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Abstract

The relationship between gambling and health has important economic and public policy implications. We develop causal evidence about the relationship between recreational gambling and health using data from the Canadian Community Health Survey (CCHS) cycles 2.1, 3.1 and 4.1. Recreational gamblers are gamblers who are classified as "non-problem" gamblers according to the Canadian Problem Gambling Index (CPGI). Gambling is treated as an endogenous regressor in the health equations. The results of instrumental variable and bivariate probit models of participation in gambling and health outcomes indicate that recreational gambling has either no or a negative impact on the probability of having certain chronic conditions. These results differ from studies that find a positive association between problem gambling and adverse health outcomes. Exogeneity tests suggest that gambling is endogenous; hence, empirical methods that address endogeneity are necessary to develop causal evidence of a relationship between gambling and health.

1 Introduction

The relationship between gambling and health holds considerable interest for policy makers and economists. From a policy perspective, legal opportunities to gamble expanded significantly around the world in the past two decades. Because gambling generates both positive and negative impacts on society, decisions about the appropriate amount of legal gambling opportunities to make available depend on a thorough understanding of these effects. Positive impacts include increased government revenues, increased jobs in the gambling industry, increased revenues for charities that benefit from legal gambling, and increased entertainment opportunities for people who enjoy gambling, among others. Negative impacts include increased incidence of gambling addictions, gambling related consumer debt, crime and bankruptcies caused by gambling losses, increased regulatory and public safety costs attributable to gambling related problems, among others. In addition, participation in gambling may have health consequences, and, since the provision of health care is an important function of federal and provincial governments Canada, understanding how, and how much, gambling affects health can help policy makers determine the appropriate amount of legal gambling opportunities to provide.

From an economic perspective, participation in gambling is an interesting form of economic behavior. The decision to gamble is a complex decision involving uncertain outcomes, potentially important financial consequences, and consumption benefits from the participation in gambling markets and the resolution of uncertain outcomes. The decision to gamble may have health consequences, as uncertainty about gambling can cause stress, which has been linked to a number of adverse health outcomes. Gambling involves decisions made about uncertain outcomes, and the decision to gamble has been linked to the decision to purchase insurance in economic models of gambling since the seminal research on decision making under uncertainty by Friedman and Savage (1948). In addition, gambling and unhealthy behaviors like smoking and excessive drinking appear to be complementary activities, so the decision to gamble might involve negative externalities that affect health.

We develop evidence about the relationship between participation in gambling activities and health outcomes using data from the Canadian Community Health Survey (CCHS). Relatively little research about the effect of gambling on health currently exists, and much of the research that does exist focuses on the adverse health consequences of problem gambling. This focus on problem gambling and health is consistent with much of the existing gambling research, which devotes an inordinate amount of attention to identifying individuals who experience adverse consequences as a result of their participation in gambling, and to exploring the implications of their behavior, while little attention is paid to the behavior of gamblers who wager recreationally. This narrow focus on problem gamblers seems misplaced, since problem gambling rates appear to be very low in most populations. We begin to address this gap in the literature and examine the relationship between gambling and health for "recreational" gamblers. Since the vast majority of gamblers are "recreational gamblers" (we eschew the phrase "non-problem gamblers" since this term perpetuates the idea that problem gambling is the most important area in gambling research), understanding the relationship between recreational gambling and health provides information about the consequences of gambling in a large sub-population of gamblers that is understudied in the gambling literature.

A number of previous studies investigated the adverse health outcomes associated with disordered or pathologic gambling. These studies, based on bio-psychological and public health approaches, established clear associations between pathologic gambling and psychiatric comorbidities such as anxiety and depressive disorders (Petry et al. (2005); Cunningham-Williams et al. (1998)), alcohol and substance abuse (Gerstein et al. (1999); Welte et al. (2001)), and cigarette smoking (Cunningham-Williams et al. (1998); Petry and Oncken (2002)). These disorders are also associated with medical conditions and adverse health outcomes including hypertension, heart diseases, cirrhosis, diabetes and obesity (Cunningham-Williams et al. (1998); Petry et al. (2005); Gerstein et al. (1999); Welte et al. (2001)). Another set of studies examined the relationship between gambling and self-assessed quality of life (Pasternak and Fleming (1999); Black et al. (2003); Scherrer et al. (2005); Erickson et al. (2005); Pietrzak et al. (2005)). However, most of these studies fail to evaluate these relationships across classes of gamblers. No studies exist that investigate the relationship between recreational gambling and health outcomes, despite the fact that recreational gambling constitutes the majority of gambling behavior.

In order to inform policy decisions about the provision of gambling, and interventions aimed at preventing or reducing the health problems associated with gambling, an understanding of the causal effect of gambling on health is needed. Previous research demonstrates a correlative relationship between problem gambling and some adverse health outcomes, but a number of confounding factors exist, for example the incidence of other problems like substance abuse and mental health problems is extremely high among problem gamblers, making the identification of causal links between gambling and health important. We seek to establish a causal connection between gambling and health outcomes in this paper. We focus on five adverse health outcomes: diabetes, high blood pressure, heart disease, mood disorder and anxiety disorder. In order to establish causality, it is necessary that we account for endogeneity within the model. Two potential sources of endogeneity exist in this setting. First, low health status may be associated with gambling through reverse causality. For example, Nyman et al. (2008) suggest that low health status makes earning income through work more difficult and, thus, makes winning income through gambling more attractive.

As a result, low health status causes gambling. Second, an unobserved confounding variable may drive both gambling participation and low health status.

Given the structure of the data used in our empirical analysis, our models of gambling and health outcomes feature a dichotomous dependent variable (health outcome) and a potentially endogenous dichotomous regressor (participation in gambling). A number of alternative estimators have been used in health economics and health services research to address endogeneity that usually involve estimating some type of two part model. Because there is not a clear consensus in the econometrics literature regarding a strictly preferred approach and because this is one of the first studies to tackle the potential endogeneity of gambling, we compare the results obtained from several estimators. The baseline, or "naive" model is a single equation probit model in which gambling participation is treated as an exogenous covariate in an equation with a health outcome (for example, diabetes) as a dichotomous dependent variable. We then estimate two models that utilize a two stage, instrumental variables (IV) approach. The first IV approach is the commonly used two stage predictor substitution (2SPS) estimator in which a first stage gambling equation is estimated and the predicted values for gambling are obtained and substituted for the endogenous observed gambling variable in the second stage. The second IV approach is the two stage residual inclusion (2SRI) estimator in which the residuals from the first stage gambling equation are calculated. The residuals along with the actual observations for the endogenous gambling variable are included in the second stage (Terza et al. (2008)). Finally we specify a recursive bivariate probit model with a reduced form gambling equation and a structural health outcome equation. The maintained assumption is that the error terms of the two equations are correlated. The model is estimated using maximum likelihood with and without an exclusion restriction.

Our results contribute to the empirical literature on gambling and health in a couple of important ways. First, exogeneity tests based on the 2SRI and bivariate probit estimators suggest rejecting the hypothesis that gambling is exogenous in the health outcomes equations. Second, accounting for endogeneity with either the IV or bivariate probit approaches leads to different estimates of the magnitude of the impact of gambling on health. The single equation probit estimates indicate that recreational gamblers are more likely to report having high blood pressure, heart disease, mood disorder and anxiety disorder. The marginal effects are modest, ranging from 0.20 to 1.2 percentage points. On the other hand, the IV and bivariate probit model estimated with an exclusion restriction indicate that gambling has no impact on the probability of reporting having heart disease and a negative impact on the probabilities of reporting having diabetes, high blood pressure, mood disorder and anxiety disorder. Third, the magnitude of the marginal effects vary substantially depending upon which approach is taken to address the endogeneity. The bivariate probit model with an exclusion restriction generates substantially smaller marginal effects than either of the IV approaches. These differences in estimated marginal impacts of recreational gambling on adverse health outcomes warrant using caution in drawing strong policy implications from our results and additional research to determine why these difference exist and if they persist in other samples. Given that caveat, our results provide the first causal evidence that recreational gamblers enjoy some health benefits relative to non-gamblers. Untangling the mechanism that triggers this relationship is an important area of future research.

2 Theoretical Framework

Even purely empirical investigations (such as ours) must establish at least a potential theoretical link between gambling and health. The difficulty is that, from a theoretical perspective, gambling either could decrease or increase health. On the one hand, recreational gambling could represent the formative stage of a gambling habit. If so, some of the same negative health behaviors-increased smoking, increased exposure to second-hand smoke, increased drinking, lack of sleep, unhealthy eating-that are associated with pathological gambling could be present in recreational gamblers, but to a lesser degree than they will be eventually, and directly impact health as a result. Alternatively, the loss of money from recreational gambling may make life harder or more stressful, resulting in less income to spend on necessities, strained relationships and a resulting decline in health. The loss of money may also generate a regretful or self-deprecating attitude that is bad for general health.

