Is exposure to family member incarceration during childhood linked to diabetes in adulthood? Findings from a representative community sample

Bradley A White1, Keri J West2 and Esme Fuller-Thomson2,3,4

Abstract
Objectives: Diabetes is a prevalent and serious public health problem, particularly among older adults. A robust literature has shown that adverse childhood experiences contribute to the development of health problems in later life, including diabetes. Family member incarceration during childhood is an under-investigated yet increasingly common adverse childhood experience in the United States. The purpose of this study was to investigate the relationship between family member incarceration during childhood and diabetes in adulthood, while considering the role of gender as well as the impact of a range of potential confounds.

Methods: A large representative community sample of adults aged 40 and older (n = 8790 men, 14,255 women) was drawn from the Behavioral Risk Factor Surveillance System 2012 optional adverse childhood experiences module to investigate the association between family member incarceration during childhood and diabetes. For each gender, nine logistic regression analyses were conducted using distinct clusters of variables (e.g. socioeconomic status and health behaviors).

Results: Among males, the odds of diabetes among those exposed to family member incarceration during childhood ranged from 2.00 to 1.59. In the fully adjusted model, they had elevated odds of 1.64 (95% confidence interval = 1.27, 2.11). Among women, the odds of diabetes was much lower, hovering around 1.00.

Conclusion: Findings suggest that family member incarceration during childhood is associated with diabetes in men, even after adjusting for a wide range of potential risk factors (e.g. sociodemographics, health behaviors, healthcare access, and childhood risk factors). Future research should explore the mechanisms linking family member incarceration during childhood and long-term negative health outcomes in men.

Keywords
Diabetes, endocrinology, risk factors, gender, adverse childhood experiences, incarceration

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Introduction
Diabetes mellitus is an increasingly common and serious public health problem, particularly among older adults. Approximately one-quarter of American adults over age 65 have diabetes and almost half have prediabetes.1 Diabetes is a chronic disease associated with inflammation and metabolic dysfunction and is characterized by chronic hyperglycemia (high blood sugar) secondary to impaired insulin production, secretion, and/or sensitivity.2 There are two predominant persistent types of diabetes. Type 1 is far less prevalent, typically develops in childhood or adolescence, and is

1Center for Youth Development and Intervention, The University of Alabama, Tuscaloosa, AL, USA
2Factor-Inwentash Faculty of Social Work, University of Toronto, Toronto, ON, Canada
3Institute for Life Course and Aging, University of Toronto, Toronto, ON, Canada
4Department of Family and Community Medicine, University of Toronto, Toronto, ON, Canada

Corresponding author:
Bradley A White, Center for Youth Development and Intervention, The University of Alabama, Box 870348, Tuscaloosa, AL 35487-0348, USA.
Email: whiteba@ua.edu
an idiopathic autoimmune disorder wherein pancreatic beta
cells, which produce insulin, are destroyed by one’s own
immune system. The vast majority (approximately 95%) of
all cases of diabetes are type 2, which typically onset in mid
to late life and involves a combination of hepatic or periph-
eral insulin resistance and beta cell dysfunction, contributing
to an inability to suppress glucose production, inadequate
glucose uptake, and relative insulin deficiency.

Diabetes is among the leading causes of death for those over
age 65 and projections suggest the prevalence of diabetes in the
United States will at least double over the next three decades,
with up to one-third of citizens diagnosed with the disease by
2050. Diabetes also represents a substantial economic burden.
In 2012, in the United States, the estimated combined direct and
indirect costs associated with diagnosed diabetes was approxi-
mately US$245 billion annually, which fails to account for the
less tangible yet substantial psychosocial burden, including
effects on patients’ quality of life and impacts on loved ones.

Given the magnitude of this problem and significant impacts on
mortality and morbidity, further research to better understand
etiological risk factors for diabetes is warranted.

Whereas sociodemographic, familial, and proximal life-
style and physical health risk factors for diabetes have been
identified (e.g. being older, obese, sedentary, or of a non-Euro-
pean American race or ethnicity increases risk of type 2), far
less is known about distal influences. However, over the past
two decades, a body of literature has demonstrated that adverse
childhood experiences (ACEs) including neglect, abuse, and
household difficulties not only disrupt a child’s experience of
stability, safety, and nurturance, but also contribute to the
development of various health problems in adulthood. While
there has been limited empirical investigation of the
relationship between early adversities and diabetes, a recent
systematic review and meta-analysis of seven studies totaling
over 87,000 participants found that exposure to certain
ACEs—specifically, physical and sexual abuse, neglect, and
wartime evacuation and separation from parents—increased
the risk of developing diabetes later in life by 32% on average,
with neglect having the strongest impact and physical abuse
the lowest among these ACEs.

Exposure to the incarceration of a family member during
one’s childhood is an under-investigated yet increasingly
common ACE for children in the United States. The preva-
ience of incarceration has dramatically increased in recent
decades, and many state and federal inmates are parents of
youth under the age of 18. Although the experience of fam-
ily member incarceration during childhood (FMIC) may
have beneficial aspects in terms of reducing child exposure
to parental criminal activity and associated risks, the impact
of incarceration itself is disruptive to family stability, includ-
ing marriages, jobs, and housing. Improving the under-
standing of the long-term biopsychosocial and physical
health impacts of FMIC can help inform clinical approaches
to assessment and intervention with FMIC-exposed individ-
uals, as well as criminal justice reform.

