Diabetes Mellitus Among HIV-infected Adults in Care in the United States, Medical Monitoring Project, 2009-2010

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BACKGROUND

- Non-AIDS related co-morbidities, such as diabetes mellitus (DM), have gained importance among the HIV-infected population [1,2]
- Representative population-based estimates of DM prevalence among HIV-infected individuals in the United States are lacking
- Whether HIV-infected individuals are at higher risk of DM remains controversial [3]

OBJECTIVES

- **Estimate the prevalence of DM among HIV-infected adults receiving medical care in the United States**
- **Compare the prevalence of DM between HIV-infected adults and adults in the general U.S. population**
- **Identify factors independently associated with prevalent DM among HIV-infected adults**

METHODS

Data sources and population:

- **Medical Monitoring Project (MMP) 2009-2010**: National surveillance system with a multistage probability design monitoring clinical outcomes and behavioral characteristics of U.S. HIV-infected persons receiving medical care through interview and medical record abstraction in 23 health department jurisdictions (Figure 1)
- **National Health and Nutrition Examination Survey (NHANES) 2009-2010:** Nationally representative survey of resident civilian non-institutionalized U.S. population assessing the health and nutritional status of adults and children through a combination of interviews and physical examinations
- **Population:** Adults aged ≥ 20 years of age

Definitions of DM prevalence:

- **Diagnosed:** Diagnosis of DM (excluding gestational diabetes) or prescription of DM medications (excluding metformin monotherapy) in an individual's medical record (MMP); self-reported diagnosis or prescription of DM medications by participants (NHANES)
- **Undiagnosed:** fasting blood glucose ≥126 mg/dl or hemoglobin A1c ≥6.5% in the absence of criteria for diagnosed DM
- **Total:** diagnosed + undiagnosed DM

Statistical analysis:

- Calculated prevalence and 95% confidence intervals [CI] of **diagnosed**, **undiagnosed**, and **total DM**
- Pooled MMP and NHANES data to estimate the adjusted prevalence of **diagnosed DM** in HIV infected adults receiving medical care compared to the general U.S. population using predicted marginal probabilities and adjusted prevalence ratios in multivariable logistic regression
- Used multivariable logistic regression to identify factors independently associated with **total DM** among HIV-infected adults receiving medical care
- All analyses accounted for state/territory, facility, and patient selection probabilities, and were adjusted for survey non-response

Figure 1. Participating areas in the Medical Monitoring Project, 2009—2010



RESULTS

Table 1. Prevalence of diagnosed, undiagnosed, and total diabetes among MMP and NHANES participants 2009-2010

	MMP (n=8,637)		NHANES (n=5,601)	
	sample n	weighted prevalence [CI]	sample n	weighted prevalence [CI]
Diagnosed DM	874	10.3 [9.2-11.5]	652	8.3 [7.2-9.4]
Undiagnosed DM*				
FBG≥126 mg/dl or HbA_{1c}≥6.5%	348	4.4 [3.4-5.7]	118	4.4 [3.4-5.7]
FBG≥126 mg/dl only	295	3.6 [2.6-5.0]	103	3.9 [3.0-5.2]
HbA_{1c}≥6.5% only	66	1.0 [0.7-1.3]	68	2.3 [1.6-3.3]
FBG≥126 mg/dl and HbA_{1c}≥6.5%	13	0.2 [0.1-0.3]	53	1.8 [1.2-2.7]
Total prevalence				
Diagnosed or, FBG≥126 mg/dl or HbA_{1c}≥6.5%	1,222	14.2 [12.8-15.7]	397	12.2 [10.2-14.4]
Diagnosed or, FBG≥126 mg/dl and HbA_{1c}≥6.5%	887	10.4 [9.4-11.6]	332	9.8 [8.5-11.4]

CI = confidence interval; FBG = fasting blood glucose; HbA_{1c} = hemoglobin A_{1c}
*Prevalence of undiagnosed diabetes among NHANES participants was only calculated for the fasting subsample (n=3,185).

Table 2. Predicted marginal prevalence and prevalence comparisons of diagnosed DM among MMP and NHANES participants 2009-2010

	MMP Adjusted prevalence [CI]	NHANES Adjusted prevalence [CI]	aPR [CI]*	P-value
Total	11.6 [10.1 - 13.4]	8.2 [7.2 - 9.3]	1.42 [1.18 - 1.70]	0.0005
Sex at birth				
Male	11.2 [9.9 - 12.6]	9.1 [7.5 - 10.9]	1.24 [1.00 - 1.53]	0.045
Female	12.0 [9.9 - 14.5]	7.4 [6.5 - 8.5]	1.61 [1.28 - 2.03]	0.0003
Race/ethnicity				
White (non-Hispanic)	10.9 [9.2 - 13.0]	6.6 [5.4 - 8.1]	1.65 [1.27 - 2.15]	0.0002
Black (non-Hispanic)	13.1 [11.3 - 15.1]	11.9 [9.7 - 14.5]	1.10 [0.87 - 1.40]	0.4
Hispanic	13.3 [11.0 - 16.0]	11.4 [9.5 - 13.7]	1.17 [0.90 - 1.51]	0.2
Other	13.3 [9.9 - 17.6]	14.6 [11.2 - 18.8]	0.91 [0.62 - 1.33]	0.6
Age in years				
20-44	6.2 [5.1 - 7.4]	2.3 [1.7 - 3.1]	2.70 [1.90 - 3.83]	<0.0001
45-60	13.0 [11.2 - 15.0]	9.5 [7.7 - 11.7]	1.37 [1.06 - 1.76]	0.01
≥ 60	21.5 [18.1 - 25.4]	19.7 [17.0 - 22.7]	1.09 [0.88 - 1.36]	0.4
Education				
Less than high school	12.4 [9.8 - 15.5]	11.0 [9.6 - 12.6]	1.12 [0.86 - 1.47]	0.4
High School or equivalent	11.1 [9.0 - 13.5]	6.6 [5.3 - 8.0]	1.69 [1.25 - 2.27]	0.001
More than high school	11.6 [10.0 - 13.4]	7.9 [6.6 - 9.3]	1.48 [1.19 - 1.83]	0.0004
Living at or below poverty line†				
No	11.6 [10.0 - 13.4]	8.2 [7.3 - 9.2]	1.41 [1.17 - 1.70]	0.0006
Yes	11.5 [9.6 - 13.8]	7.9 [5.6 - 11.0]	1.46 [1.01 - 2.12]	0.03
Obesity (BMI ≥30 kg/m²)				
No	7.7 [6.2 - 9.6]	4.5 [3.6 - 5.5]	1.72 [1.27 - 2.35]	0.001
Yes	17.9 [15.8 - 20.1]	14.0 [12.2 - 15.9]	1.28 [1.08 - 1.52]	0.005

