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Appropriateness of Screening of Angiopathic Complications Prevention in Ambulatory Patients with Diabetes

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Abstract

Background: Preventive care of diabetic foot and eye complications is essential. However, data on the prevalence of and factors associated with screening of angiopathic complications in ambulatory patients with diabetes are very limited in Switzerland. We aimed to fill this gap of knowledge. Methods: Cross-sectional data on recommended preventive care using RAND's criteria in a random sample of patients aged 50 - 80 years in 2005-2006. Participants were recruited from 4 Swiss university primary care settings (in Lausanne, Geneva, Zürich and Basel). Scores for general preventive care in patients with and without diabetes were calculated by using generalized estimating equation binomial models. Multivariate regression models were used to identify determinants of appropriateness of angiopathic complications prevention. The main outcome measure was appropriateness of screening for angiopathic complications based on the 2005 American Diabetes Association recommendations corresponding to the period of data collection. Results: Among the 1002 patients aged 50 - 80 years, 292 (29.1%) had diabetes (101/292 [34.6%] female, mean BMI 30.7 [SD 5.7]). Fifty-nine percent had appropriate preventive foot care and 55.8% had appropriate

preventive eye care. Only 34.6% had appropriate preventive care of both foot and eye. No differences in aggregate scores for general preventive care in patients with and without diabetes were found (67.5% vs. 69.1%, p value 0.39). In multivariate model, obesity was negatively (OR = 0.28, 0.15 - 0.53) and hyperlipidemia positively (OR = 2.29, 1.20 - 4.38) associated with appropriate eye preventive care and with appropriate combined foot and eye preventive care (OR = 0.35, 0.18 - 0.70 for obesity and OR = 2.82, 1.24 - 6.40 for hyperlipidemia). Conclusions: Preventive care of diabetic angiopathic complications is low among ambulatory patients despite universal health care coverage. Particular attention should be paid to obese patients with diabetes.

Keywords

Diabetes, Appropriateness, Angiopathic Complications, Prevention, Primary Care

1. Introduction

Diabetes and its complications are among the most important and costly chronic diseases in developed countries. It is the major cause of adult blindness, kidney disease, and lower limb amputation [1]. Cost related to diabetes and its complications is very high (e.g., $176 billion/year in 2012 in the United States, CHF 0.88 billions/year in 1998 [1 CHF ≈ 1 US$ as of June 2014] in Switzerland) [2]. Particular attention should be paid to the prevention of angiopathic complications such as foot ulcers and retinopathy.

Fifteen percent of patients with diabetes will suffer from foot ulcer during their lifetime [3] [4], one out of four foot ulcers will not heal, and up to 28% will result in amputation [5]. Factors such as previous foot ulcer or amputation, peripheral neuropathy, smoking, minor trauma, impaired visual acuity, and foot deformities have been associated with increased risk of foot ulcers [6]-[9].

Diabetic retinopathy is one of the most important causes of visual loss in the world. Patients with diabetes have a 25 times increased risk of blindness in comparison with the general population [10]. Because most patients remain asymptomatic until the very late stage, appropriate regular screening is essential [4] [11].

Guidelines from the American Diabetes Association (ADA) recommend annual careful exam of feet by the primary care physician, including inspection (skin integrity, foot deformities, callus), research of pedial pulses, test for neuropathy, and advice for prophylactic foot care [1]. The European Association for the Study of Diabetes (EASD) 2013 guidelines recommend annual exam of feet including inspection of indirect signs of ischemia completed with measurement of ankle brachial index [12]. Retinopathy screening by an ophthalmologist is recommended annually for patients with diabetes [1] in both guidelines.

Data from the U.S. National Health and Nutrition Examination Survey and the Behavioral Risk Factor Surveillance System have been used to evaluate the 1999-2010 trends in quality of care in patients with diabetes. While annual eye examination prevalence did not change, glycemic control increased by 7.9%, and annual foot examination increased by 6.8% [13].

Data on the quality of preventive care of angiopathic complications in patients with diabetes in Switzerland are very limited. A 2007 review of medical file and assessment with 186 community-based primary physicians in the French-speaking part of Switzerland [14] showed that screening and counselling was adequate but regular follow-up of microangiopathic complications was suboptimal (62% annual eye examination and 65% annual foot examination). The quality of prevention and management of a random sample of 1002 patients from 4 Swiss university primary care settings has been semi-quantitatively assessed in a retrospective cohort [15]. Appropriateness of the prevention of angiopathic complications (*i.e.*, foot ulcers, retinopathy) was clearly lower than other preventive care (e.g., control of Hb1Ac, arterial blood pressure, glucose and cholesterol levels). Factors associated with the quality of care and prevention of angiopathic complications in Switzerland are currently unknown.

Recognizing this, we aimed to assess the prevalence and determinants of appropriate prevention of foot ulcer and retinopathy in patients with diabetes in Switzerland. For the purpose of the study, we defined appropriateness of care when annual foot and/or eye exam was annually completed, using international recommendations. Specifically, we assessed whether demographic (e.g., age, gender, origin), socio-economic status (e.g., marital

status, legal status, insurance status), and comorbidities (e.g., obesity, smoking, psychiatric disorders) were associated with appropriate prevention of foot ulcer and retinopathy preventive care in patients with diabetes. We also compared the use of general recommended preventive care in patients with and without diabetes. Switzerland offers a particular study setting to assess preventive care as it is characterized by universal health insurance coverage. Health insurance coverage in Switzerland is compulsory and insurance premiums are paid independently of income. The patient pays part of the cost of treatment (an annual flat deductible according to which premiums are adjusted, and a 10% co-pay of the costs up to an annual amount of CHF 700). In the last ten years, health insurance premiums increased by 77% [16].

2. Methods

2.1. Study Design

We used data from the Corif study [15], which has been described elsewhere [14] [17]. Briefly, informations from medical charts have been abstracted from 1002 patients randomly selected in four of the five Swiss university centers (Lausanne, Geneva, Zürich and Basel), aged 50 to 80 years, followed in 2005-2006. Diabetes was defined as at least one prescription of insulin or oral hypoglycemic agent, at least 2 outpatient diagnoses of diabetes or one outpatient diagnosis of diabetes plus HbA1c ≥ 7%, at least one hospital discharge with a primary diabetes-related diagnosis, at least 2 fasting glycemia ≥ 7 mmol/l or at least 2 times 2-hour plasma glucose ≥ 11 mmol/l during an oral glucose tolerance test [18]. Among 1002 patients, 292 (29.1%) had diabetes. Data abstracted included socio-demographic factors, comorbidities, and 37 selected indicators for chronic and preventive care. The indicators were derived from RAND's Quality QA Tools, a system established for evaluation of quality of care, based on review of the literature and confronted choice of experts [19]-[21], developed by the RAND Health group in the US.