A growing literature supports the link between FMIC and
both psychosocial and physical health outcomes. Recent
investigations suggest that FMIC predicts a variety of health
concerns related to inflammation, such as asthma, elevated
cholesterol, and myocardial infarction. Early adverse experiences may influence later life health
outcomes via interwoven biopsychosocial processes that
unfold over the course of development. Because “health is
not a state but a lifetime achievement,” the life-course
approach is a useful theoretical framework for understanding
pathophysiology, particularly for diseases with multiple etio-
logical influences that interact over the course of develop-
ment. The life-course model helps to identify exposures at
critical developmental stages that may elevate disease risk in
later life and informs early intervention efforts and the devel-
opment of policies that can improve health trajectories.

Current theories of biological impacts of stressors support
the expectation that ACEs would increase the risk of diabetes
in later life. In particular, Hertzman’s theory of biological
embedding proposes that early adversities can disrupt the
development of systems involved in stress and inflammation
response (e.g. the hypothalamus–pituitary–adrenal axis),
chronically altering the individual’s metabolic and inflam-
matory responses to stressors (e.g. as indexed by elevated
C-reactive protein), which can in turn lead to organ system
dysfunction and pathology. While the etiology of diabetes
is not fully elucidated, emerging literature implicates the
contribution of inflammatory processes in insulin resistance
and metabolic dysfunction. Further supporting this per-
spective, ACEs have been shown to be associated with dys-
regulated stress responsivity in adulthood, including elevated
inflammation, which in turn appears to contribute to the
development of metabolic disorders, including diabetes.

Furthermore, oxidative stress, defined as an imbalance
between the production of free radicals (reactive oxygen spe-
cies) by subcellular components (e.g. mitochondria) and
their neutralization by antioxidants, is similarly associated
with both early adversity and with the pathogenesis of type 2
diabetes.

Despite the prevalence of incarceration in the United
States, few studies on ACEs have considered the experience
of FMIC as a potential risk factor for physical health prob-
lems in later life. For instance, the aforementioned system-
atic review of ACEs and diabetes did not report on any
studies examining FMIC. Furthermore, much of the exist-
ing research on the role of ACEs in diabetes is based on clini-
cal samples and does not control for a number of potentially
confounding variables. One recent study on health effects
of parental incarceration in young adults (mean age
28.8 years; n = 15,701) did consider diabetes. Parental
incarceration was common in this sample (12.5%), predomi-
nantly of fathers (85%). However, no association was
observed between parental incarceration and diabetes, per-
haps because diabetes prevalence was quite low (2.6%),
although parental incarceration was associated with other
more prevalent physical health effects (e.g. elevated cholesterol, asthma, migraines).  

There is growing evidence that ACEs may differentially impact long-term health outcomes based on gender, with impacts being stronger for men.  

Men appear to be especially vulnerable to biological embedding of early adversities and they exhibit more cortisol reactivity to stress than do women. In addition, studies suggest that stress is associated with a reduction in testosterone levels in men and that the cortisol-to-testosterone ratio is associated with insulin resistance syndrome. Furthermore, men are incarcerated in the United States at much higher rates than women, and the majority of these men have children under age 18. Incarceration interferes with the ability of fathers to maintain contact with children, and loss of contact with fathers may be particularly impactful on their sons, interfering with emotion regulation and ability to cope with daily stressors into adulthood. Men who experienced paternal absence in childhood tend to have elevated cortisol levels, in contrast to women who experienced paternal absence. Finally, girls and women are more likely to pursue psychosocial support following adversities than are boys and men.

**Objectives**

Based on the conceptual and empirical foundations discussed above, the purpose of this study was to investigate the relationship between FMIC and diabetes in adulthood using a representative community sample of adults, while considering the role of gender as well as the impact of various potential confounds, detailed below, on these relationships. Our goal was to test two hypotheses: (1) FMIC will be associated with diabetes even after controlling for many of the known diabetes risk factors and (2) the FMIC–diabetes relationship will be stronger for men than for women.

**Diabetes risk factors**

Younger adults are more likely to experience FMIC as a result of growing rates of incarceration in the last 40 years. Also, African Americans and Hispanics experience more FMIC exposure than non-Hispanic Whites. Gender, race, and age are all related to diabetes risk. Men have a higher prevalence of type 2 diabetes than women, and the prevalence of diabetes tends to peak among individuals aged 65 and older. Those from historically underrepresented and underserved racial and ethnic groups experience diabetes at greater prevalence compared to non-Hispanic Whites, with the highest risk reported among Aboriginal people. FMIC is associated with lower levels of education and lower average household income in adulthood. There is likewise an association between lower socioeconomic status (SES) and type 2 diabetes prevalence. The same relationship exists for educational attainment and risk of type 2 diabetes.