On the other hand, a number of potentially positive pathways could exist. First, gambling appears to be more likely in those who are having trouble at work (Nyman et al. (2008)). For example, some people may be having trouble with their boss, or dislike their job, or experience physical pain in performing their duties at work. By representing a way out of these problem (albeit in an ill-advised and probably short-lived way out), gambling may relieve stress and thereby promote health. Second, as has been suggested by Conlisk (1993) and Simon (1998), gambling may have a consumption aspect, namely, the fun and relaxation, the social interactions, or the promotion of hopeful perspectives through thinking about a jackpot realized. This consumption value of gambling may have direct positive effects on the mental and emotion health of gamblers, and have spillovers to physical health. Third, the experience of gambling may periodically remind the gambler of the uncertainty of life and health, and thus promote a more realistic and accepting view of the ups and downs of living, generating an increase in health. In light of these alternative and opposing theoretical relationships, the effect of gambling on health must be investigated empirically.

3 Data Source and Description

We use data from the Canadian Community Health Survey (CCHS) cycles 2.1, 3.1 and 4.1. The CCHS is a cross-sectional, nationally representative survey containing data on health status, health care utilization and health determinants. The CCHS also contains detailed demographic and economic characteristics for the survey respondents and their households. The CCHS target population is all Canadians over the age of 12, excluding those living on First Nations reserves and in institutions and serving in the armed forces. Data are collected through a random digit dial telephone survey. Cycle 2.1 of the CCHS was conducted in 2003, Cycle 3.1 was conducted in 2005 and Cycle 4.1 was conducted in 2007.

One explanatory variable of interest in this study is participation in some form of gambling. The CCHS contains an optional module with questions about gambling that some provinces chose to administer. Our analysis sample contains data from provinces that administered the gambling module: Ontario and Saskatchewan in 2003; New Brunswick in 2005; and Quebec, Ontario and Saskatchewan in 2007. The sample contains 82,729 observations.

The CCHS asks detailed questions about gambling activities and experiences. A sample question is:

> *In the past 12 months, how often have bet or spent money on instant win/scratch tickets or daily lottery tickets (Keno, Pick 3, Encore, Banco, Extra)?*

The respondents then select a frequency category:

> *1=Daily; 2=Between 2 and 6 times a week; 3=About once a week; 4=Between 2 to 3 times a month; 5=About once a month; 6=Between 6 to 11 times a year; 7=Between 1 to 5 times a year; 8=Never; DK (do not know); R(refused).*

The next set of questions in the gambling module ask about attitudes and experiences with gambling and the extent to which gambling interferes with the respondents' lives. The responses to these questions are intended to measure characteristics of gamblers and are used to identify types of gamblers. The characteristics of the gamblers are based on a modified version of the Canadian Problem Gambling Index (CPGI). The CPGI is based on a 31-item measure that assigns all CCHS survey participants into one of five groups. The CPGI accounts for both behavioral problems associated with gambling, like financial problems feelings of guilt and inability to stop gambling, and correlates to gambling problems like alcohol and drug abuse. The CPGI is intended to reflect the likelihood that an individual has experienced adverse consequences as a result of gambling, and is similar to other measures of problem gambling behavior like the DSM criteria. Gamblers (called "non-problem gamblers" in the CPGI) report no behavioral problems associated with their gambling although they may gamble frequently, and "probably will not have experienced any adverse consequences of gambling." Low risk gamblers respond positively to at least one of the indicators of behavioral problems in the 31-item measure. Moderate risk gamblers respond affirmatively to more of the questions about adverse consequences of gambling, and problem gamblers have experienced most of the adverse consequences of gambling.

Table 1 shows the characteristics of gamblers in the sample, and the participation rate in gambling. 53% of the sample reported not participating in any type of gambling activity in the previous year and 47% reported participating in some type of gambling.

Table 1: Characteristics of Gamblers and Gambling Behavior

Gambler Type	**% of Sample**	**% of Participants**
Non-Gambler	53.07	—-
Nonproblem Gambler	43.81	93.34
Low Risk Gambler	2.00	4.25
Moderate Risk Gambler	0.86	1.83
Problem Gambler	0.27	0.58

Among the gamblers in the sample, the vast majority of them, more than 93%, fall into the "non-problem gambler" category that we call "gamblers." We use this CPGI classification of gamblers to construct our measure of gambling participation in this study which is an indicator variable that takes on the value of one if the individual gambles and is a "non-problem" gambler and 0 if the individual does not gamble. Just over 6% of gamblers fall into the "low" or "moderate" risk categories and one half of one percent are classified as "problem gamblers". The very small percentage of gamblers who are even considered at risk for becoming problem gamblers or are classified as "problem gamblers" provides our rationale for focusing our analysis on "non-problem" or "recreational" gamblers.

The other explanatory variable of interest in our study is health status. Health status is measured using the detailed information in the CCHS about health outcomes. We focus on five health outcomes in this study: individuals who report having diabetes, high blood pressure, heart disease, mood disorder, and anxiety disorder. Studies that use bio-psychological and public health approaches have established associations between pathologic gambling and psychiatric comorbidities such as anxiety and depressive disorders (Petry et al. (2005); Cunningham-Williams et al. (1998)), alcohol and substance abuse (Gerstein et al. (1999); Welte et al. (2001)), and cigarette smoking (Cunningham-Williams et al. (1998); Petry and Oncken (2002)). These disorders are also associated with medical conditions and adverse health outcomes including hypertension, heart diseases, cirrhosis, diabetes and obesity (Cunningham-Williams et al. (1998); Petry and Oncken (2002); Gerstein et al. (1999); Welte et al. (2001)).

Each health outcome is measured as a binary variable taking on the value of 1 if the individual reported having any of these conditions and zero otherwise. The introductory statement to the chronic conditions module of the CCHS is:

> *Now Id like to ask about certain chronic health conditions which you may have. We are interested in "long-term conditions" which are expected to last or have already lasted 6 months or more and that have been diagnosed by a health professional.*

This statement is followed by a number of questions regarding chronic conditions, such as:

> *Do you have diabetes?*

Table 2: Prevalence Rate of Health Conditions

Condition	**Prevalence Rate in Sample**
Diabetes	6.09%
High Blood Pressure	20.99%
Heart Disease	6.79%
Anxiety Disorder	5.68%
Mood Disorder	6.99%

Table 2 shows the prevalence rate of the six health conditions and self-assessed health status that we focus on in the sample. Note that these are not population prevalence rates for the four Canadian provinces in the sample. The most commonly reported health condition is high blood pressure at 20.99% of the sample. The percentage of the sample reporting having the other chronic conditions ranged from 5.7% to 7%.

We include a number of socio-economic and demographic characteristics that are commonly included in determinants of gambling and health studies. Positive relationships between income and education and health have been documented in numerous studies. In our data, household income is measured in categories. The categorical income variables allow us to account for differences in the relative income position of the households in the analysis. It also allows for a nonlinear relationship between income and gambling and health to exist. Households earning less than $15,000 per year comprise the excluded category. Education is also measured in discrete categories: less than high school, high school, some college and college graduate. Less than high school is the excluded category. We include employment status (full-time and part-time), home ownership and welfare as the primary source of income as additional measures of the economic environment. Home ownership can be thought of as a measure of social class. Individual characteristics included are age, marital status, gender, presence of young children in the household, and native born Canadian. All empirical models include a vector of indicator variables for province of residence to account for unobservable heterogeneity in provincial characteristics that affect gambling and health outcomes. Finally, we include height as a continuous exogenous variable because it is known to be a good predictor of mortality and morbidity risks and captures heterogeneity in initial health endowments (Balia and Jones (2008)).

Table 3: Summary Statistics, Other Covariates - Full Sample, n=82,729

Variable	**Mean**	**Std. Dev.**
Age	47.5373	20.245
Male	0.448	0.497
Single	0.285	0.451
Full Time Employment	0.444	0.497
Part Time Employment	0.099	0.299
Household income $0-$15k	0.110	0.313
Household income $15-$30k	0.188	0.390
Household income $30-$50k	0.171	0.377
Household income $50-$80k	0.145	0.353
Household income >$80k	0.255	0.436
On welfare	0.039	0.193
Owns Home	0.745	0.436
Less than High School	0.268	0.443
High School Graduate	0.155	0.362
Some College	0.069	0.254
College Graduate	0.498	0.500
Children in Home	0.201	0.401
Native Canadian	0.845	0.362
Height (in inches)	66.28	3.92

Table 3 contains summary statistics for the demographic and economic characteristics of individuals in the sample. The age of individuals in the sample ranged from 15 to 85. The sample skews female, with only 44% males. Just over a quarter (28.5%) of the sample is single. 20% of the sample reported having children in the home. Almost half the sample graduated from college, and three quarters own their own home. 44% of the sample reported working full-time. The majority of the sample (85%) are native Canadians.