2.2. Statistical Analysis

Continuous variables were expressed as medians (interquartile range, IQR) or means (standard deviation, SD). The difference in median or means between the two groups (appropriate versus inappropriate care) was tested using Wilcoxon rank test or Student's test, and two-sided p-values were reported. Categorical variables were expressed as number and percentage. P value was calculated by Chi^2 test or exact Fisher test. We calculated the proportion of patients with appropriate foot and eye care following the 2005 ADA recommendations, the year of the Corif study recruitment [1].

Last update of ADA recommendations from 2014 [22] concerning foot and eye preventive care are very similar to 2005. According to these guidelines, preventive care was considered *appropriate* if done at least annually, or *inappropriate* otherwise. Appropriate foot exam was defined as annual pallesthesia and/or annual visual exams.

To determine and compare the prevalence of appropriateness of general preventive care (others than particular recommended measurements for screening of diabetic complications) in patients with and without diabetes, global aggregate scores were compared. Aggregate scores were calculated using generalized estimating equation binomial models by dividing the number of provided recommended care by the number of times the patients were eligible for, as described elsewhere [15]. As obesity appeared to be a major determinant of angiopathic complications, we also compared the global aggregate score of general recommended preventive care between obese and non-obese patients. We used multivariable generalized linear regression to determine factors associated with appropriateness of preventive care for angiopathic complications. We *a priori* selected considered socio-economic, demographic, and comorbidities factors that may influence diabetes care. To build the model, factors associated with foot and/or eye angiopathic complications preventive care in univariate analysis were entered in the final multivariable model. Age, sex, and center were forced into the model.

For the purpose of this study, obesity was defined as BMI ≥ 30 kg/m^2; occupation categorized as retired, employed, at home/in education/other, and social aid/unemployed; civil status as married, divorced or separated, single or widow/-er. Hyperlipidemia was defined as any lipid-lowering treatment or if any previous LDL cholesterol value was equal to or higher than the risk-appropriate cut-point value defined by NCEP ATP III. Number of outpatient visits to the general practitioner concerned the 2-year review period only. Family history of cardiovascular disease was considered positive if a man below 55 years of age or a woman below 65 years of

age in the family had coronary heart disease (angina, myocardial infarction).

Statistical significance was considered for p < 0.05. Statistical analyses were performed with Stata version 12 (Stata Corporation, College Station, TX, USA).

3. Results

The main characteristics of the patients with and without diabetes included in the Corif study are presented in **Table 1**. Patients with (N = 292, 29.1%) and without diabetes (N = 710, 70.9%) differed by several means such as sex, birth place, legal status, occupation, cardiovascular diseases, hyperlipidemia, hypertension, and obesity. The median (IQR) number of outpatient visits during the two years of the study was 12 (9 - 17) and 10 (6 - 14) in patients with and without diabetes (p value < 0.001), respectively.

Among patients with diabetes, the mean (SD) age and BMI were 63.5 (7.7) years and 30.7 (5.7) kg/m^2, respectively. Thirty-five percent were women, 31.0% current smokers, 79.5% had dyslipidemia, 87.7% hypertension, 43.5% cardiovascular disease and 26.4% chronic pulmonary disease. Among the 292 patients with diabetes, 5 (1.7%) and 56 (19.2%) had a history of amputation and diabetic retinopathy, respectively.

3.1. Prevalence of Appropriate Angiopathic Complications Preventive Care

Sixty percent of the patients with diabetes had appropriate annual foot exam, and 55.8% of the patients with diabetes had appropriate annual eye exam (**Figure 1**).

Nineteen percent of patients with diabetes had neither annual eye exam nor annual foot exam; 21.2% had annual eye exam but no annual foot exam; 24.7% had annual foot exam but no annual eye exam; and 34.6% had annual foot and eye exams (**Supplementary Figure S1**). Among the 173 patients with diabetes and annual foot exam, 79.2% had both foot pallesthesia and foot visual exams; 2.9% had pallesthesia only; 17.9% had foot visual exam only (**Supplementary Figure S2**).

Twenty-one percent of patients with diabetes were considered as having appropriate foot preventive care although the exam was incomplete (either no pallesthesia or no foot visual exam).

3.2. General Preventive Recommended Care

Compared to patients without diabetes, patients with diabetes had a similar aggregate score for general preventive care (67.5% *vs*. 69.1% in patients without diabetes, p value 0.39) (**Supplementary Table S1**).

3.3. Determinants of Appropriateness of Foot and Eye Preventive Care

In univariate analysis, BMI, obesity, family history of cardiovascular disease, hyperlipidemia, follow-up visit at least 2x/year and Hb1Ac controlled at least 2x/year were associated with combined appropriate care of foot and eye exam at least once a year (**Supplementary Table S2**). Work, civil status, number of visits to the general practitioner, family history of cardiovascular disease, blood sugar monitoring if on insulin therapy, follow-up visit at least 2x/year and control of Hb1Ac at least 2x/year were associated with appropriate foot preventive care. BMI, obesity, and hyperlipidemia were associated with appropriate eye preventive care (**Supplementary Table S2**). Among these factors, obesity and hyperlipidemia remained independently associated with appropriateness of combined foot and eye preventive care in multivariate analysis (**Table 2**). Obesity was negatively associated with appropriateness of combined foot and eye preventive care. Compared to non-obese patients with diabetes, obese patients with diabetes were less likely to have appropriateness of combined foot and eye preventive care (Odds Ratio OR: 0.35, 95%CI 0.18 - 0.70). The association between obesity and appropriateness of preventive care for angiopathic complications was also found for eye (OR 0.28, 95%CI 0.15 - 0.53) but not for foot exams (OR 1.26, 95%CI 0.61 - 2.59). Associations appeared to be specific to obesity as no association was found in overweight patients with diabetes (N = 86) (OR $_{overweight}$ 1.39, 95%CI 0.47 - 4.11, p = 0.55 for combined foot and eye preventive care and OR $_{overweight}$ 1.19, 95% CI 0.44 - 3.24, p = 0.74 for eye preventive care only).