FMIC has been linked to high levels of cigarette smoking in adulthood, and smoking increases the risk of developing diabetes. Some research supports a link between FMIC exposure and obesity as well as lower physical activity, although other research has not observed such associations. Obesity is known to contribute to type 2 diabetes development. Sedentary lifestyle is also associated with diabetes, independent of obesity. FMIC predicts early adulthood depression. Research has shown a bidirectional association between diabetes and depression.

Children exposed to FMIC experience other difficult circumstances at home, some of which are directly or indirectly related to the incarceration of a family member. Problems with impulse control, substance use problems, and domestic violence are more common among men who ultimately are incarcerated, and incarceration itself can also lead to the development of substance use disorders and depression. Parental depression appears to be inversely associated with diabetes-related outcomes in adulthood. For instance, living with a depressed mother or father is associated with having a lower body mass index (BMI) in middle adulthood. Paternal depression is likewise associated with better glucose control, as indicated by lower glycosylated hemoglobin levels. To our knowledge, no prior studies have looked specifically at the relationship between parental substance abuse and diabetes risk in adulthood. However, exposure to parental alcoholism has been linked to adult obesity. Additionally, witnessing parental domestic violence increases the likelihood of being diagnosed with diabetes and obesity in adulthood.

Marriage can provide socioemotional support with physical health benefits, particularly for men. However, to our knowledge, the relationship between marital status and FMIC has not previously been the focus of empirical investigation, thus it is unclear what role FMIC may play in marriage. A large prospective study reported increased risk of type 2 diabetes onset among widowed men compared with married men. Neither divorced/separated men nor never married men had an elevated risk of incident type 2 diabetes compared with married men. Widowhood has similarly been shown to be predictive of diabetes status in cross-sectional Australian cohorts. In contrast, other prospective research has not found marital status to predict diabetes among obese men and women.

Those who are exposed to FMIC likely experience reduced access to a primary doctor or health insurance because FMIC has deleterious socioeconomic effects on the family. The relationship between medical care access and diabetes may be multifaceted. Previous research has suggested that adults with diabetes have higher rates of health insurance coverage compared to those without diabetes. However, nationally representative research suggests that an estimated 16% of US adults with known diabetes are uninsured. Lack of insurance coverage is associated with under-diagnosis of diabetes and poorer diabetes management.
Methods

Data source and sample

As has been described elsewhere, we used data derived from a large representative data set of the CDC’s Behavioral Risk Factor Surveillance System (BRFSS) to test our hypotheses. Computer-assisted telephone interviews were used to collect data over the phone from a large, representative sample of non-institutionalized adults living in households using telephone landlines and cellular phones across all 50 states, the District of Columbia, and three US territories.

Secondary data analysis of the 2012 optional ACE module was used for this study. The module, adapted from the original CDC-Kaiser ACE study, was answered by respondents aged 18 and older in five states (response rates): Iowa (56.8%), Tennessee (45.4%), North Carolina (40.4%), Oklahoma (47.8%), and Wisconsin (50.4%). To focus on adulthood risk, data for BRFSS participants aged 40 and older were included. Those with missing data on any of the variables in the analysis were excluded (6.9% missing for men; 6.4% missing for women).

Measures

FMIC exposure. Respondents with a positive history of FMIC before the age of 18 were identified through a response of “once” or “more than once” to the following question: “Did you live with anyone who served time or was sentenced to serve time in a prison, jail, or other correctional facility?” Individuals reporting “never” or “don’t know/not sure” to the latter question were categorized as not experiencing FMIC.

Outcome. A history of diabetes was determined by a “yes” response to a question of whether “a doctor, nurse, or other health professional had ever told you had diabetes?” We only counted self-reported diabetes diagnosis. Respondents who reported prediabetes, borderline, or gestational diabetes were coded as “no.”

Control variables. Several demographic characteristics were assessed, including age (categorized as 40–64, 65–79, and 80+ years), gender, and race (dichotomized as non-Hispanic White, vs non-White or Hispanic). Education and household income were used to characterize adult SES. Education was assessed based on the following categories: did not graduate high school, graduated high school, attended college or technical school, and graduated from college or technical school. Household income, reported in 2012 dollars, was categorized as less than US$15,000, US$15,000–25,000, US$25,000–50,000, US$50,000–75,000, and above US$75,000.

Childhood risk factors were based on participants’ responses to questions regarding experiences before the age of 18, including parental substance abuse (endorsement of “Did you live with anyone who was a problem drinker or alcoholic?”) and/or “Did you live with anyone who used illegal street drugs or who abused prescription medications?”), mentally ill family member (“Did you live with anyone who was depressed, mentally ill, or suicidal?”), exposure to domestic violence (“How often did your parents or adults in your home ever slap, hit, kick, punch, or beat each other up?” dichotomized as never vs once or more), physical abuse (“How often did a parent or adult in your home ever hit, beat, kick, or physically hurt you in any way (excluding spanking)?” dichotomized as ever vs never), sexual abuse (“How often did anyone at least 5 years older than you or an adult, ever touch you sexually?” dichotomized as ever vs never), and verbal abuse (“How often did a parent or adult in your home ever swear at you, insult you, or put you down?” dichotomized as one time or less vs two times or more).