We augment the individual-level CCHS data with province-level data about the types and number of gambling opportunities available in the four provinces in our sample. Table 4 shows the fraction of the sample from the four provinces in the sample and the opportunities to gamble in each of the provinces in either 2005 or 2007.

Table 4: Provincial Characteristics, Gambling Opportunities

		Number of Facilities per 1,000 population, 2005, 2007					
Province/Year	**% Sample**	**Bingo**	**Casinos**	**VLTs**	**Racetracks**	**Poker**	**Lottery**
New Brunswick (2005)	6.02	—-	—-	1.04	0.005	—-	1.67
Quebec (2007)	27.19	0.420	0.004	0.44	0.003	0.0004	1.39
Ontario (2007)	55.21	0.008	0.001	—	0.010	0.0008	1.04
Saskatchewan (2007)	11.58	0.240	0.009	0.88	0.125	—-	1.01

Note the considerable variation in gambling opportunities across the provinces. New Brunswick has no bingo halls or casinos, but many video lottery terminals (VLTs) in bars and restaurants and lottery outlets per capita. Quebec has many bingo halls and lottery outlets, some casinos, and few VLTs. Ontario, the largest province in terms of population, has no VLTs, many casinos and race tracks. Saskatchewan has many casinos, VLTs and racetracks, but few bingo halls and lottery outlets. The poker rooms were present only in 2007 in Quebec and Ontario, but few exist. The access to gambling opportunities in the provinces also varies over time, because of changes in the number of facilities and population growth. The extent of time variation is limited in our sample since only Ontario and Saskatchewan administered the gambling module in multiple waves of the CCHS. The variation in the repeated cross-sectional units is the variation we are using to identify gambling in the empirical analysis.

4 Econometric Methods

We seek to develop evidence about the causal connection between gambling and health outcomes. This requires careful analysis since gamblers may be either more likely to engage in, or engage in more frequently, a variety of detrimental or stressful behaviors-smoking, excess drinking, lack of sleep, lack of physical activity, theft, other violent crimes, marital abuse or instability, work productivity issues, unemployment, etc.-and these behaviors can result in diminished health status. Causality is difficult to establish because of the possibility of endogeneity within a model of the determination of health status that includes gambling participation as a covariate. The gambling variable may be an endogenous regressor due to unobservable individual heterogeneity driving both gambling and health outcomes, omitted variables correlated with both gambling and health, or reverse causality. In addition, since we are estimating the impact of a binary treatment (gambling) on binary outcomes (presence of chronic health conditions), our estimation approaches must account for this distributional characteristic.

A couple of approaches can be used to address the endogeneity of gambling in the health outcome equation and the binary nature of the gambling and health outcomes variables. The first is an instrumental variables (IV)-based approach that extends linear two-stage least squares estimator to nonlinear models. The second approach is to specify a recursive bi- or multivariate probit model with endogenous regressors. Both approaches have been widely employed in health economics in applications where there are *a priori* reasons to expect a binary dependent variable to be simultaneously determined with a binary regressor.

4.1 Instrumental Variables Approaches

Two instrumental variables approaches have been widely used in empirical health economics research to address endogeneity: two-stage predictor substitution (2SPS); and two-stage residual inclusion (2SRI). (See Terza et al. (2008) for a list of some citations for both methods.) Both methods entail first estimating an equation in which the endogenous regressor is the dependent variable. With 2SPS, the predicted values from the first stage regression replace the endogenous regressor in the second stage. With 2SRI, the first-stage residuals, rather than the first stage fitted values, are included in the second stage along with the observed values of the endogenous regressor. Adopting a two stage least squares method in our study means that we first estimate a gambling equation:

$$y_{gi} = \beta_g X_{gi} + u_{gi} \tag{1}$$

where y_{gi} is a dichotomous gambling participation indicator variable, X_{gi} is a vector of explanatory variables that affect gambling participation, β_g are unknown parameters to be estimated and u_{gi} is the error term. Angrist and Krueger (2001) argue that it is preferable to treat the dichotomous dependent variable as a linear probability and estimate Equation (1) using ordinary least squares via the linear probability model. Using the predicted probability from a non-linear probit model as an instrument for gambling in the second stage is not recommended because the first stage functional form must be correctly specified in order to generate consistent estimates in the second stage. We follow Angrist and Krueger and estimate Equation (1) via the linear probability model, since consistency of the estimates from the second stage IV regression does not require that the first stage functional form be correctly specified. Using the 2SPS, we then estimate a health outcome equation:

$$y_{hi} = \alpha \hat{y}_{gi} + \beta_h X_{hi} + u_{hi} \tag{2}$$

where y_{hi} is the binary health outcome variable, $\hat{y}_{gi}$ are the fitted values of y_{gi} obtained from estimating Equation (1) using OLS, X_{hi} is a vector of explanatory variables that affect health outcomes, α and β_h are unknown parameters to be estimated, and u_{hi} is the error term. We specify Equation (2) as a probit equation and estimate it using maximum likelihood.

The first-stage of the 2SRI estimator is identical to that of the 2SPS. We first estimate Equation (1) as a linear probability model using OLS. The second-stage health outcome equation under 2SRI is

$$y_{hi} = \alpha y_{gi} + \beta_h X_{hi} + \delta \hat{y}_u + u_{hi} \tag{3}$$

where y_{hi} and X_{hi} are the same as in Equation (2), y_{gi} are the observed values of the endogenous gambling variable, $\hat{y}_u$ are the residuals obtained from estimating Equation (1), α, β, and δ are unknown parameters to be estimated, and u_{hi} is the regression error term. Smith and Blundell (1986) show that the t-statistic for the estimate of δ is an asymptotically efficient test for the exogeneity of gambling in the health outcome equations. If δ is not statistically significant then gambling is exogenous.

In order for the parameters of the health outcomes equations (Equations (2) and (3)) to be consistently estimated, a variable must be included in the first-stage gambling equation (Equation (1)) that is not included in Equation (2) or Equation (3). This variable should explain variation in gambling participation but be uncorrelated with health outcomes. Our instrumental variable is based on the number of gambling facilities per capita in a province. We posit the existence of a relationship between the number of gambling opportunities in a province and participation in gambling. Rassen et al. (2009) document the extensive use of regional level variables as instruments in IV regressions involving health outcomes. In addition, similar instruments have been used by Forrest and McHale (2011) and Huang and Humphreys (2011) to identify participation in physical activity in instrumental variables regressions with self-reported happiness as the dichotomous dependent variable.

The 2SRI method has not been used as frequently as the 2SPS in health economics empirical research but there are several studies that use this approach. (DeSimone (2002); Norton and Van Houtven (2006); Shea et al. (2007); Shin and Moon (2007); and Lindrooth and Weisbrod (2007) are a few examples.) Terza et al. (2008) examine the statistical properties and performance of the 2SPS and 2SRI methods for estimating nonlinear models with endogenous regressors. They show that the 2SRI estimator is generally consistent while the 2SPS estimator is not. Simulation analyses revealed that the potential bias from using the 2SPS method can be large. In short, Terza et al. argue in favor of using the 2SRI method over the 2SPS method to estimate nonlinear models with endogenous regressors.

4.2 Bivariate Probit Approach

An alternative to IV approaches to addressing the endogeneity of gambling is to estimate a bivariate probit model. Our recursive bivariate probit model is a two equation binary outcome model with correlated error disturbances and is defined as:

$$y^*_{gi} = \beta_g X_{gi} + u_{gi}, \quad (4)$$

$$y^*_{hi} = \alpha y_{gi} + \beta_h X_{hi} + u_{hi}, \quad (5)$$

where y^*_{hi} represents the latent stock of health of individual i, and y^*_{gi} represents the latent benefit that individual i derives from gambling activity g. Since y^*_{ji}, $j = (g, h)$, is unobservable, we only observe y_{ji}, where $y_{ji} = 1$ if $y^*_{ji} > 0$, and zero otherwise. X_{gi} and X_{hi} are vectors of explanatory variables that affect participation in gambling activities and health outcomes. These variables include demographic, psychological, and economic characteristics of individuals in the sample. β_g, β_h, α and are unknown parameters to be estimated. The error terms (u_{gi} and u_{hi}) are assumed to be distributed bivariate normal (with probability density function ϕ_2 and cumulative density function Φ_2), mean zero, constant variance, and $\text{corr}(u_{gi}, u_{hi}) = \rho$. The error terms capture all other factors that affect gambling activity and health outcomes.