Sixty percent of non-obese patients had appropriate eye preventive care compared to 40.2% of obese patients with diabetes (p < 0.001) (**Figure 2**). Forty-nine percent of non-obese patients with diabetes had appropriate foot preventive care compared to 51.0% of obese patients with diabetes (p = 0.54). Combined foot and eye preventive care was appropriate in 59.5% of non-obese patients with diabetes and 40.5% of obese patients with diabetes (p = 0.003).

Table 1. Characteristics of the patients included in the CoRiF study (2005-2006), by diabetes status.

| Characteristics	All patients (N = 1002)	Patients with diabetes (N = 292)	Patients without diabetes (N = 710)	p value
Age, mean (SD)	63.5 (8.3)	63.5 (7.7)	63.5 (8.5)	0.93
Range, minimum-maximum	50 - 80	50 - 80	50 - 80	
Women, N (%)	445/1002 (44.4)	101/292 (34.6)	344/710 (48.5)	**<0.001**
Birth place, N (%)				**0.008**
Europe	197/992 (19.7)	58/290 (20)	137/702 (19.5)	
Eastern europe	177/992 (17.8)	66/290 (22.8)	111/702 (15.8)	
Africa	59/992 (6.0)	24/290 (8.3)	35/702 (5.0)	
Latin America and other	102/992 (10.3)	24/290 (8.3)	78/702 (11.1)	
Switzerland	459/992 (46.3)	118/290 (40.7)	341/702 (48.6)	
Legal status, N (%)				**0.001**
Swiss	101/507 (19.9)	22/166 (13.3)	79/341 (23.2)	
Residence permit	325/507 (64.1)	125/166 (75.3)	200/341 (58.6)	
Asylum seeker, demand rejected or illegal	81/507 (16.0)	19/166 (11.5)	62/341 (18.2)	
Occupation, N (%)				**<0.001**
Retired	372/982 (37.9)	107/287 (37.3)	265/695 (38.1)	
Employed	285/982 (29.0)	60/287 (20.9)	225/695 (32.4)	
At home or in education or other	118/982 (12.0)	36/287 (12.5)	82/695 (11.8)	
Social aid or unemployed	207/982 (21.1)	84/287 (29.3)	123/695 (17.7)	
Civil status, N (%)				0.36
Married	506/993 (51.0)	155/290 (53.5)	351/703 (49.9)	
Divorced, separated	233/993 (23.5)	72/290 (24.8)	161/703 (22.9)	
Single	151/993 (15.2)	38/290 (13.1)	113/703 (16.1)	
Widow/-er	103/993 (10.4)	25/290 (8.6)	78/703 (11.1)	
Comorbid conditions, N (%)				
Cardiovascular disease	364/1002 (36.3)	127/292 (43.5)	237/710 (33.4)	**0.002**
Chronic pulmonary disease[1]	261/1002 (26.1)	77/292 (26.4)	184/710 (25.9)	0.88
Chronic gastrointestinal disease	329/1002 (32.8)	86/292 (29.5)	243/710 (34.2)	0.14
Cancer	142/1002 (14.2)	43/292(14.7)	99/710 (13.9)	0.75
Dementia	24/1002 (2.4)	6/292 (2.1)	18/710 (2.5)	0.82
AIDS	13/1002 (1.3)	1/292 (0.3)	12/710 (1.7)	0.12
Psychiatric disorders[1]	294/1002 (29.3)	83/292 (28.4)	211/710 (29.7)	0.68
Number of GP visits over 2 years				
Median (interquartile range)	10 (7 - 15)	12 (9-17)	10 (6 - 14)	**<0.001**
Range, minimum-maximum	2.0 - 63.0	3.0 - 48.0	2.0 - 63.0	
Cardiovascular risk factors, N (%)				
Hyperlipidemia	622/1001 (62.1)	232/292 (79.5)	390/709 (55.0)	**<0.001**
Hypertension	753/1002 (75.2)	256/292 (87.7)	497/710 (70.0)	**<0.001**
Diabetic complications	151/1002 (15.1)	151/292 (51.7)	0/710 (0.0)	**<0.001**
Family history of cardiovascular disease	99/1002 (9.9)	24/291 (8.3)	75/710 (10.6)	0.27
Current smoker[1]	230/789 (29.2)	71/227 (31.3)	159/562 (28.3)	0.40
Obesity (BMI $\geq$ 30)	288/759 (37.9)	113/225 (50.2)	175/534 (32.8)	**<0.001**

[1]Numbers may differ from Collet *et al*. [15] as variables were categorized differently.

Table 2. Multivariate associations (Odds ratio and 95% confidence interval) of characteristics with appropriate[*] preventive care for angiopathic complications in the 292 patients with diabetes in the Corif study (2005-2006).

	Combined foot and eye preventive care			Foot care			Eye care		
	Odds Ratio[1]	95%CI	p value	Odds Ratio[1]	95%CI	P value	Odds Ratio[1]	95%CI	p value
Occupation									
Social aid/unemployed	Ref			Ref			Ref		
At home or in education	0.16	0.04 - 0.59	**0.006**	0.18	0.05 - 0.75	**0.018**	0.75	0.21 - 2.69	0.66
Employed	0.36	0.13 - 1.01	0.053	0.36	0.12 - 1.06	0.063	0.53	0.22 - 1.27	0.16
Retired	0.69	0.24 - 1.96	0.49	0.64	0.18 - 2.20	0.48	1.21	0.43 - 2.91	0.81
Civil status									
Single	Ref			Ref			Ref		
Divorced, separated	1.55	0.58 - 4.15	0.38	5.27	1.64 - 16.90	**0.005**	1.29	0.50 - 3.37	0.60
Widow, -er	1.09	0.30 - 3.99	0.90	2.05	0.50 - 8.47	0.32	1.00 - 0.66	0.28 - 3.61	1.00
Married	1.32	0.51 - 3.43	0.56	3.83	1.32 - 11.10	**0.013**	1.15	0.47 - 2.82	0.76
Number of visit to GP over 2 years[2]	0.98	0.93 - 1.03	0.38	1.02	0.97 - 1.07	0.53	1.00	0.96 - 1.05	0.85
Obesity (BMI $\geq$ 30 kg/m^2)	0.35	0.18 - 0.70	**0.003**	1.26	0.61 - 2.59	0.54	0.28	0.15 - 0.53	**<0.001**
Family history of cardiovascular disease[3]	2.22	0.70 - 7.05	0.18	1.84	0.52 - 6.51	0.34	2.00	0.68 - 5.88	0.21
Hyperlipidemia[4]	2.82	1.24 - 6.40	**0.013**	2.05	0.87 - 4.82	0.10	2.29	1.20 - 4.38	**0.012**
Blood sugar monitoring at home if insulin therapy	0.88	0.45 - 1.70	0.70	0.62	0.27 - 1.44	0.27	0.94	0.51 - 1.74	0.84
Follow-up visit at least 2x/year	1.76	0.61 - 5.03	0.29	4.02	1.35 - 11.92	**0.012**	1.31	0.45 - 3.80	0.62
Hb1Ac at least 2x/year	2.27	0.99 - 5.21	0.052	1.75	0.76 - 4.06	0.19	1.58	0.80 - 3.17	0.19