The health risk behaviors controlled in this study were BMI, smoking status, and physical activity level. Self-reported weight in kilograms (kg) was divided by self-reported height in squared meters (m²) to define BMI, which was then categorized into ranges defining normal weight (BMI <25 kg/m²), overweight (BMI = 25–29.99 kg/m²), and obese (BMI = 30 kg/m² or higher). Respondents who endorsed smoking at least 100 cigarettes in their entire life were classified as smokers and those who smoked less than 100 were classified as non-smokers. Physical activity was dichotomized as having, in the past month, exercised outside of work or not.

Marital status was categorized as being either married or common-law versus being single, divorced, separated, or never married. Depression history was dichotomized based on participant response to the question of whether one had ever been told by a doctor, nurse, or other health professional that he or she had a depressive disorder, including depression, minor depression, dysthymia, or major depression. Finally, healthcare access was measured based on responses to two items: whether or not the respondent had current healthcare coverage insurance, including prepaid or government plans, and how many persons they think of as their “personal doctor or health care provider” (zero vs one or more).

Statistical analyses

The purpose of the analyses was to determine the odds of diabetes for individuals who reported FMIC. Of particular interest was the degree to which potential confounds might attenuate the relationship between FMIC exposure and diabetes. Logistic regression analyses were conducted separately for men and women, with FMIC as the focal exposure and diabetes as the outcome. We applied a weighting variable that was constructed by the CDC to correct for non-response and likelihood of selection in order for the sample to be representative of community dwellers in each of the five states. This weighting variable was then rescaled to a mean of 1 for the subsample, which is the standardized technique of normalizing weights so as to avoid falsely narrowing the confidence intervals (CIs).
Each model included age and race as well as FMIC. The first model included only age and race. The second model also adjusted for childhood risk factors, the third for health behaviors, the fourth for adult SES, the fifth for depression, the sixth for marital status, the seventh for healthcare access, the eighth for state of residency, and the final model fully adjusted for all the aforementioned variables.

We conducted a sensitivity analysis to determine if the odds of diabetes among those with FMIC varied if we included prediabetes and borderline diabetes, and for women, gestational diabetes in the dependent variable. We found that the estimated odds ratios associated with FMIC were quite comparable. Among men, the odds of the more inclusive diabetes variable were slightly more elevated and remained statistically significant. For example, among men, when prediabetes and borderline diabetes were included in the outcome variable, the odds of diabetes among those with FMIC were 1.70 (95% CI = 1.33, 2.17). When those with prediabetes and borderline diabetes were excluded from the analysis, the odds of diabetes in the fully adjusted model (Model 9) among those with FMIC were 1.64 (95% CI = 1.27, 2.11).

Results

As shown in Table 1, 16.6% of men and 13.8% of women in the sample had diabetes. Among men, those with diabetes were much more likely to have had FMIC exposure than those without diabetes (7.9% vs 4.8%, p < 0.001). Among women, FMIC was not significantly associated with diabetes in the bivariate analysis (p = 0.075). For both women and men, the prevalence of FMIC was higher among younger respondents, Hispanic or non-White respondents, compared to non-Hispanic White, those with less than a high school education, those with lower income, and single/divorced/separated respondents. Those who had been exposed to adverse childhood events had a much higher prevalence of FMIC exposure as well and this was evident for all six forms of childhood adversities examined (i.e. parental substance abuse, parental mental illness, parental domestic violence, childhood physical abuse, childhood sexual abuse, childhood verbal abuse). Ever smokers, those with depressive disorders, and those who were without healthcare coverage or a personal doctor also had a higher prevalence of FMIC. Of the five states included in this analysis, the prevalence of FMIC was highest in Tennessee. Women who were obese and who did not exercise regularly also reported a higher prevalence of FMIC exposure, but these two factors were not statistically significant for men.

As shown in Figure 1, across nine different models, FMIC exposure was robustly associated with elevated odds of diabetes among men. These odds ranged from a low of 1.59 (for the model adjusting for adult SES) to a high of 2.00 (for the model adjusting for healthcare access). In the fully adjusted model that included all of the variables in the previous eight models, the odds of diabetes were 1.64 for those reporting FMIC (p < 0.001).

As shown in Figure 2, for women, the first eight logistic regression models hovered around 1, ranging from 0.99 to 1.27. In the fully adjusted model, which took into account 18 variables, the odds declined to 0.77.

Table 2 provides two logistic regression models for each gender: the first logistic regression adjusts for age and race only (Model 1 in Figures 1 and 2), and the second provides the fully adjusted model (Model 9 in Figures 1 and 2). Table 2 shows a large number of characteristics associated with diabetes in both men and women. These include older age, Hispanic or non-White ethnicity, lower income, lower levels of exercise, obesity, lifetime history of depression, and not having a personal healthcare professional. Once all the lifestyle and socioeconomic characteristics were taken into account concurrently in the fully adjusted logistic regression analyses, neither marital status, smoking history, nor the six childhood adversity variables (i.e. parental substance abuse, parental mental illness, parental domestic violence, childhood physical abuse, childhood sexual abuse, childhood verbal abuse) were statistically significant for men or women.