The correlation between the error terms (u_{gi} and u_{hi}) derives from the assumption each error is comprised of two components: (i) unobserved individual heterogeneity (η_i); and (ii) a constant part unique to each model (ϵ_{gi} and ϵ_{hi} respectively):

$$\begin{aligned} u_{gi} &= \eta_i + \epsilon_{gi}, \\ u_{hi} &= \eta_i + \epsilon_{hi}, \end{aligned}$$

If $\rho = 0$, then the bivariate probit is equivalent to two independent probit models. We estimate our recursive bivariate probit model using the bivariate probit (`biprobit`) command, with robust standard errors, in STATA/SE11. The `biprobit` command uses maximum likelihood to estimate the model.

The bivariate probit model is recursive in that health outcomes depend on the exogenous variables X_{hi} and participation in gambling, y_{gi}. In this context the gambling equation (Equation (4)) is a reduced form equation which depends on the exogenous variables, X_{gi}. The health outcome equation (Equation (5)) is a structural equation which depends on the exogenous variables, X_{hi}, and gambling participation, y_{gi}. Maddala (1983) described methods for estimating recursive systems of equations like Equations (4) and (5). In order for the parameters to be consistently estimated, the system must be identified. In this case, an explanatory variable must appear in X_{gi} that does not appear in X_{hi}. Following this approach, we need to exclude a regressor in y^*_{hi} that affects gambling behavior but does not affect health outcomes. However, Wilde (2000) shows that an exclusion restriction is not required to identify the parameters in Equation (4), as long as X_{gi} and X_{hi} each contain one varying explanatory variable. This approach is commonly referred to as "identification by functional form" and relies heavily on the assumption of bivariate normality. Since bivariate normality may be a strong assumption, exclusion restrictions are often imposed to improve identification (Jones (2007)). We compare both approaches to identification in our empirical analysis. Our exclusion restriction is the same as the instrumental variable used to identify the gambling equation described in Section 4.1, that is, the number of gambling facilities per capita in a province.

Bhattacharya et al. (2006) use a Monte Carlo simulation to compare the performance of four estimators commonly used to estimate the effect of a binary treatment variable on a binary outcome variable: single equation probit; two-step probit; two-stage least squares linear probability model (specifically, the 2SPS method); and bivariate probit. They find that the bivariate probit model performs best in generating consistent estimates of the treatment effect (in our case, the effect of gambling on health outcomes). The linear probability model produces good estimates of the treatment effect when there is a single, binary treatment variable and the data generating process is normal.

5 Empirical Results: Gambling and Chronic Conditions

Since few, if any, empirical studies of the effect of gambling on health address the issue of endogeneity and since there are alternative approaches to handling endogeneity, we estimate our empirical models using four different methods: 1) two-stage predictor substitution (2SPS); 2) two-stage residual inclusion (2SRI); 3) recursive bivariate probit without an exclusion restriction; and 4) recursive bivariate probit with an exclusion restriction. We also estimate a single equation probit model. This model assumes that gambling is an exogenous regressor in the health outcome equation. The rationale for estimating this "naive" model is to provide a basis for evaluating the extent to which our results are sensitive to the assumption that gambling is an exogenous regressor. As discussed in Section 1, many studies in the epidemiological literature find that gamblers, and problem gamblers in particular, have lower health status than non-gamblers. However, since these studies do not treat gambling as an endogenous regressor in the health status equation, these findings can only be interpreted as correlations or associations rather than causal.

We estimate separate models for each health outcome/gambling combination. Recall that y_{gi} is an indicator variable that is equal to one if individual i gambles and zero otherwise. We restrict our analysis to one class of gambler, "recreational gamblers" in this study. A "recreational gambler" is an individual who gambles and is not identified as having any risk of being a problem gambler. "At risk" gamblers (n=2,586) are excluded from the analysis. The summary statistics for the sample of non-gamblers and recreational gamblers (n=78,882) used in the empirical analysis are provided in Table 5. Not surprisingly, the summary statistics are essentially the same as those reported for the full sample in Section 3 since only a small percentage of the full sample is classified as "at risk' gamblers.

5.1 Exogeneity Tests - 2SRI and Bivariate Probit

Previous research, primarily in epidemiology and medicine, finds a correlative, rather than causal, relationship between problem gambling and some adverse health outcomes. Establishing evidence of a causal relationship between any type of gambling, recreational or problem, requires addressing the potential endogeneity of gambling in the health outcome equations. The first step in addressing this issue is evaluating the results from statistical tests of exogeneity. The 2SRI and bivariate probit models allow for testing the assumption of exogeneity in a relatively straightforward manner.

The exogeneity test in the 2SRI model arises from the second stage health outcome equation. Recall the second stage of the 2SRI model given by Equation (3) includes the actual values of the presumed endogenous gambling variables and the residuals from the first stage gambling regression given by Equation (1). Smith and Blundell (1986) show that an asymptotically efficient test of exogeneity of the dichotomous gambling variable can be constructed from the following null and alternative hypotheses: $H_0 : \delta = 0$ and $H_a : \delta \neq 0$ where δ is the parameter estimate on $\hat{y}_u$, the residuals obtained from the first stage regression. If the test statistic (in our case, the z-statistic) is significantly different from zero, then we reject H_0 and the assumption of exogeneity of the gambling variable in the health outcomes equation.

The exogeneity test in the bivariate probit model arises from allowing the correlation between the error terms (u_{gi} and u_{hi}) to be non-zero. The exogeneity test can be constructed from the

Table 5: Summary Statistics - Analysis Sample, n=78,882

Variable	**Mean**	**Std. Dev.**
Gambler		
Recreational Gambler	0.454	.498
Chronic Conditions		
Has Diabetes	0.069	0.253
Has High Blood Pressure	0.212	0.408
Has Heart Disease	0.069	0.253
Has Mood Disorder	0.069	0.253
Has Anxiety Disorder	0.055	0.229
Covariates		
Age	47.824	20.224
Male	0.448	0.497
Single	0.282	0.450
Full Time Employment	0.443	0.497
Part Time Employment	0.010	0.299
Household income \$0-\$15k	0.109	0.312
Household income \$15-\$30k	0.188	0.391
Household income \$30-\$50k	0.172	0.377
Household income \$50-\$80k	0.146	0.353
Household income >\$80k	0.255	0.436
On welfare	0.038	0.191
Owns Home	0.748	0.434
Less than High School	0.265	0.442
High School Graduate	0.155	0.361
Some College	0.069	0.253
College Graduate	0.500	0.500
Children in Home	0.202	0.401
Native Canadian	0.844	0.362
Height (in inches)	66.25	3.92

following null and alternative hypotheses: $H_0 : \rho = 0$ and $H_a : \rho \neq 0$ where ρ is the coefficient of correlation between the residuals from Equations (4) and (5). H_0 corresponds to the assumption of exogeneity of the gambling variable in the health equation y^*_{hi}. If $\rho = 0$, then the bivariate probit is equivalent to two independent probit models. We can interpret this as saying the factors affecting the probability of gambling (y_{gi}) and the factors affecting the probability of a health outcome (y_{hi}) are exogenous. In this case, the error terms, u_{gi} and u_{hi} are independent and the gambling variable is exogenous. Under H_0, Maddala shows that the log-likelihood function of the bivariate probit model becomes the sum of the log-likelihood functions of two single equation probits and the parameters can be obtained by separate estimation of the probit equations.

However, if the error terms are not independent ($\rho \neq 0$), then we interpret this as evidence of unobservable factors that influence the probability of gambling (y_{gi}) also influence the probability of a health outcome (y_{hi}). Maddala (1983) shows that the parameter estimates from separate ML probit estimation are inconsistent in this case. Estimating the health outcome and gambling equations simultaneously as a bivariate probit using ML is required to obtain consistent parameter estimates when the error terms are correlated. Alternative approaches are available for testing $H_0 : \rho = 0$. We use two different tests for exogeneity. First, we use an asymptotic z-test for the significance of the estimated ρ from each model. Second, we use the likelihood ratio (LR) test to compare the log-likelihood of the bivariate probit model with the sum of the log-likelihoods of the two single equation probit models. Monfardini and Radice (2008) show that a likelihood ratio (LR) test performs better than Lagrange multiplier (LM) and conditional moment (CM) tests.

We estimate separate 2SRI and bivariate probit models for each health outcome. We compare the results of the exogeneity tests when the bivariate probit models are identified by functional form and with an exclusion restriction. In general, the variable identifying gambling in the IV approaches and the exclusion restriction identifying gambling in the bivariate probit model should be a variable that is related to gambling but unrelated to u_{hi}, the error term capturing unobservable factors that affect an individual's health. As discussed in Sections 4.1 and 4.2, we use the same variable to identify gambling in both approaches, that is the number of gambling facilities per capita in a province. Staiger and Stock (1997) propose using the F-statistic from an OLS regression of the endogenous variable on the instrument as a test of instrument strength. This F-statistic is 172.58 indicating that we do not have a weak instrument.