[*]appropriateness of care was based on ADA recommendations and not on RAND QA Tool; [1]associations are adjusted for variables listed in the table as well as for age, sex and study center; [2]number of outpatient visits to the general practitioner concerned the 2-year review period only; [3]positive if a man < 55 y or a woman < 65 y in the family had coronary heart disease (angina, myocardial infarction); [4]hyperlipidemia was considered if any lipid-lowering treatment or if any previous LDL cholesterol value $\geq$ risk-appropriate cut-point value defined by NCEP ATP III.
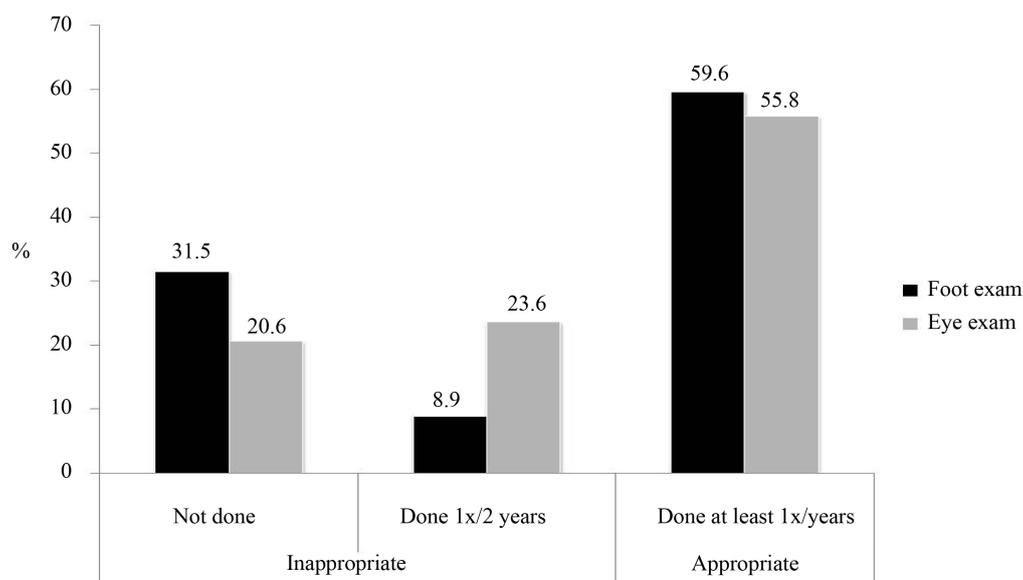
Figure 1. Prevalence of foot and eye exam in 292 patients with diabetes from the Corif study (2005-2006).
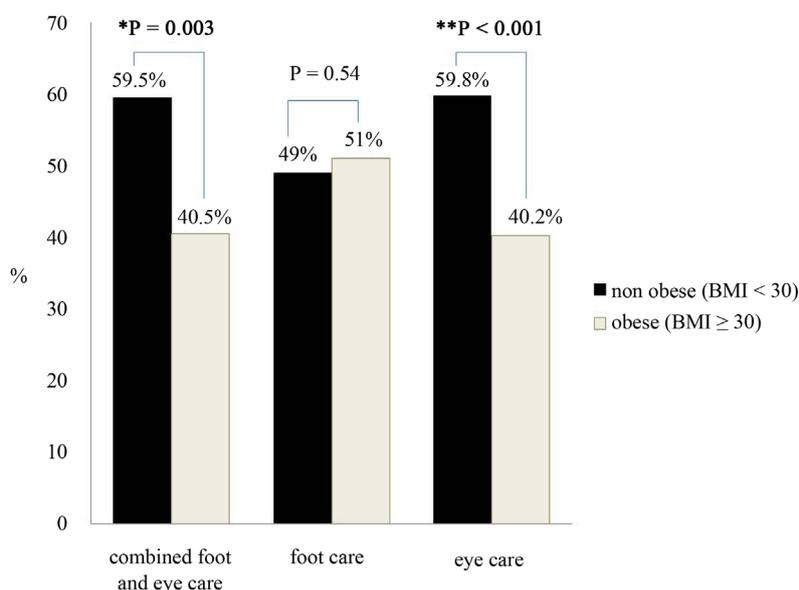
Figure 2. Proportion of appropriate care in the corif study (2005-2006), by obesity status (p values based in multivariate analysis adjusted for age, sex, study center, occupation, civil status, number of visits to GP over the two years of study, obesity, family history of cardiovascular disease, hyperlipidemia, blood sugar monitoring at home in case of insulin therapy, follow-up visit at least twice annually and measurement of Hb1Ac at least twice annually).

Of note, among the 56 patients with a history of diabetic retinopathy, 73.2% had appropriate eye preventive care and 3 among the 5 patients (60%) with diabetes and a past amputation had appropriate foot preventive care.

Hyperlipidemia was positively associated with combined foot and eye preventive care (OR 2.82, 95% CI 1.24 - 6.40) and eye preventive care only (OR 2.29, 95% CI 1.20 - 4.38).