In comparison to respondents from Iowa, women from Oklahoma had higher odds of diabetes, and women from Wisconsin had lower odds. Among men, only respondents from Tennessee had significantly higher odds of diabetes than men from Iowa. The more detailed information on the association between FMIC and diabetes for each of the nine logistic regression analyses is provided in Figures 1 and 2.

Discussion

The current investigation sought to examine the impact of an increasingly common yet insufficiently examined early adverse experience, family member incarceration during one’s childhood (FMIC), on the development of diabetes mellitus, a prevalent, chronic disease in later life that is among the leading causes of mortality and is associated with inflammation and metabolic dysfunction. Based on a large data set with representative data from five states, and consistent with predictions, we found that the age-race adjusted odds of diabetes were higher for men exposed to FMIC compared to those who had not experienced that childhood adversity.

After adjustment for 18 risk factors that included age, ethnicity, childhood risk factors (i.e. physical abuse, sexual abuse, verbal abuse, parental substance abuse, parental mental illness, and parental domestic violence), as well as adult SES (i.e. income and education), health behaviors (i.e. physical activity, smoking, body mass), marital status, depression, and access to healthcare (i.e. health insurance, personal healthcare provider), the odds of diabetes among those exposed to FMIC in comparison to those not exposed to FMIC remained significantly high. This finding is consistent with the view of life-course and biological-embedding models that suggest exposure to early adversities at critical developmental stages disrupts the development of systems involved in stress and inflammation responses,15,18 including insulin...
Table 1. Unweighted sample sizes and weighted percentages of males and females in the adverse childhood experiences module of the 2012 BRFSS.

| Sample characteristics                      | Men (n = 8790) | p-value | Women (n = 14,255) | p-value |
|---------------------------------------------|---------------|---------|-------------------|---------|
| Diabetes                                    |               |         |                   |         |
| Yes (not borderline or gestational)         | 16.6          | 7.9     | 13.8              | 5.4     |
| No                                          | 83.4          | 4.8     | 86.2              | 4.5     |
| Demographics                                |               |         |                   |         |
| Age                                         |               |         |                   |         |
| 40–64 years                                 | 73.0          | 6.3     | 68.0              | 5.8     |
| 65–79 years                                 | 22.2          | 2.8     | 24.4              | 2.5     |
| 80+ years                                   | 4.9           | 1.6     | 7.5               | 1.7     |
| Race                                        |               |         |                   |         |
| Non-Hispanic White                          | 81.4          | 4.5     | 82.8              | 4.0     |
| Hispanic or non-White                       | 18.6          | 8.8     | 17.2              | 8.0     |
| Education                                   |               |         |                   |         |
| Less than high school                       | 15.0          | 12.8    | 12.8              | 8.9     |
| High school graduate                        | 30.8          | 4.2     | 32.0              | 4.5     |
| Some college or technical school            | 28.9          | 4.9     | 31.9              | 4.9     |
| College or technical school graduate        | 25.3          | 2.6     | 23.3              | 2.2     |
| Household income                            |               |         |                   |         |
| <US$15,000                                  | 8.5           | 12.7    | 9.6               | 9.0     |
| US$15,000–24,999                            | 14.4          | 8.4     | 16.5              | 7.8     |
| US$25,000–49,999                            | 25.3          | 5.2     | 23.5              | 4.6     |
| US$50,000–74,999                            | 15.8          | 4.2     | 13.9              | 3.7     |
| ≥US$75,000                                 | 26.3          | 2.2     | 20.3              | 2.4     |
| Do not know/refused/missing                 | 9.7           | 4.9     | 16.2              | 2.7     |
| Marital status                              |               |         |                   |         |
| Married/common-law                          | 70.1          | 4.2     | 60.7              | 3.5     |
| Single/divorced/separated                   | 29.9          | 7.9     | 39.3              | 6.5     |
| Adverse childhood events                    |               |         |                   |         |
| Parent abused drugs or alcohol              |               |         |                   |         |
| Yes                                         | 23.0          | 15.7    | 26.6              | 13.5    |
| No                                          | 77.0          | 2.2     | 73.4              | 1.4     |
| Lived with mentally ill household member in childhood | | | | |
| Yes                                         | 10.2          | 14.5    | 15.0              | 12.0    |
| No                                          | 89.8          | 4.2     | 85.0              | 3.3     |
| Parental domestic violence in childhood     |               |         |                   |         |
| Yes                                         | 15.5          | 14.3    | 16.2              | 14.1    |
| No                                          | 84.5          | 3.6     | 83.8              | 2.8     |
| Physical abuse                              |               |         |                   |         |
| Yes                                         | 13.4          | 14.5    | 13.5              | 12.9    |
| No                                          | 86.6          | 3.9     | 86.5              | 3.4     |
| Verbal abuse                                |               |         |                   |         |
| Yes                                         | 22.3          | 11.4    | 22.8              | 10.5    |
| No                                          | 77.7          | 3.6     | 77.2              | 2.9     |
| Sexual abuse                                |               |         |                   |         |
| Yes                                         | 1.9           | 17.4    | 5.4               | 23.5    |
| No                                          | 98.1          | 5.1     | 94.6              | 3.6     |
| Health                                      |               |         |                   |         |
| Smoking status                              |               |         |                   |         |
| Smoked ≥100 cigarettes                       | 57.7          | 6.7     | 43.8              | 7.1     |
| Never smoked 100 cigarettes                  | 42.3          | 3.3     | 56.2              | 2.8     |
| Exercised in the past month                 |               |         |                   |         |
| Yes                                         | 73.1          | 5.2     | 71.0              | 4.0     |
| No                                          | 26.9          | 5.6     | 29.0              | 6.2     |