Table 6 reports: 1) the z-score and significance level for the z-test from the 2SRI regressions; 2) the estimated correlation between the error terms ($\hat{\rho}$), the z-score and significance level for the z-test from the bivariate probit models; and 3) the χ^2 statistic and significance level for the LR test from the bivariate probit models. Consider first the z-test for $H_0 : \delta = 0$ shown in column (1). The z-statistic is statistically significant at least the 1% level for all health outcomes except heart disease. These results indicate rejection of the null hypothesis that the gambling variable is exogenous in the health outcome equations. Estimates obtained from a single equation probit model are inconsistent.

Next consider the results for the exogeneity tests emanating from the bivariate probit modeles As shown in columns (2) and (5), most estimated correlations are positive (with the exception of $\hat{\rho}$ for diabetes in column (2)). We interpret this to say that the correlation between the errors in

Table 6: Exogeneity Tests- H_0: $\delta = 0$; H_0: $\rho = 0$

	2SRI	BVP: No Exclusion Restriction			BVP: Exclusion Restriction		
	z-stat	$\hat{\rho}$	z-test	LR-test	$\hat{\rho}$	z-test	LR-test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Has Diabetes	5.47***	-0.012	0.11	0.012	0.449	5.45***	29.73***
Has High Blood Pressure	4.33***	0.208	0.36	0.128	0.487	5.72***	32.72***
Has Heart Disease	-0.35	0.216	1.81*	3.26*	0.079	0.40	0.159
Has Mood Disorder	3.51***	0.106	2.60***	6.77***	0.313	3.72***	13.86***
Has Anxiety Disorder	3.45***	0.100	3.31***	10.94***	0.252	4.07***	16.60***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the gambling equation and the health outcome equation is positive which suggests unobservable factors that increase the probability of gambling also increase the probability of a health outcome.

The results of the exogeneity tests are sensitive to use of an exclusion restriction. The z-test and LR-test without an exclusion restriction, as shown in columns (3) and (4), suggest that the estimated correlations are statistically significant from zero at the 1% level for mood and anxiety disorder. The correlations are weakly significant for heart disease and insignificant for diabetes and high blood pressure. In contrast, the estimated correlations are statistically significant at the 1% level for all conditions except heart disease when an exclusion restriction is used to identify the bivariate probit model. These results suggest that ignoring this correlation and simply using two independent probit models for y_{gi} and y_{hi} would generate estimates with an upward bias.

Taken together, the exogeneity test results generally indicate that, as expected, the gambling variable appears to be endogenous for most chronic conditions. The consistent exception is heart disease. This means that an estimation approach, whether it be an instrumental variables or bivariate probit, that addresses the endogeneity of gambling is needed for identifying a causal relationship between gambling and health outcomes. The challenge in accounting for this endogeneity lies in finding a good instrument for the IV methods and a reasonable exclusion restriction for the bivariate probit approach. Fortunately for this study, the availability of gambling opportunities in the province is sufficiently variable to identify recreational gambling.

5.2 Comparison of Alternative Estimators

Since the relationship between the recreational gambling and health outcomes is the primary focus of this investigation, we do not report full regression results for each gambling and health outcome model in the body of the paper. Instead, we report the estimated marginal effects of gambling on health outcomes in Table 7. The full set of parameter estimates from all models are presented in the Appendix.

For each health outcome, Table 7 reports the partial marginal effect of gambling on health outcomes. The partial marginal effect is the effect of a change in gambling status from 0 to 1 on the probability of achieving a particular health outcome. This is approximately equivalent to the the difference between $E[Pr(y_{hi} = 1, y_{gi} = 0)]$ and $E[Pr(y_{hi} = 1, y_{gi} = 1)]$. Z-statistics are reported in parentheses. We refer to the partial marginal effect as the marginal effect when discussing the results.

Table 7: Marginal Effects: Alternative Estimators

	Single Eq. Probit	BVP: No ER	BVP: ER	2SPS	2SRI
	(1)	(2)	(3)	(4)	(5)
Has Diabetes	0.002	0.00003	-0.060***	-0.353***	-0.485***
	(1.31)	(0.00)	(-3.63)	(-5.45)	(-5.44)
Has High Blood Pressure	0.012***	-0.036	-0.116***	-0.463***	-0.429***
	(4.45)	(-0.27)	(-4.61)	(-4.22)	(-4.22)
Has Heart Disease	0.002*	-0.015	-0.004	0.020	0.020
	(1.84)	(-1.30)	(-0.28)	(0.39)	(0.39)
Has Mood Disorder	0.004**	-0.009*	-0.038**	-0.239***	-0.255***
	(2.23)	(-1.88)	(-2.66)	(-3.45)	(-3.45)
Has Anxiety Disorder	0.003**	-0.007*	-0.024***	-0.232***	-0.267***
	(2.11)	(-2.31)	(-2.91)	(-3.41)	(-3.40)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

BVP:No ER - Bivariate Probit, no exclusion restriction; BVP:ER - bivariate probit, exclusion restriction; 2SPS: 2-stage predictor substitution; 2SRI: 2-stage residual inclusion

The results shown in Table 7 reveal some interesting and new findings. First consider Column (1) of Table 7 where the marginal effects from the single equation probit model are reported. Gambling increases the probability of negative health outcomes for four of the five health conditions examined. The marginal impacts are small. The health outcome probabilities are increased by a low of 0.2 percentage points for heart disease to a high of 1.2 percentage points for high blood pressure. The maintained assumption of the single equation probit model is that gambling is an exogenous regressor in the health outcome equations. In this respect, our results for recreational gamblers are largely consistent with results from the epidemiology literature that find a positive correlation between pathological gambling and poor health. However, the single equation probit is a reduced form equation and the results are suggestive of only an association between gambling and health. They cannot be interpreted as providing causal evidence that gambling adversely impacts health.

The bivariate probit and instrumental variables results presented in Columns (2)-(5) of Table 7 can be interpreted as causal evidence of a relationship between gambling and health outcomes. After accounting for endogeneity, a different picture emerges of the effect of gambling on health. In general, recreational gambling decreases the probability of negative health outcomes, except for heart disease where recreational gambling has no effect on health. The bivariate probit estimates with an exclusion restriction (Table 7, Column (3)) suggest that recreational gambling has a positive but modest impact on health. Recreational gamblers are 6 percentage points less likely to report having diabetes, 11.6 percentage points less likely to report having high blood pressure, 3.8 percentage points less likely to have been diagnosed with a mood disorder; and 2.4 percentage points less likely to have been diagnosed with an anxiety disorder. The instrumental variables results (Table 7, Columns (4) and (5) indicate that recreational gambling has a substantial positive impact on health. Taken at face value, the marginal impact of recreational gambling on having diabetes is a 35.3 to 48.5 percentage point reduction. The corresponding percentage point reductions in recreational gamblers having chronic diseases are 42.9 to 46.3 for high blood pressure, 23.9 to 25.5 for mood disorder and 23.3 to 26.7 for anxiety disorder. These IV and bivariate probit results comprise the first causal evidence that we aware of in the literature that recreational gambling can have a positive impact on health. These results seem plausible but are quite different from other results that treat gambling as an exogenous regressor and find a negative association between problem (or pathological) gambling and health. The exogeneity tests discussed in Section 5.1 argue for treating gambling as an endogenous regressor.

The estimates of the marginal impact of gambling on health are both robust and sensitive to the estimation approach. They are robust in that the IV and bivariate probit results consistently indicate no effect of gambling on heart disease and a negative effect on the other chronic conditions. The difference in the size of the estimates produced by the alternative estimates reveals sensitivity to the estimation approach. Consider first the comparison of the estimates generated by the two IV approaches, 2SPS and 2SRI reported in Table 7, Columns (4) and (5). Terza et al. (2008) show that in a nonlinear framework the 2SRI estimator is generally consistent while the 2SPS method is not. An illustrative example produced estimates from the 2SRI method that were substantially different in magnitude than the estimates from the 2SPS approach. Terza et al. argue in favor of the 2SRI approach over the 2SPS approach. With the exception of diabetes, the estimated marginal effects from the 2SRI and 2SPS methods are not substantially different suggesting that even if the 2SPS estimates are biased, the extent of the bias is small. Assuming that the 2SPS estimates are biased, the direction of the bias is downward for diabetes, mood disorder and anxiety disorder and upward for high blood pressure.

Next, it is useful to compare the estimates from the IV approaches relative to the bivariate probit model. Bhattacharya et al. (2006) perform a Monte Carlo simulation to compare the performance of the naive probit model, the 2SPS model in which the first stage equation is specified as a linear probability model and the bivariate probit model. Of interest for our results are the findings with respect to the bias in the estimated partial marginal effects (or treatment effects) of the estimators. Bhattacharya et al. find that the naive probit estimator is uniformly worse than the alternatives. The bivariate probit estimates of the treatment effect appear to be unbiased over the range of the true treatment effects. The 2SPS estimator generally performs well but does exhibit some upward bias in the estimates of the true treatment effects when the true treatment effect increases. These findings suggest that the estimates of the marginal effects from the bivariate probit model with an exclusion restriction are closest to the true marginal effects and that the 2SPS estimates may be overstated.

