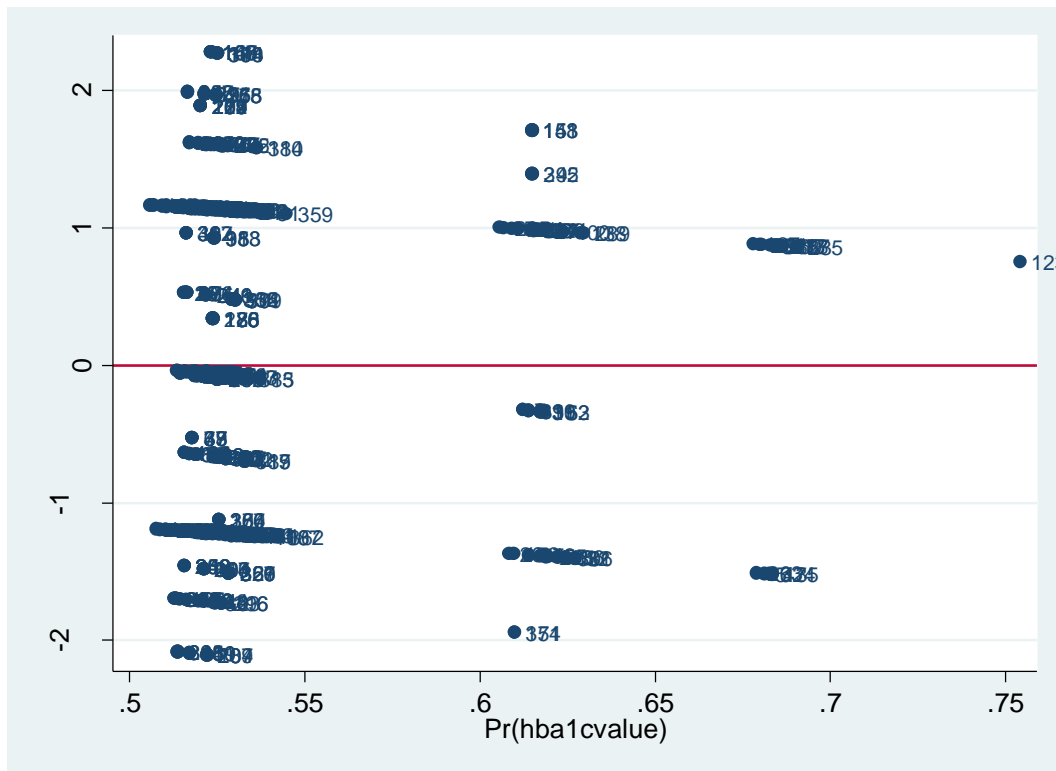
2 points that are potential outliers but hard to identify because the numbers overlap.