(Continued)
Table 1. (Continued)

| Sample characteristics | Men (n = 8790) | p-value | Women (n = 14,255) | p-value |
|------------------------|---------------|---------|-------------------|---------|
|                        | Total % | % who had FMIC |                  | Total % | % who had FMIC |
| Body mass index category |        |                  |                  |        |                  |
| Not overweight/obese   | 21.0    | 4.9             |                  | 33.2    | 3.3             |
| Overweight             | 43.7    | 5.0             |                  | 30.0    | 4.1             |
| Obese                  | 34.5    | 5.9             |                  | 30.4    | 7.0             |
| Do not know/refused/missing | 0.8     | 5.8             |                  | 6.4     | 3.3             |
| Depressive disorder    | <0.001  |                  |                  | <0.001  |                  |
| Yes                    | 15.0    | 10.5            |                  | 22.0    | 8.0             |
| No                     | 85.0    | 4.4             |                  | 78.0    | 3.7             |
| Healthcare coverage    | <0.001  |                  |                  | <0.001  |                  |
| Yes                    | 88.3    | 4.5             |                  | 89.4    | 4.1             |
| No                     | 11.7    | 11.2            |                  | 10.6    | 8.9             |
| Has personal doctor    | <0.001  |                  |                  | <0.001  |                  |
| Yes                    | 84.3    | 4.7             |                  | 91.3    | 4.4             |
| No                     | 15.7    | 8.6             |                  | 8.7     | 7.8             |
| State of residency     | <0.001  |                  |                  | 0.001   |                  |
| Iowa                   | 11.2    | 4.0             |                  | 11.6    | 3.7             |
| North Carolina         | 37.2    | 4.7             |                  | 37.0    | 4.9             |
| Oklahoma               | 7.4     | 5.1             |                  | 7.2     | 4.5             |
| Tennessee              | 22.4    | 7.8             |                  | 22.5    | 5.7             |
| Wisconsin              | 21.8    | 4.3             |                  | 21.6    | 3.6             |

BRFSS: Behavioral Risk Factor Surveillance System; FMIC: family member incarceration during childhood.

Figure 1. Odds ratio and 95% confidence interval of diabetes among males reporting family member incarceration during childhood. All data are adjusted for age and race. Sample size n = 8790 in all models.

Resistance and metabolic dysfunction implicated in the etiology of diabetes.19,20

In contrast to men, the odds of diabetes for women hovered around 1.0 for all of the different analyses. An odds ratio of 1.0 indicates that those with FMIC have comparable odds of diabetes to those without. This observed gender difference fits prior evidence suggesting men may be more vulnerable biologically to early adversities than women.25,28 They may experience stress-related testosterone suppression, which is linked to insulin resistance.28 Furthermore, incarceration frequently interferes with fathers’ contact with children, which may particularly impact their sons’ coping with stress,29,31 and boys and men are less likely than girls and women to seek psychosocial support in response to adverse events.58

The findings of this study should be interpreted in light of several limitations. First, data are cross-sectional, thus we are unable to draw causal inferences regarding the relationship between FMIC and diabetes. We are not able to determine what aspects of FMIC-exposed households contribute to boys’ negative long-term health. Both our exposure (FMIC) and outcome (diabetes) variables were measured via self-report of exposure and diagnosis, respectively. Notably, prior research
supports the accuracy of self-report of diabetes, including high agreement with medical records.59 Although underreporting of FMIC should bias our finding toward the null, external validation of reporting via review of records, including the nature of the crime leading to incarceration, as well as its timing, duration, and frequency would be desirable.34

Due to limitations in the BRFSS database, we were unable to control for certain known diabetes risk factors, including diabetic family history, nutritional influences, or serum cholesterol level. With regard to sociodemographic factors, we unfortunately could not control for childhood SES or parental education, which are related to parental incarceration and higher diabetes risk.37,60 Notable disparities exist among racial and ethnic groups in US incarceration rates,33 and while we controlled for race, due to power limitations we unfortunately were not able to perform race-specific analyses. A further limitation of the BRFSS data is the absence of information regarding the relationship of the incarcerated family member to the respondent, the age at which the FMIC exposure occurred, as well as the duration of the incarceration. Finally, we did not have information on the gender-specific response rate for each state. It is possible that gendered variation in response rate and/or different response rates by state may have biased the results. Because the response rates may have varied by gender, state, ethnicity, diabetes, and so on, all findings must be interpreted with caution.