6 Conclusions

We examine the relationship between gambling and health for all individuals who report participating in gambling in a number of waves of the Canadian Community Health Survey. We restrict our analysis to recreational gamblers for two reasons. First, a very small percentage of gamblers are classified as problem gamblers or "at risk" gamblers. Second, most of the studies about gambling and health in the epidemiological, health behavior and psychological literature are concerned with the health status of pathological or problem gamblers. Very little is known about the relationship between gambling and health among the far more common recreational gambler. We estimate separate models for five chronic conditions that have been associated with gambling. A gambler is considered a recreational gambler if the respondent is classified as a non-problem gambler by the CPGI questions in the CCHS. We have good *a priori* reasons to expect gambling to be an endogenous regressor in this context. Tests of exogeneity of the gambling variable generally indicate that the gambling variables are endogenous. We address the endogeneity issue by estimating recursive bivariate probit and instrumental variables probit models, two standard endogeneity corrections in the health econometrics literature.

Regardless of the estimation method used, after accounting for endogeneity, our results provide evidence of a causal relationship between recreational gambling and the prevalence of chronic conditions. The results indicate that recreational gambling has either no impact or a negative impact on the probability of having certain chronic conditions. In particular, the partial marginal effects of gambling on health are negative and significant for high blood pressure, diabetes, mood disorder and anxiety disorder but insignificant for heart disease. The results are sensitive to the estimation approach.

These results have several important implications for future research on the relationship between gambling and health, and for public policy about gambling. First, the econometric analysis of the relationship between participation in gambling and health requires considerable care on the part of the researcher. Even using the relatively large sample here, the size, sign, and significance of the relationship between gambling and health shows sensitivity to model specification and exclusion restrictions. The exogeneity tests from the 2SRI and bivariate probit methods indicate that the decision to participate in gambling is endogenous in empirical models explaining variation in health outcomes. Simple reduced form evidence about the relationship between gambling and health is not likely to reflect a causal relationship and should be interpreted with care. Empirical methods that explicitly account for the endogenous nature of the relationship between gambling and health, like instrumental variables and recursive bivariate probit models, should be the preferred methodological approaches in future research. In addition, future research should address the adequacy of the instrument used here, the availability of gambling opportunities at the provincial level, and look for additional instruments that can be used to identify gambling participation in health outcome models.

Second, our results indicate that recreational participation in gambling has some health benefits, in that recreational or casual gamblers are less likely to have any of the chronic conditions examined in this study, except heart disease where we find no evidence of an impact of gambling. This result underscores the importance of focusing more on the consequences of gambling for recreational gamblers and less on the consequences of at risk gamblers in future research. If recreational gambling has some positive health benefits, then policy makers should incorporate them into their analyses.

Finally, if recreational gambling produces some modest health benefits, then additional research should focus on understanding the mechanism by which the beneficial effects are generated. In the introduction, we have suggested a number of potential mechanisms-an ill-advised but effective way out for those frustrated at work, a source of relaxation and positive thought for the stressed, a realistic reminder of the uncertain nature of life-but detailing how these and other potential mechanisms actually would work is left to future research. Moreover, the mechanisms will likely differ for the different measures of health. A better understanding of the mechanisms may also increase our understanding of the basic demand for gambling.

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A Appendix

Table A.1: Coefficient Estimates - Single Equation Probit Model

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.020***	0.033***	0.027***	-0.002***	-0.006***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Male	0.273***	0.059***	0.292***	-0.290***	-0.245***
	(0.021)	(0.016)	(0.023)	(0.020)	(0.021)
Single	-0.125***	-0.148***	-0.088***	-0.080***	-0.099***
	(0.025)	(0.018)	(0.026)	(0.022)	(0.023)
Full Time Employment	-0.104***	-0.089***	-0.268***	-0.117***	-0.121***
	(0.021)	(0.015)	(0.023)	(0.019)	(0.020)
Part Time Employment	-0.130***	-0.100***	-0.116***	-0.083***	-0.087***
	(0.032)	(0.023)	(0.033)	(0.026)	(0.027)
Household income : $15k-$30k	0.001	0.056***	0.024	0.019	-0.033
	(0.02)	(0.017)	(0.021)	(0.020)	(0.022)
Household income: $30-$50k	-0.009	0.042**	-0.009	-0.045**	-0.101***
	(0.023)	(0.018)	(0.024)	(0.022)	(0.024)
Household income: $50-$80k	-0.076	0.021	-0.037	-0.122***	-0.170***
	(0.027)	(0.021)	(0.029)	(0.025)	(0.027)
Household income: >$80k	-0.142***	-0.027	-0.119***	-0.219***	-0.174***
	(0.027)	(0.020)	(0.029)	(0.024)	(0.025)
On welfare	0.394***	0.283***	0.268***	0.708***	0.596***
	(0.034)	(0.030)	(0.038)	(0.029)	(0.030)
Owns Home	-0.106***	0.001	-0.080***	-0.218***	-0.213***
	(0.018)	(0.014)	(0.019)	(0.016)	(0.017)
High School Graduate	-0.076***	-0.001	-0.077***	0.111***	0.093***
	(0.024)	(0.018)	(0.024)	(0.024)	(0.025)
Some College	-0.018	-0.033	-0.017	0.193***	0.190***
	(0.033)	(0.026)	(0.036)	(0.030)	(0.031)
College Graduate	-0.072***	-0.061***	-0.060***	0.188***	0.111***
	(0.018)	(0.015)	(0.019)	(0.019)	(0.021)
Children in Home	-0.190***	-0.262***	-0.180***	-0.111***	-0.135***
	(0.028)	(0.021)	(0.035)	(0.021)	(0.022)
Height (in inches)	-0.014***	-0.014***	-0.010***	0.011***	-0.001
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Native Canadian	0.016	0.034**	0.086***	0.157***	0.253***
	(0.020)	(0.016)	(0.021)	(0.021)	(0.024)
Quebec	-0.070**	-0.130***	-0.114***	-0.095***	0.012
	(0.032)	(0.025)	(0.033)	(0.034)	(0.034)
Ontario	0.002	-0.060**	-0.075**	0.215***	0.105***
	(0.031)	(0.024)	(0.032)	(0.032)	(0.033)
Saskatchewan	-0.061*	-0.080***	-0.173***	0.117***	-0.125***
	(0.037)	(0.028)	(0.038)	(0.037)	(0.040)
Recreational Gambler	0.020	0.051***	0.029*	0.032**	0.033**
	(0.015)	(0.012)	(0.016)	(0.014)	(0.015)
Intercept	-1.505***	-1.513***	-2.278***	-2.128***	-1.199***
	(0.183)	(0.142)	(0.196)	(0.169)	(0.179)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.2: Coefficient Estimates - First Stage Linear Probability Model for 2SPS and 2SRI

	Coefficient	Std. Error
Age	0.0003***	0.000
Male	-0.0330***	0.005
Single	-0.0476***	0.005
Full Time Employment	0.0874***	0.004
Part Time Employment	0.0482***	0.006
Household income : $15k-$30k	0.0261***	0.005
Household income: $30-$50k	0.0428***	0.006
Household income: $50-$80k	0.0544***	0.006
Household income: >$80k	0.0689***	0.006
On welfare	0.0281***	0.010
Owns Home	-0.0134***	0.004
High School Graduate	0.0969***	0.006
Some College	0.1123***	0.008
College Graduate	0.0921***	0.005
Children in Home	-0.0175***	0.005
Height (in inches)	0.0045***	0.001
Native Canadian	0.1042***	0.005
Quebec	0.3785***	0.065
Ontario	0.907***	0.125
Saskatchewan	0.434***	0.060
Gambling Facilities per Capita	0.5417***	0.076
Intercept	-1.5136***	0.210