CI = confidence interval; aPR = adjusted prevalence ratio; BMI = body mass index
*Prevalence ratio using NHANES as the referent category
†Calculated using the ratio of annual household income to number of people in the household

Figure 2. Adjusted prevalence of total DM by selected characteristics among HIV-infected adults receiving care in the United States, 2009-2010

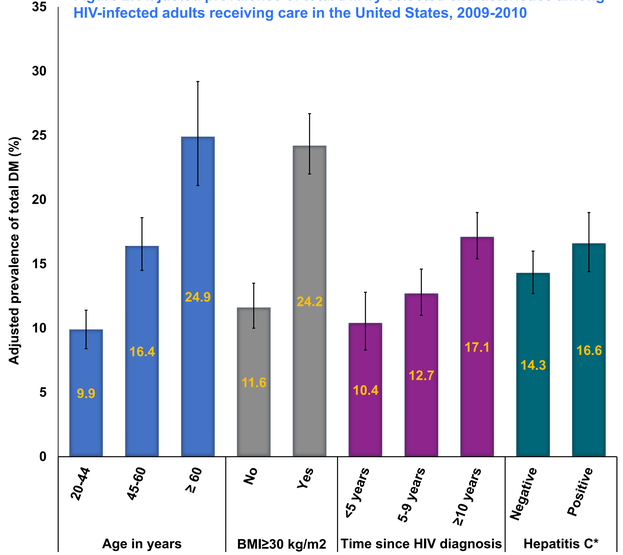

Table 3. Factors associated with total DM among MMP participants 2009--2010

Characteristics	aPR [CI]
Age in years	
20-44	ref.
45-60	1.67 [1.45-1.91]‡
≥ 60	2.53 [2.05-3.14]‡
Obesity (BMI ≥30 kg/m²)	
No	ref.
Yes	2.08 [1.79-2.43]‡
Time since HIV diagnosis	
Less than 5 years	ref.
5-9 years	1.23 [0.98-1.52]
10 or more years	1.65 [1.38-1.99]‡
Hepatitis C*	
Positive	1.16 [1.02-1.33]†
Negative	ref.

aPR = adjusted prevalence ratio; CI = 95% confidence interval; BMI = body mass index
*A total of n=7158 were screened for Hepatitis C (HCV) in our sample. HCV positivity was defined as having a documented positive Anti-HCV EIA/RIBA, HCV genotype, or HCV RNA PCR.
†P<0.05; ‡P<0.0001

SUMMARY

- Prevalence of DM among HIV-infected adults receiving medical care in the U.S. ranged from 10-14% depending on criteria
- After adjusting for sex, race/ethnicity, age, education, poverty, and body mass index, the prevalence of DM among HIV-infected adults receiving medical care was 1.4 times that of adults in the general U.S. population.
- Differences in DM prevalence were highest among individuals aged 20-44 years (aPR=2.7) and non-obese individuals (aPR=1.72), and important differences were observed among non-Hispanic Whites (aPR=1.65) and women (aPR=1.61)
- Factors associated with diabetes among HIV-infected adults included: older age, obesity, longer duration of HIV infection, and hepatitis C coinfection

LIMITATIONS

- Unable to ascertain whether FBG measurements were truly fasting, which limited our comparisons to the general population
- No assessment of cumulative ART exposure
- Other known risk factors for diabetes mellitus, such as family history/genetics, diet, and exercise were not included in our analysis and could explain some of the excess prevalence observed among HIV-infected adults
- MMP data are only representative of HIV-infected adults receiving medical and cannot be generalized to HIV-infected adults not diagnosed or not receiving medical care

CONCLUSIONS

- In the United States, one in seven HIV-infected adults has diagnosed or undiagnosed DM
- Compared to the general U.S. population aged 20-44 years, same-aged HIV-infected adults are almost three times as likely to have DM
- Obesity is a major risk factor for DM among HIV-infected adults
- DM may be present at an earlier age in the context of HIV-infection and in the absence of traditional risk factors
- Healthcare providers should implement recommended screening for DM to promote early interventions, including lifestyle modifications for individuals with and at higher risk for DM
- Further research is important to determine the best diabetes management and control strategies for HIV-infected adults

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