Compared with social aid or unemployed, patients at home or in education were significantly less likely to have combined foot and eye preventive care (OR 0.16, 95% CI 0.04 - 0.59), and particularly foot preventive care (0.18, 95% CI 0.05 - 0.75).

4. Discussion

Using data from a random sample of patients with and without diabetes aged 50 - 80 years followed over 2 years (2005-2006) in 4 Swiss university primary care settings, we found that inappropriate foot and eye preventive care was frequent among patients with diabetes. Obesity was independently and negatively associated with appropriateness of preventive care for diabetic retinopathy.

While we found that patients with diabetes received as much general recommended preventive care as patients without diabetes, inappropriateness of angiopathic preventive care in patients with diabetes was frequent (57 patients, 19.5%) had neither annual eye exam, nor annual foot exam during the review period) with potential consequences on morbidity related to limb amputation and risk of impaired visual acuity or blindness. Delayed eye preventive care can result in greater risk of retinopathy [11]. Of note, one out of five patients with diabetes who had annual foot exam had actually an incomplete care with only pallesthesia or visual exams.

Obesity was negatively associated with appropriate combined foot and eye preventive care and specifically with eye preventive care. We found that compared to non-obese patients with diabetes, obese patients with diabetes were less likely to have appropriate preventive care for angiopathic complications. This association between obesity and eye preventive care was independent of major potential confounders. Further adjustment for smoking status, which is known to be often associated with screening and obesity, did not change meaningfully the results. The lower prevalence of appropriate eye preventive care among obese patients with diabetes compared to non-obese patients with diabetes is of particular importance given that obesity might be an independent risk factor for diabetic retinopathy. While the relationship of obesity with angiopathic complications care in pa-

tients with diabetes has been sparsely explored, obesity has been positively associated with diabetic retinopathy [23]-[26]. Mechanisms such as inflammation and endothelial dysfunction have been proposed to explain the increased risk of diabetic retinopathy in obese patients [24] [25]; our findings suggest that suboptimal eye preventive care might be another explanation.

Some studies have investigated the association between obesity and appropriate preventive care, particularly in preventive cancer screening. Results are conflicting with some studies reporting less preventive care in breast, cervical, and colorectal cancer in obese than in non-obese adults [27]-[31], while other more recent studies reported no differences [31]-[34]. Methodology differences and selection of patients may explain, in part, these divergent results [33]. Patients- and healthcare providers-related barriers to preventive care in obese adults including unadapted equipment [30], reluctance to physical exam because of embarrassment [35] [36], and perceived lack of motivation/compliance [37]-[40] have been reported. The high number of comorbidities in obese patients has been suggested to explain, in part, the suboptimal preventive care generally reported in obese patients [35]. But in our study, obese patients were not less likely to have general preventive care (global aggregate score for general preventive care for obese vs non-obese patients: 73.0 vs 75.3, p = 0.08) (**Table S3**). In addition, patients with diabetes and obesity presented a very similar aggregate score for general preventive care (72.0%, 95% CI 68.9 - 75.0) than patients without diabetes or obesity (75.7, 95% CI 74.0 - 77.3).

This should be interpreted with the fact that patients with diabetes have significantly more GP visits compared to patients without diabetes. This suggests that the medical care by GPs can also be improved.

Whether obese patients are at greater risk of diabetic retinopathy because of physiological mechanisms or suboptimal preventive care or both, our findings support the need for implementing interventions to improve eye preventive care among obese patients.

Hyperlipidemia was positively associated with appropriate eye and combined foot and eye preventive care. It is possible that patient with diabetes and hyperlipidemia requires regular lipid screening that may raise physician's attention to the prevention of others cardiovascular risk factors or angiopathic complications. Of note, some studies suggest dyslipidemia as a risk factor in combination with suboptimal glycemic control and high blood pressure for diabetic retinopathy [26].

We found no statistical interaction between hyperlipidemia and obesity (p value for interaction = 0.69).

Finally, occupation and civil status were associated with appropriate care for angiopathic complications. Previous studies have explored the associations between race/ethnicity and income with appropriatenes of care in patients with diabetes and results have been inconsistant. The role of occupation and civil status is worthy of future research.

Strengths and Limitations

Our study highlights a particularly vulnerable group of patients with obesity and diabetes, which requires special attention from the general practitioner. To our knowledge, this is the first study to demonstrate a strong association between obesity and inappropriateness of eye preventive care. Results from our study should be interpreted in the light of its limitations. Causal inference is not possible in cross-sectional studies. We lack information on the duration and severity of diabetes. Our study is limited to patients aged 50 - 80 years old visiting university primary care settings and our results may not be generalizable to other age groups and/or settings. Our study is based on data available from abstracted medical charts. Information abstracted from medical charts has limitations [41]-[43]. For example, measurements of quality of care was 5% lower using clinical vignettes and 10% lower using standardized patients, compared with medical chart abstraction [43]. We cannot exclude that some care may have been appropriately done but not reported in the medical chart, especially for eye exam that might have been done by an external physician. Yet, to ensure continuity of care in a context of frequent changes of physicians in university primary care settings, systematic reporting in the medical file is essential [44], and missing information about preventive care in patients with diabetes could suggest inappropriate care *per se*.

The small number of patients with diabetes included in our analysis is an important limitation and our analysis may have lacked statistical power. For example, in contrast to some studies, appropriate preventive care for angiopathic complications in patients with diabetes was not independently associated with age, race, legal status or religion in our study [45] [46]. Insufficient statistical power might explain, at least in part, this lack of association. For foot exam, the ADA recommends visual exam, pallesthesia and neurological exam, and palpation of pedial pulses. We lack data on neurological exam and pedial pulse palpation. We lack information on preventive

care performed before the study 2-year period as well as information on the severity of angiopathic complications. For eye preventive care, it is possible that some patients with one or more normal previous eye exam had less frequent exams in line with the ADA recommendations [1]. Different guidelines for preventive care in patients with diabetes exist [12] [47]. We used the 2005 ADA recommendations to define appropriate preventive care in patients with diabetes, which suggest annual foot and eye exams. Other major guidelines such as the National Institute of Health and Care Excellence clinical guidelines are in line with the ADA annual recommendation [47]. By contrast, the RANDS's Quality Tools developed in this study defined appropriate foot care as foot exam twice a year. Of note, using the RANDS's Quality Tools instead of the ADA would have led to even more frequent inappropriate care.