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.3: Coefficient Estimates - 2SPS, 2nd Stage Health Outcome Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.020***	0.033***	0.027***	-0.001***	-0.005***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Male	0.151***	-0.01	0.299***	-0.358***	-0.323***
	(0.031)	(0.023)	(0.031)	(0.028)	(0.031)
Single	-0.297***	-0.244***	-0.078*	-0.176***	-0.210***
	(0.04)	(0.029)	(0.040)	(0.035)	(0.039)
Full Time Employment	0.214***	0.088**	-0.288***	0.063	0.085
	(0.062)	(0.044)	(0.061)	(0.054)	(0.063)
Part Time Employment	0.048	-0.001	-0.127***	0.018	0.029
	(0.045)	(0.032)	(0.046)	(0.039)	(0.043)
Household income : $15k-$30k	0.096***	0.110***	0.018	0.072***	0.027
	(0.027)	(0.021)	(0.027)	(0.025)	(0.028)
Household income: $30-$50k	0.154***	0.134***	-0.019	0.046	0.001
	(0.037)	(0.028)	(0.038)	(0.034)	(0.038)
Household income: $50-$80k	0.132***	0.139***	-0.049	-0.005	-0.037
	(0.047)	(0.034)	(0.047)	(0.042)	(0.047)
Household income: >$80k	0.110**	0.115***	-0.134**	-0.079*	-0.013
	(0.053)	(0.038)	(0.052)	(0.047)	(0.052)
On welfare	0.497***	0.340***	0.261***	0.765***	0.662***
	(0.039)	(0.033)	(0.042)	(0.033)	(0.036)
Owns Home	-0.157***	-0.027*	-0.076***	-0.247***	-0.246***
	(0.02)	(0.016)	(0.020)	(0.018)	(0.020)
High School Graduate	0.275***	0.194***	-0.100	0.307***	0.320***
	(0.068)	(0.049)	(0.067)	(0.061)	(0.070)
Some College	0.390***	0.193***	0.044	0.421***	0.452***
	(0.082)	(0.059)	(0.081)	(0.072)	(0.082)
College Graduate	0.259***	0.122***	-0.082	0.374***	0.324***
	(0.063)	(0.045)	(0.062)	(0.056)	(0.065)
Children in Home	-0.254***	-0.298***	-0.176***	-0.146***	-0.175***
	(0.031)	(0.022)	(0.037)	(0.023)	(0.025)
Height (in inches)	0.002	-0.005*	-0.011***	0.020***	0.009**
	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Native Canadian	0.393***	0.246***	0.062	0.369***	0.496***
	(0.072)	(0.051)	(0.070)	(0.064)	(0.075)
Quebec	-0.362***	-0.294***	-0.095	-0.259***	-0.176***
	(0.063)	-0.045	(0.061)	(0.058)	(0.064)
Ontario	0.035	-0.04	0.076**	0.234***	0.126***
	(0.032)	(0.025)	(0.032)	(0.032)	(0.033)
Saskatchewan	-0.042	-0.065**	0.174***	0.131***	-0.110***
	(0.037)	(0.028)	(0.038)	(0.037)	(0.040)
Recreational Gambler	-3.619***	-1.988***	0.253	-2.002***	-2.303***
	(0.665)	(0.471)	(0.643)	(0.580)	(0.676)
Intercept	-1.648***	-1.581***	-2.262***	-2.204***	-1.287***
	(0.185)	(0.143)	(0.198)	(0.171)	(0.181)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.4: Coefficient Estimates - 2SRI, 2nd Stage Health Outcome Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.020***	0.033***	0.027***	-0.001***	-0.005***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Male	0.151***	-0.01	0.299***	-0.358***	-0.323***
	(0.031)	(0.023)	(0.031)	(0.028)	(0.031)
Single	-0.297***	-0.245***	-0.078*	-0.176***	-0.210***
	(0.040)	(0.029)	(0.040)	(0.035)	(0.039)
Full Time Employment	0.215***	0.090**	-0.287***	0.063	0.085
	(0.062)	(0.044)	(0.061)	(0.054)	(0.063)
Part Time Employment	0.048	0.000	-0.127***	0.018	0.029
	(0.045)	(0.032)	(0.046)	(0.039)	(0.043)
Household income : \$15k-\$30k	0.096***	0.109***	0.018	0.072***	0.027
	(0.027)	(0.021)	(0.027)	(0.025)	(0.028)
Household income: \$30-\$50k	0.154***	0.133***	-0.019	0.046	0.001
	(0.037)	(0.028)	(0.038)	(0.034)	(0.038)
Household income: \$50-\$80k	0.131***	0.138***	-0.05	-0.005	-0.037
	(0.047)	(0.034)	(0.047)	(0.042)	(0.047)
Household income: >\$80k	0.110**	0.114***	-0.134**	-0.079*	-0.013
	(0.053)	(0.038)	(0.052)	(0.047)	(0.052)
On welfare	0.497***	0.341***	0.262***	0.766***	0.662***
	(0.039)	(0.033)	(0.042)	(0.033)	(0.036)
Owns Home	-0.157***	-0.027*	-0.076***	-0.247***	-0.246***
	(0.020)	(0.016)	(0.020)	(0.018)	(0.020)
High School Graduate	0.275***	0.196***	-0.099	0.307***	0.319***
	(0.068)	(0.049)	(0.067)	(0.061)	(0.070)
Some College	0.390***	0.196***	-0.042	0.421***	0.452***
	(0.082)	(0.059)	(0.081)	(0.072)	(0.082)
College Graduate	0.260***	0.125***	-0.08	0.374***	0.323***
	(0.063)	(0.045)	(0.062)	(0.056)	(0.065)
Children in Home	-0.254***	-0.298***	-0.176***	-0.146***	-0.175***
	(0.031)	(0.022)	(0.037)	(0.023)	(0.025)
Height (in inches)	0.002	-0.005*	-0.011***	0.020***	0.009**
	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Native Canadian	0.393***	0.246***	0.063	0.368***	0.495***
	(0.072)	(0.051)	(0.070)	(0.064)	(0.075)
Quebec	-0.363***	-0.294***	-0.096	-0.259***	-0.176***
	(0.063)	(0.045)	(0.061)	(0.058)	(0.064)
Ontario	0.034	-0.041*	-0.077**	0.234***	0.126***
	(0.032)	(0.025)	(0.032)	(0.032)	(0.033)
Saskatchewan	-0.042	-0.067**	-0.175***	0.131***	-0.110***
	(0.037)	(0.028)	(0.038)	(0.037)	(0.040)
Recreational Gambler	-3.617***	-1.988***	0.251	-2.001***	-2.298***
	(0.665)	(0.471)	(0.643)	(0.580)	(0.676)
Residuals	3.639***	2.041***	-0.222	2.034***	2.332***
	(0.665)	(0.472)	(0.643)	(0.580)	(0.676)
Intercept	-1.652***	-1.595***	-2.269***	-2.207***	-1.289***
	(0.185)	(0.143)	(0.198)	(0.171)	(0.181)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.5: Coefficient Estimates - Bivariate Probit (No Exclusion Restriction), Structural Health Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.020***	0.033***	0.027***	-0.002***	-0.006***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Male	0.272***	0.046	0.275***	-0.295***	-0.250***
	(0.022)	(0.039)	(0.025)	(0.020)	(0.021)
Single	-0.126***	-0.162***	-0.104***	-0.088***	-0.106***
	(0.026)	(0.038)	(0.027)	(0.022)	(0.023)
Full Time Employment	-0.103***	-0.058	-0.232***	-0.101***	-0.106***
	(0.026)	(0.090)	(0.031)	(0.020)	(0.020)
Part Time Employment	-0.129***	-0.081	-0.097***	-0.074***	-0.079***
	(0.033)	(0.060)	(0.035)	(0.026)	(0.027)
Household income : \$15k-\$30k	0.002	0.064**	0.033	0.024	-0.029
	(0.021)	(0.026)	(0.021)	(0.020)	(0.022)
Household income: \$30-\$50k	-0.008	0.056	0.007	-0.037	-0.094***
	(0.025)	(0.042)	(0.026)	(0.023)	(0.024)
Household income: \$50-\$80k	-0.075**	0.04	-0.017	-0.111***	-0.160***
	(0.029)	(0.055)	(0.031)	(0.026)	(0.027)
Household income: >\$80k	-0.140***	-0.003	-0.093***	-0.206***	-0.162***
	(0.029)	(0.067)	(0.032)	(0.024)	(0.025)
On welfare	0.394***	0.289***	0.275***	0.710***	0.599***
	(0.035)	(0.030)	(0.038)	(0.029)	(0.030)
Owns Home	-0.107***	-0.004	-0.083***	-0.220***	-0.215***
	(0.018)	(0.019)	(0.018)	(0.016)	(0.017)
High School Graduate	-0.074**	0.032	-0.042	0.127***	0.109***
	(0.029)	(0.091)	(0.032)	(0.024)	(0.025)
Some College	-0.016	0.005	0.023	0.212***	0.208***
	(0.038)	(0.110)	(0.042)	(0.030)	(0.031)
College Graduate	-0.071***	-0.029	-0.027	0.204***	0.125***
	(0.024)	(0.090)	(0.026)	(0.020)	(0.021)
Children in Home	-0.190***	-0.265***	-0.183***	-0.114***	-0.137***
	(0.028)	(0.021)	(0.035)	(0.021)	(0.022)
Height (in inches)	-0.014***	-0.013***	-0.008**	0.012***	-0.001
	(0.003)	(0.006)	(0.003)	(0.003)	(0.003)
Native Canadian	0.018	0.069	0.121***	0.175***	0.269***
	(0.027)	(0.094)	(0.028)	(0.022)	(0.024)
Quebec	-0.071**	-0.156**	-0.140***	-0.109***	-0.001
	(0.035)	(0.069)	(0.035)	(0.034)	(0.034)
Ontario	0.002	-0.056**	-0.071**	0.216***	0.106***
	(0.031)	(0.027)	(0.031)	(0.032)	(0.033)
Saskatchewan	-0.061*	-0.076**	-0.168***	0.118***	-0.123***
	(0.037)	(0.031)	(0.037)	(0.037)	(0.040)
Recreational Gambler	0.001	-0.284	-0.319*	-0.139**	-0.129**
	(0.177)	(0.911)	(0.188)	(0.067)	(0.051)
Intercept	-1.506***	-1.511***	-2.264***	-2.129***	-1.203***
	(0.183)	(0.152)	(0.196)	(0.169)	(0.179)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.6: Coefficient Estimates - Bivariate Probit (No Exclusion Restriction), Reduced Form Gambling Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.001**	0.001**	0.001**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	-0.090***	-0.090***	-0.090***	-0.090***	-0.090***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Single	-0.124***	-0.124***	-0.124***	-0.124***	-0.124***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Full Time Employment	0.229***	0.229***	0.229***	0.229***	0.229***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Part Time Employment	0.132***	0.132***	0.132***	0.132***	0.132***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Household income : $15k-$30k	0.069***	0.070***	0.070***	0.069***	0.069***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Household income: $30-$50k	0.116***	0.116***	0.116***	0.116***	0.116***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Household income: $50-$80k	0.148***	0.148***	0.148***	0.148***	0.148***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Household income: >$80k	0.178***	0.178***	0.178***	0.178***	0.178***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
On welfare	0.077***	0.077***	0.076***	0.077***	0.077***
	(0.025)	(0.026)	(0.025)	(0.025)	(0.025)
Owns Home	-0.036***	-0.036***	-0.036***	-0.036***	-0.036***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
High School Graduate	0.254***	0.255***	0.255***	0.254***	0.254***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Some College	0.296***	0.296***	0.296***	0.296***	0.296***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
College Graduate	0.241***	0.241***	0.241***	0.241***	0.241***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Children in Home	-0.047***	-0.047***	-0.047***	-0.047***	-0.047***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Height (in inches)	0.012***	0.012***	0.012***	0.012***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Native Canadian	0.271***	0.271***	0.272***	0.271***	0.272***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Quebec	-0.210***	-0.210***	-0.210***	-0.210***	-0.210***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Ontario	0.024	0.024	0.024	0.024	0.024
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Saskatchewan	0.019	0.018	0.019	0.019	0.019
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Intercept	-1.444***	-1.444***	-1.443***	-1.445***	-1.444***
	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.7: Coefficient Estimates - Bivariate Probit (Exclusion Restriction), Structural Health Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.018***	0.031***	0.027***	-0.002***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Male	0.230***	0.027	0.287***	-0.298***	-0.254***
	(0.022)	(0.017)	(0.027)	(0.020)	(0.021)
Single	-0.152***	-0.174***	-0.094***	-0.102***	-0.116***
	(0.024)	(0.018)	(0.030)	(0.022)	(0.023)
Full Time Employment	-0.033	-0.011	-0.256***	-0.068***	-0.082***
	(0.023)	(0.019)	(0.039)	(0.023)	(0.022)
Part Time Employment	-0.083***	-0.051**	-0.110***	-0.054**	-0.064**
	(0.031)	(0.023)	(0.037)	(0.026)	(0.027)
Household income : $15k-$30k	0.021	0.073***	0.027	0.033	-0.022
	(0.020)	(0.016)	(0.022)	(0.020)	(0.022)
Household income: $30-$50k	0.026	0.074***	-0.003	-0.02	-0.081***
	(0.023)	(0.018)	(0.028)	(0.023)	(0.024)
Household income: $50-$80k	-0.029	0.065***	-0.03	-0.089***	-0.143***
	(0.027)	(0.021)	(0.034)	(0.027)	(0.028)
Household income: >$80k	-0.083***	0.03	-0.110***	-0.177***	-0.143***
	(0.027)	(0.021)	(0.037)	(0.026)	(0.026)
On welfare	0.390***	0.284***	0.272***	0.701***	0.596***
	(0.033)	(0.029)	(0.039)	(0.029)	(0.030)
Owns Home	-0.109***	-0.01	-0.081***	-0.219***	-0.215***
	(0.017)	(0.014)	(0.019)	(0.016)	(0.017)
High School Graduate	0.001	0.077***	-0.065	0.158***	0.132***
	(0.026)	(0.021)	(0.040)	(0.026)	(0.026)
Some College	0.067*	0.060**	-0.003	0.245***	0.233***
	(0.034)	(0.028)	(0.052)	(0.031)	(0.032)
College Graduate	0.001	0.017	-0.048	0.230***	0.146***
	(0.022)	(0.019)	(0.035)	(0.021)	(0.022)
Children in Home	-0.192***	-0.257***	-0.182***	-0.117***	-0.139***
	(0.027)	(0.020)	(0.035)	(0.020)	(0.022)
Height (in inches)	-0.010***	-0.009***	-0.009***	0.013***	0.001
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Native Canadian	0.091***	0.114***	0.099**	0.206***	0.291***
	(0.023)	(0.019)	(0.039)	(0.023)	(0.025)
Quebec	-0.124***	-0.184***	-0.124***	-0.134***	-0.022
	(0.032)	(0.025)	(0.041)	(0.034)	(0.035)
Ontario	0.009	-0.048**	-0.074**	0.213***	0.106***
	(0.030)	(0.023)	(0.032)	(0.031)	(0.032)
Saskatchewan	-0.053	-0.069**	-0.172***	0.117***	-0.120***
	(0.035)	(0.027)	(0.038)	(0.036)	(0.039)
Recreational Gambler	-0.707***	-0.735***	-0.099	-0.473***	-0.373***
	(0.118)	(0.115)	(0.319)	(0.128)	(0.097)
Intercept	-1.453***	-1.445***	-2.280***	-2.093***	-1.198***
	(0.176)	(0.138)	(0.196)	(0.167)	(0.177)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