As an investigation into how a particular early adversity may impact later development of a serious health condition, this study also has some noteworthy strengths. It is, to our knowledge, the first study to examine the potential impact of FMIC exposure on diabetes with gender-specific analysis using representative data from disparate states. Our findings are consistent with recent evidence for an association between FMIC and myocardial infarction for sons but not for daughters and support the view that, as an ACE, FMIC is linked to important lasting physical health impacts in men.8 In contrast, among women, FMIC was not a major factor associated with diabetes in adulthood, potentially due to gender differences in psychosocial and biological responses to FMIC, in particular, disruption of contact from fathers, although these proposed mechanisms require further direct investigation.

**Conclusion and implications**

In this large representative community sample, we found an association between higher odds of diabetes among FMIC-exposed men compared to those without exposure to this form of early adversity. FMIC was not associated with diabetes in women. This research provides a helpful profile of those most susceptible which may be informative for future targeted outreach and intervention.

With regard to criminal justice policy, our findings suggest that the dramatic increase in recent decades of incarceration, particularly in the United States,11 may have detrimental long-term health effects for individuals exposed to FMIC persisting into later life. These impacts extend beyond previously identified effects on family stability and psychopathology13 and lend support to consideration of alternatives to current incarceration policies and practices, such as investment in diversion strategies to redirect individuals to community-based rehabilitative programs,61 facilitating family contact by placing incarcerated individuals in facilities close to their communities,62,63 and eliminating visitation policies that create excessive burden for family members, such as restrictive visitation hours and prohibitive fees for visitor background checks or for phone calls.64 Future research should examine the impacts of changing incarceration patterns, such as the growth of the US women’s prison population, on children’s long-term health.

These findings also have important implications for policies and practices aimed at reducing health inequities in vulnerable populations. With regard to clinical practice, our results suggest that early identification, assessment, and intervention with youth exposed to FMIC, particularly boys, may be beneficial. Given that FMIC appears to confer higher odds

**Figure 2.** Odds ratio and 95% confidence interval of diabetes among females reporting family member incarceration during childhood. All data are adjusted for age and race. Sample size n = 14,255 in all models.
Table 2. Gender-specific logistic regression models of diabetes among respondents reporting versus never reporting family member incarceration during childhood of the BRFSS 2012.

| Model | Men (n=8790) | Women (n=14,255) |
|-------|--------------|------------------|
|       | Age-race adjusted | Fully adjusted | Age-race adjusted | Fully adjusted | p-value | Age-race adjusted | Fully adjusted | p-value |
|       | OR (95% CI) | p-value | OR (95% CI) | p-value | OR (95% CI) | p-value | OR (95% CI) | p-value |
| Key variable of interest | | | | | | | | |
| FMIC | 1.85 (1.48–2.31) | <0.001 | 1.64 (1.27–2.11) | <0.001 | 1.27 (1.02–1.57) | 0.032 | 0.77 (0.61–0.99) | 0.039 |
| Control variables | | | | | | | | |
| Age | | | | | | | | |
| 40–64 | 1.00 (Ref.) | 1.00 (Ref.) | 1.00 (Ref.) | 1.00 (Ref.) | | | | |
| 65–79 | 2.27 (2.00–2.57) | 0.001 | 2.21 (1.91–2.55) | 0.001 | 2.06 (1.85–2.29) | 0.001 | 1.87 (1.66–2.12) | 0.001 |
| ≥80 | 1.88 (1.47–2.40) | <0.001 | 2.01 (1.53–2.63) | 0.001 | 1.83 (1.54–2.18) | 0.001 | 2.01 (1.65–2.46) | 0.001 |
| Race | | | | | | | | |
| Non-Hispanic White | 1.00 (Ref.) | 1.00 (Ref.) | 1.00 (Ref.) | 1.00 (Ref.) | | | | |
| Hispanic or non-White | 1.63 (1.42–1.87) | <0.001 | 1.47 (1.26–1.71) | <0.001 | 1.89 (1.68–2.12) | <0.001 | 1.44 (1.26–1.64) | <0.001 |
| Education | | | | | | | | |
| Below high school | 1.13 (0.90–1.41) | 0.298 | | | | | | |
| High school graduate | 1.04 (0.87–1.25) | 0.654 | | | | | | |
| Some college or technical school | 1.06 (0.89–1.27) | 0.530 | | | | | | |
| College or technical school graduate | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Household income | | | | | | | | |
| No or <US$15,000 | 2.14 (1.62–2.81) | <0.001 | | | | | | |
| US$15,000–25,000 | 2.39 (1.91–2.99) | <0.001 | | | | | | |
| US$25,000–50,000 | 1.45 (1.19–1.76) | <0.001 | | | | | | |
| US$50,000–75,000 | 1.41 (1.14–1.74) | 0.001 | | | | | | |
| ≥US$75,000 | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Missing data | 1.23 (0.95–1.58) | 0.118 | | | | | | |
| Childhood adversity | | | | | | | | |
| Physical abuse | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 0.90 (0.74–1.11) | 0.329 | | | | | | |
| Sexual abuse | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 0.85 (0.54–1.33) | 0.476 | | | | | | |
| Verbal abuse | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 1.14 (0.96–1.35) | 0.136 | | | | | | |
| Parental substance abuse | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 0.96 (0.81–1.13) | 0.607 | | | | | | |
| Lived with mentally ill | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 0.84 (0.68–1.05) | 0.126 | | | | | | |
| Domestic violence | | | | | | | | |
| No | 1.00 (Ref.) | 1.00 (Ref.) | | | | | | |
| Yes | 1.13 (0.93–1.36) | 0.219 | | | | | | |
| Adult health | | | | | | | | |
| Smoker | | | | | | | | |
| Never smoked 100 | 1.00 (Ref.) | | | | | | | |
| Smoked 100 or more | 0.91 (0.80–1.04) | 0.170 | | | | | | |