5. Conclusion

Despite health care universal coverage, preventive care of diabetic angiopathic complications (foot and eye complications) is frequently inappropriate among ambulatory patients. Preventive eye care is particularly inappropriate in obese patients with diabetes. Interventions to improve angiopathic complication preventive care are warranted.

Acknowledgements

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Supplementary Tables

Table S1. Recommended preventive care and aggregate score in the Corif study (2005-2006), by diabetes status.

	Patients with diabetes (N = 292)			Patients without diabetes (N = 710)			p value
	Eligible patients (N)	Care provided[1] (N)	Care provided % (95% CI)	Eligible patients (N)	Care provided[1] (N)	Care provided % (95% CI)	
Physical examination							
Annual blood pressure measurement	292	280	96.0 (92.9 - 97.9)	710	672	94.6 (92.7 - 96.2)	0.86
Weight measurement	292	281	96.2 (93.4 - 98.1)	710	671	94.5 (92.6 - 96.1)	0.44
Height measurement	292	220	75.3 (70.0 - 80.2)	710	533	75.1 (71.7 - 78.2)	0.99
Alcohol consumption counseling							
Asked about drinking problem	292	195	66.8 (61,1 - 72.2)	710	476	67.0 (63.4 - 70.5)	0.99
Smoking cessation counseling							
Smoking status documented	292	227	77.7 (72.5 - 82.4)	710	562	79.2 (76.0 - 82.1)	0.69
Annual advice to quit smoking	71	54	76.1 (64.5 - 85.4)	159	111	69.8 (62.0 - 76.8)	0.33
Counseling offered to smokers attempting to quit	20	12	60 (36.1 - 80.9)	57	40	70.2 (56.6 - 81.6)	0.43
Pharmacotherapy offered to smokers attempting to quit if > 10 cigarettes/day	20	11	55 (31.5 - 76.9)	57	26	45.6 (32.4 - 59.3)	0.90
Abstinence documented 4 weeks after smoking cessation counseling	12	5	41.7 (15.2 - 72.3)	40	19	48.0 (31.5 - 63.9)	0.71
Cancer screening[2]							
Screening for colon cancer (aged 50 - 80)	285	88	30.9 (25.6 - 36.6)	699	257	36.8 (33.2 - 40.4)	0.82
Screening for breast cancer (aged 5 0- 70)	78	34	43.6 (32.4 - 55.3)	232	91	39.2 (32.9 - 45.8)	0.88
Influenza immunization[3]							
Annual influenza vaccine for patients ≥ 65 years	126	48	38.1 (29.6 - 47.2)	300	102	34.0 (28.7 - 39.7)	0.78
Annual influenza vaccine for immunocompromissed patients <65 years	151	34	22.5 (16.1 - 30.0)	125	47	37.6 (29.1 - 46.7)	**0.006**
Global aggregate score for preventive care			**67.5 (65.5 - 69.4)**			**69.1 (67.8 - 70.3)**	**0.39**

[1]when care was refused by eligible patients, it was considered as provided care and when care was provided less frequently than recommended, it was considered as unprovided; [2]if patients had a prior diagnostic of colon or breast cancer, they were excluded from screening; [3]recommendations for influenza vaccination for < 65 years: living in a nursing home, chronic cardiovascular disease, chronic obstructive pulmonary disease, renal failure, diabetes, immunosuppression, hemoglobinopathy.

Table S2. Appropriateness of angiopathic complication preventive care, by characteristics.