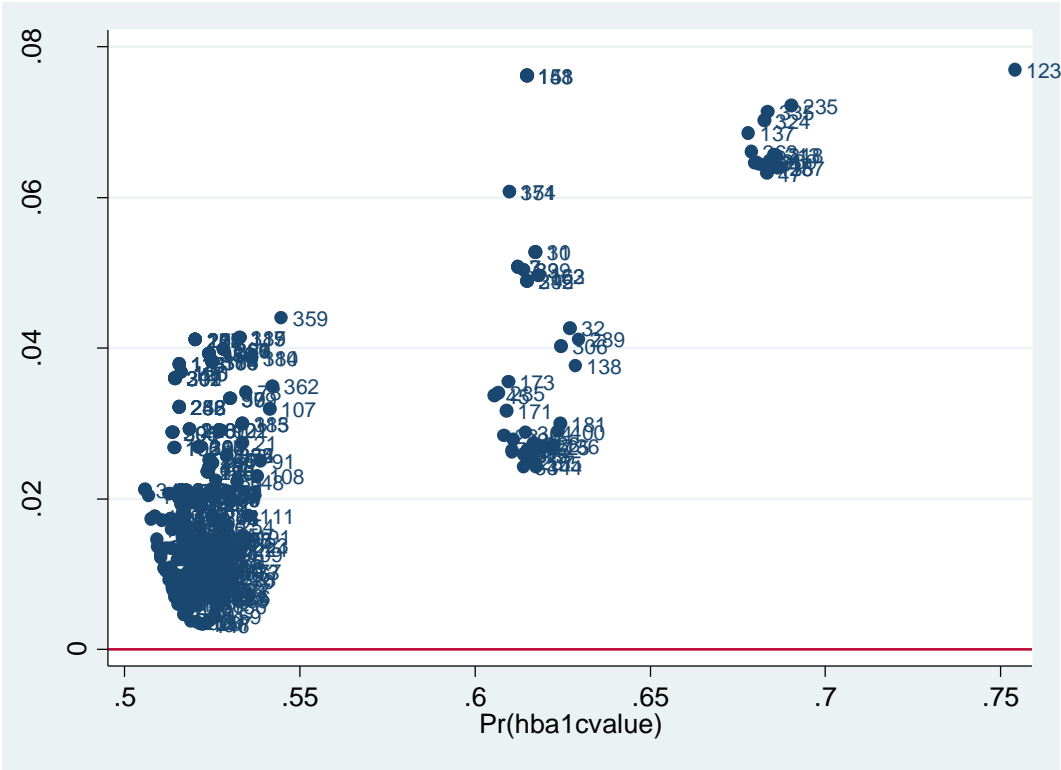




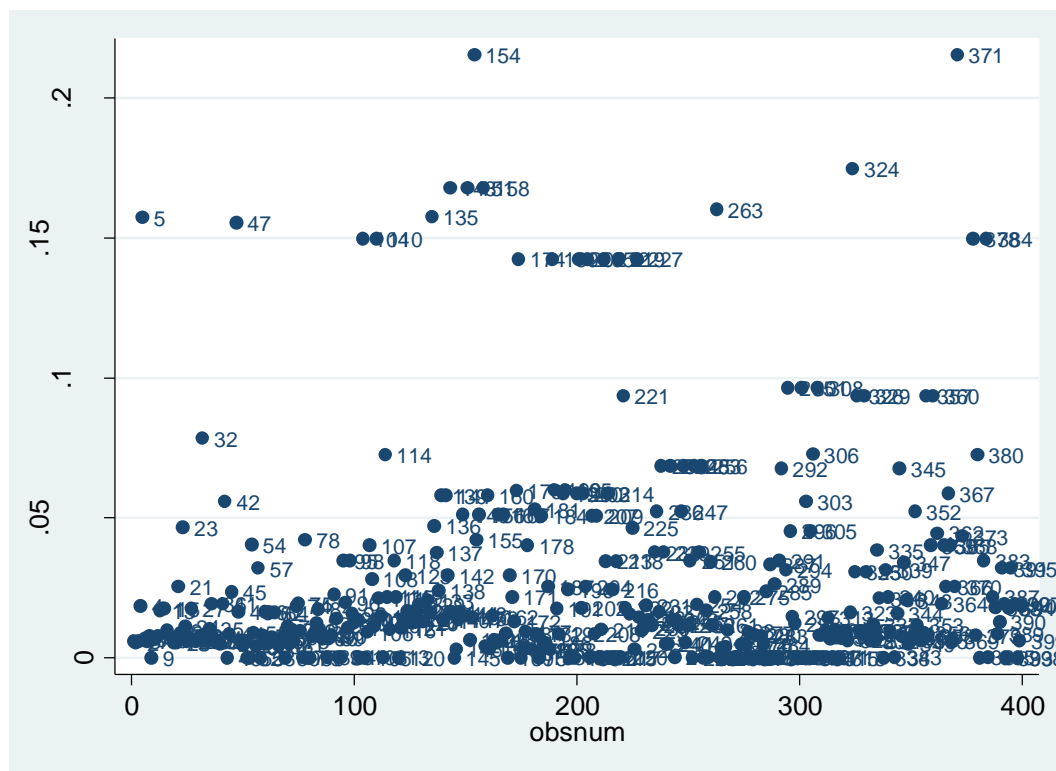
No obvious outliers, except observation number 123 again. All residuals  $< 2$  and  $> -2$ .



No obvious outliers, except maybe observation number 123. Several points  $<-2$  and  $>2$  but hard to identify.



Again observation number 123 is seen as having high leverage.



Observation 371 is an older male officer aged 57 who lives in a moderately large base and had a HbA1c > 7.0%. Nothing really remarkable about this. No reason to remove point.

Observation 154 is also an older male officer aged 57 from the same base with a HbA1c > 7%. These 2 patients are unique. No data entry errors were detected.

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