(Continued)
of diabetes and other chronic health conditions, screening for FMIC among adults presenting with diabetes may facilitate early detection and/or prevention of other adverse health outcomes. Furthermore, the development, implementation, and dissemination of empirically supported interventions designed to mitigate the health impacts of FMIC exposure among older adults should be investigated in future research.

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval
The University of Toronto Research Ethics Board waives the requirement to obtain an ethics approval for secondary analysis of publicly available deidentified data from large governmental agencies and institutions, such as Statistics Canada and the CDC. Because the Behavioral Risk Factor Surveillance System (BRFSS) data are publicly available and deidentified, and informed consent was obtained at the time of the original data collection of the BRFSS by the CDC, no ethical approval or written informed consent is required for this study.

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Informed consent
Informed consent was not sought for this study because the study was based on secondary analysis of publicly available deidentified data from large governmental agencies and institutions, such as Statistics Canada and the CDC. Because the Behavioral Risk Factor Surveillance System (BRFSS) data are publicly available and deidentified, and informed consent was obtained at the time of the original data collection of the BRFSS by the CDC, no ethical approval or written informed consent is required for this study.

Model

| Model                  | Men (n = 8790) |          | Women (n = 14,255) |          |
|------------------------|---------------|----------|--------------------|----------|
|                       | Age-race      | p-value  | Fully adjusted p-value | Age-race adjusted p-value |
|                       | OR (95% CI)   |          | OR (95% CI)        |          |
| Exercised in past month | Yes           | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | No            | 1.17 (1.02–1.33) | 0.135            | 1.36 (1.22–1.51) |
| Body mass index category | Not overweight or obese | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | Overweight    | 1.63 (1.34–1.98) | 0.001            | 2.11 (1.80–2.47) |
|                       | Obese         | 4.53 (3.75–5.48) | 0.001            | 5.17 (4.45–6.01) |
|                       | Missing/refused/etc. | 1.80 (0.87–3.76) | 0.115            | 3.10 (2.47–3.90) |
| Marital status        | Single/divorced/separated/never married | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | Married       | 0.90 (0.78–1.03) | 0.135            | 1.00 (0.89–1.13) |
| Depressive disorder   | No            | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | Yes           | 1.79 (1.52–2.11) | 0.001            | 1.46 (1.29–1.65) |
| Healthcare            | Healthcare coverage | Yes | 1.28 (1.01–1.62) | 0.044 |
|                       | No            | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | Number of healthcare professionals | 0 | 1.00 (Ref.) | 0.025 |
|                       | >= 1          | 3.06 (2.38–3.93) | 0.001            | 2.35 (1.86–2.98) |
| State of residence    | Iowa          | 1.00 (Ref.) | 0.025              | 1.00 (Ref.) |
|                       | North Carolina | 1.09 (0.88–1.34) | 0.446            | 1.13 (0.94–1.35) |
|                       | Oklahoma      | 1.41 (1.07–1.85) | 0.014            | 1.05 (0.83–1.35) |
|                       | Tennessee     | 1.15 (0.92–1.43) | 0.232            | 1.27 (1.06–1.54) |
|                       | Wisconsin     | 0.76 (0.60–0.96) | 0.021            | 0.94 (0.77–1.14) |
| –2 Log-likelihood     | 7695.1        | 0.041 | 0.178              | 0.034 |
| Nagelkerke R²         |               | 0.178 | 0.034              | 0.180 |

OR: odds ratio; CI: confidence interval; BRFSS: Behavioral Risk Factor Surveillance System; FMIC: family member incarceration during childhood.
data. Informed consent was obtained at the time of the original data collection of the Behavioral Risk Factor Surveillance System (BRFSS) by the CDC.

**ORCID iDs**
Bradley A White https://orcid.org/0000-0002-7477-9956
Keri J West https://orcid.org/0000-0003-3324-1102
Esme Fuller-Thomson https://orcid.org/0000-0002-9705-6216

**Supplemental material**
Supplemental material for this article is available online.

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