|	N[1]	Combined foot and eye preventive care			Foot care			Eye care		
		Appropriate	Inappropriate	p value	Appropriate	Inappropriate	P value	Appropriate	Inappropriate	p value
All patients with diabetes	292	102/292 (34.9)	190/292 (65.1)		173/292 (59.3)	119/292 (40.8)		163/292 (55.8)	129/292 (44.2)	
General socio-demographic characteristics										
Age, mean (SD)	292	63.9 (7.4)	63.3 (7.9)	0.56	64.1/(7.5)	62.8 (8.0)	0.17	63.3 (7.6)	63.8 (7.9)	0.57
Female, N(%)	292	37/102 (36.6)	64/190 (33.5)	0.59	61/173 (35.3)	40/119 (33.6)	0.77	59/163 (36.2)	42/129 (32.6)	0.52
Insurance N(%)	210			0.67			0.80			0.56
Private or semi-private		2/86 (2.3)	4/124 (3.2)		4/146 (2.7)	2/64 (3.1)		2/116 (1.7)	4/94 (4.3)	
General		80/86 (93)	117/124 (94.4)		136/146 (93.2)	61/64 (95.3)		110/116 (94.8)	87/94 (92.6)	
None		4/86 (4.7)	3/124 (2.4)		6/146 (4.1)	1/64 (1.6)		4/116 (3.4)	3/94 (3.2)	
Birth place N(%)	290			0.22			0.08			0.57
Europe		18/99 (18.2)	40/191 (20.9)		37/171 (21.6)	21/119 (17.7)		27/161 (16.8)	31/129 (24.0)	
Eastern europe		17/99 (17.2)	49/191 (25.3)		30/171 (17.5)	36/119 (30.3)		37/161 (23)	29/129 (22.5)	
Africa		10/99 (10.1)	14/191 (7.3)		15/171 (8.8)	9/119 (7.6)		15/161 (9.3)	9/129 (7.0)	
Latin america and other		12/99 (12.1)	12/191 (6.3)		18/171 (10.5)	6/119 (5.0)		15/161 (9.3)	9/129 (7.0)	
Switzerland		42/99 (42.4)	76/191 (39.8)		71/171 (41.5)	47/118 (39.5)		67/161 (41.6)	51/129 (39.5)	
Legal status N(%)	166			0.36			0.58			0.32
Swiss		7/55 (12.7)	15/111 (13.5)		15/98 (15.3)	7/68 (10.3)		10/91 (11.0)	12/75 (16.0)	
Residence		39/55 (70.9)	86/111 (77.5)		71/98 (72.5)	54/68 (79.4)		68/91 (74.7)	57/75 (76.0)	
asylum seeker, demand rejected or illegal		9/55 (16.4)	10/111 (9.0)		12/98 (12.2)	7/68 (10.3)		13/91 (14.3)	6/75 (8.0)	
Religion N(%)	201			0.31			0.18			0.23
Christian		30/55 (54.6)	61/146 (41.8)		53/100 (53.0)	38/101 (37.6)		47/109 (43.1)	44/92 (47.8)	
Muslim		13/55 (23.6)	35/146 (24)		20/100 (20.0)	28/101 (27.7)		32/109 (29.4)	16/92 (17.4)	
Other		7/55 (12.7)	26/146 (17.8)		14/100 (14.0)	19/101 (18.8)		17/109 (15.6)	16/92 (17.4)	
None		5/55 (9.1)	24/146 (16.4)		13/100 (13.0)	16/101 (15.8)		13/109 (11.9)	16/92 (17.4)	
Occupation N(%)	287			0.07			**0.008**			0.76
Social aid or unemployed		34/100 (34.0)	50/187 (26.7)		53/171 (31.0)	31/116 (26.7)		49/160 (30.6)	35/127 (27.6)	
At home, in education or other		7/100 (7.0)	29/187 (15.5)		14/171 (8.2)	22/116 (19.0)		22/160 (13.8)	14/127 (11)	
Employed		17/100 (17.0)	43/187 (23.0)		31/171 (18.1)	29/116 (25.0)		31/160 (19.4)	29/127 (22.8)	
Retired		42/100 (42.0)	65/187 (34.8)		73/171 (42.7)	34/116 (29.3)		58/160 (36.3)	49/127 (38.6)	
Civil status N(%)	290			0.10			**0.005**			0.9
Single		15/100 (15.0)	23/190 (12.1)		19/172 (11.1)	19/118 (16.1)		23/161 (14.2)	15/128 (11.7)	
Divorced		32/100 (32.0)	40/190 (21.1)		55/172 (32.0)	17/118 (14.4)		41/162 (25.3)	31/128 (24.2)	
Widow, -er		9/100 (9.0)	16/190 (8.4)		16/172 (9.3)	9/118 (7.6)		13/162 (8.0)	12/128 (9.4)	
Married		44/100 (44.0)	111/190 (58.4)		82/172 (47.7)	73/118 (61.9)		85/162 (52.5)	70/128 (54.7)	
Health care provider's characteristics										
Main physician function N(%)	291			0.26			0.07			0.74
Medical student or resident		90/100 (90.0)	179/191 (93.7)		155/172 (90.1)	114/119 (95.8)		149/162 (92)	120/129 (93)	
Senior resident or attending		10/100 (10.0)	12/191 (6.3)		17/172 (9.9)	5/119 (4.2)		13/162 (8)	9/129 (7)	
Nb of visit to GP over 2 years Median (IQR)	292	12.0 (9.0 - 16.0)	12.0 (8.0 - 17.0)	0.58	13.0 (9.0 - 18.0)	11.0 (8.0 - 16.0)	**0.031**	12 (9.0 - 16.0)	11 (8.0 - 18.0)	0.3
Patients' comorbidities										
BMI, mean (SD)	225	29.7 (4.5)	31.4 (6.3)	**0.035**	30.6 (5.3)	31.0 (6.5)	0.60	29.8 (4.7)	31.9 (6.6)	**0.005**
Obesity (BMI ≥ 30 kg/m^2) N(%)	225	34/84 (40.5)	79/141 (56.0)	**0.024**	75/147 (51.0)	38/78 (48.7)	0.74	49/122 (40.2)	64/103 (62.1)	**0.001**
Family history of cardiovascular disease N(%)	291	13/100 (13.0)	11/191 (5.8)	**0.033**	20/172 (11.6)	4/119 (3.4)	**0.012**	16/162 (9.8)	8/129 (6.2)	0.26
Cardiovascular disease[2] N(%)	292	50/101 (49.5)	77/191 (40.3)	0.13	82/173 (47.4)	45/119 (37.8)	0.11	73/163 (44.8)	54/127 (41.9)	0.62
Current smoker[3] N(%)	71	23/71 (32.4)	48/71 (67.6)	0.18	42/71 (59.2)	29/71 (40.9)	0.23	39/71 (54.9)	32/71 (45.1)	0.57
Hyperlipidemia N(%)	292	87/101 (86.1)	145/191 (75.9)	**0.040**	139/173 (80.4)	93/119 (78.2)	0.65	140/163 (85.9)	92/129 (71.3)	**0.002**
Hypertension N(%)	292	92/101 (91.1)	164/191 (85.9)	0.20	154/173 (89.0)	102/119 (85.7)	0.40	146/163 (89.6)	110/129 (85.3)	0.27

Continued

	N			p			p			p
Alcohol consumption[4] N(%)	182			0.50			0.16			0.56
None		47/73 (64.4)	69/109 (63.3)		83/122 (68.0)	33/60 (55.0)		66/103 (64.1)	50/79 (63.3)	
Normal		7/73 (9.6)	6/109 (5.5)		9/122 (7.4)	4/60 (6.7)		9/103 (8.7)	4/79 (5.1)	
Excessive		19/73 (26.0)	34/109 (31.2)		30/122 (24.6)	23/60 (38.3)		28/103 (27.2)	25/79 (31.7)	
Other preventive care										
Regular aspirin therapy N(%)	292	68/101 (67.3)	115/191 (60.2)	0.23	109/173 (63.0)	74/119 (62.2)	0.89	108/163 (66.3)	75/129 (58.1)	0.15
Lipid measurements at least 1x/2 years N(%)	292	97/101 (96.0)	178/191 (93.2)	0.32	163/173 (94.2)	112/119 (94.1)	0.97	156/163 (95.7)	119/129 (92.2)	0.21
Blood sugar monitoring at home if insulin therapy N(%)	292			0.08			**<0.001**			0.38
yes		43/101 (42.6)	58/191 (30.4)		75/173 (43.4)	26/119 (21.9)		62/163 (38)	39/129 (30.2)	
no		0/101	2/191 (1.1)		0/173	2/119 (1.7)		1/163 (0.6)	1/129 (0.8)	
non applicable[5]		58/101 (57.4)	131/191 (68.6)		98/173 (56.7)	91/119 (76.5)		100/163 (61.3)	89/129 (69)	
Follow-up visit at least 2x/year N(%)	292	95/101 (94.1)	164/191 (85.8)	**0.035**	164/173 (94.8)	95/119 (79.7)	**<0.001**	148/163 (90.8)	111/129 (86)	0.2
Hb1Ac at least 2x/year N(%)	292	83/101 (82.2)	127/191 (66.5)	**0.005**	137/173 (79.2)	73/119 (61.3)	**0.001**	124/163 (76.1)	86/129 (66.7)	0.08
Urine microalbumin/creatinine ratio at least 1x/2 years N (%)	291	64/101 (63.4)	137/190 (72.1)	0.13	118/173 (68.2)	83/118 (70.3)	0.70	111/162 (68.5)	90/129 (69.8)	0.66