Table A.8: Coefficient Estimates - Bivariate Probit (Exclusion Restriction), Reduced Form Gambling Equation

	Diabetes	High Blood Pressure	Heart Disease	Mood Disorder	Anxiety Disorder
Age	0.001**	0.001**	0.001**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	-0.089***	-0.089***	-0.089***	-0.089***	-0.089***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Single	-0.124***	-0.123***	-0.125***	-0.124***	-0.124***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Full Time Employment	0.227***	0.227***	0.227***	0.228***	0.227***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Part Time Employment	0.128***	0.128***	0.129***	0.128***	0.129***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Household income : $15k-$30k	0.070***	0.070***	0.070***	0.070***	0.070***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Household income: $30-$50k	0.112***	0.113***	0.112***	0.112***	0.112***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Household income: $50-$80k	0.140***	0.141***	0.141***	0.141***	0.141***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Household income: >$80k	0.178***	0.178***	0.178***	0.178***	0.178***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
On welfare	0.076***	0.078***	0.076***	0.076***	0.076***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Owns Home	-0.035***	-0.034***	-0.035***	-0.035***	-0.035***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
High School Graduate	0.256***	0.256***	0.256***	0.256***	0.256***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Some College	0.296***	0.296***	0.296***	0.296***	0.296***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
College Graduate	0.244***	0.244***	0.243***	0.243***	0.243***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Children in Home	-0.046***	-0.047***	-0.047***	-0.047***	-0.047***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Height (in inches)	0.012***	0.012***	0.012***	0.012***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Native Canadian	0.272***	0.272***	0.273***	0.272***	0.273***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Quebec	1.103***	1.075***	0.977***	1.034***	1.021***
	(0.168)	(0.162)	(0.169)	(0.168)	(0.169)
Ontario	2.592***	2.536***	2.344***	2.456***	2.431***
	(0.327)	(0.315)	(0.328)	(0.327)	(0.329)
Saskatchewan	1.238***	1.212***	1.121***	1.174***	1.162***
	(0.157)	(0.151)	(0.157)	(0.157)	(0.157)
Gambling Facilities per Capita	1.551***	1.517***	1.401***	1.468***	1.453***
	(0.197)	(0.190)	(0.198)	(0.197)	(0.198)
Intercept	-5.665***	-5.572***	-5.257***	-5.441***	-5.400***
	(0.548)	(0.528)	(0.550)	(0.547)	(0.550)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; standard errors in parentheses

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