[1]numbers of patients with information available. [2]cardiovascular diseases include cerebrovascular diseases, coronary artery disease, angina, myocardial infarction, congestive heart failure, and peripheral vascular disease. [3]≥1 cigarette/day at the first visit or any time during the review period. [4]normal consumption considered as two units/day for women and three units/day for men, excessive consumption considered as more than two units/day for women and more than three units/day for men. [5]unable to use insulin treatment, no insulin therapy.

Table S3. Recommended preventive care and aggregate score in the Corif study (2005-2006), by obesity status.

	Obese patients (N = 288)			Non-obese patients (N = 471)			p value
	Eligible patients (N)	Care provided[1] (N)	Care provided % (95% CI)	Eligible patients (N)	Care provided[1] (N)	Care provided % (95% CI)	
Physical examination							
Annual blood pressure measurement	288	281	97.6 (95.1 - 99.0)	471	442	97.6 (95.1 - 99.0)	0.99
Weight measurement	288	287	99.7 (98.1 - 100.0)	471	471	100 (99.2 - 100.0)	**<0.001**
Height measurement	288	284	98.6 (96.5 - 99.6)	471	465	98.7 (97.2 - 99.5)	0.99
Alcohol consumption counseling							
Asked about drinking problem	288	205	71.2 (65.6 - 76.3)	471	368	78.1 (74.1 - 81.8)	**0.03**
Smoking cessation counseling							
Smoking status documented	288	239	83.0 (78.1 - 87.1)	471	407	86.4 (83.0 - 89.4)	0.27
Annual advice to quit smoking	65	50	76.9 (64.8 - 86.5)	113	79	70.0 (60.6 - 78.2)	0.30
Counseling offered to smokers attempting to quit	23	13	56.5 (34.5 - 76.8)	39	31	79.5 (63.5 - 90.7)	0.08
Pharmacotherapy offered to smokers attempting to quit if > 10 cigarettes/day	23	9	39.1 (19.7 - 61.5)	39	23	59.0 (42.1 - 74.4)	0.11
Abstinence documented 4 weeks after smoking cessation counseling	13	8	61.5 (31.6 - 86.1)	31	14	45.2 (27.3 - 64.0)	0.30
Cancer screening[2]							
Screening for colon cancer (aged 50 - 80)	282	89	31.6 (26.2 - 37.3)	462	174	37.7 (33.2 - 42.3)	0.10
Screening for breast cancer (aged 50 - 70)	125	45	36.0 (27.6 - 45.1)	128	54	42.2 (33.5 - 51.2)	0.33
Influenza immunization[3]							
Annual influenza vaccine for patients ≥ 65 years	96	37	38.5 (28.8 - 49.0)	209	70	33.5 (27.1 - 40.3)	0.31
Annual influenza vaccine for immunocompromised patients <65 years	99	27	27.3 (18.8 - 37.1)	108	29	26.9 (18.8 - 36.2)	0.99
Global aggregate score for preventive care			**73.0 (71.1 - 74.8)**			**75.3 (73.8 - 76.7)**	**0.08**

[1]when care was refused by eligible patients, it was considered as provided care and when care was provided less frequently than recommended, it was considered as unprovided. [2]if patients had a prior diagnostic of colon or breast cancer, they were excluded from screening. [3]recommendations for influenza vaccination for < 65 years: living in a nursing home, chronic cardiovascular disease, chronic obstructive pulmonary disease, renal failure, diabetes, immunosuppression, hemoglobinopathy.
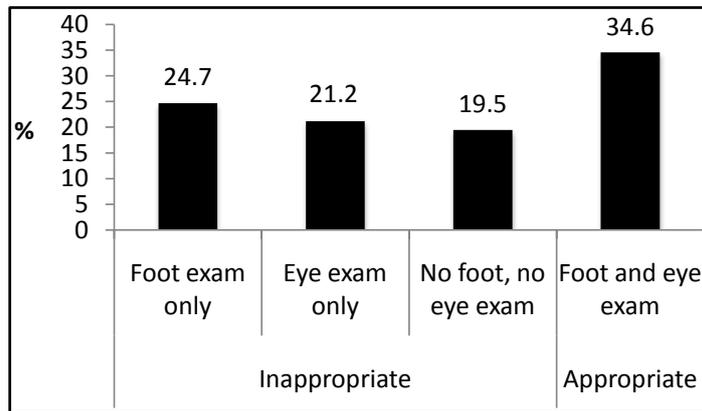
Figure S1. Prevention of angiopathic complications in 292 patients with diabetes included in the Corif Study (2005-2006).
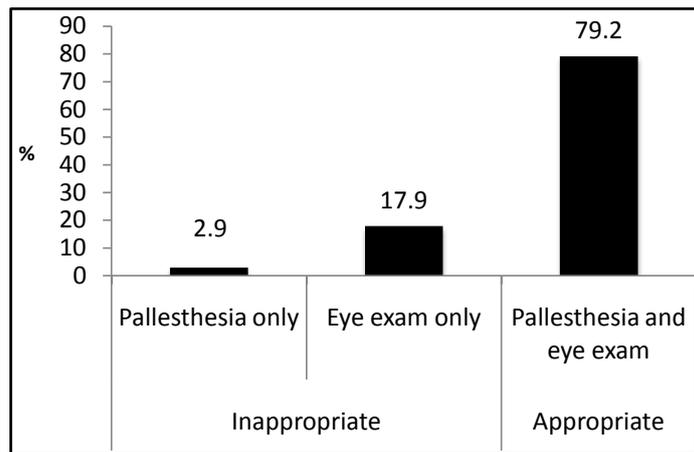
Figure S2. Details of foot exam in 173 patients with diabetes with appropriate annual foot exam included in the Corif Study (2005-2006).