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Population Attributable Risk of Cardiovascular Disease Associated with not Meeting Physical Activity Guidelines in Montana Adults

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Abstract **Background**: Coronary heart disease (CHD) is the number 1 cause of death in United States (U.S.) with stroke also a leading killer at number 5. Aside from decreased quality of life and increased years of potential life lost (YPLL), cardiovascular disease (CVD) has a major impact on health care costs. While many CVD events can be prevented by adopting a healthy lifestyle, data quantifying this are sparse. The aim of this study was to assess the proportion of CVD cases that can be attributed to not meeting physical activity (PA) guidelines in a specific adult population. **Methods**: The Montana Behavioral Risk Factor Surveillance System (BRFSS, 2019) was used for this study. A dichotomous PA variable was created indicating whether or not a participant met current PA guidelines. Seven other healthy lifestyle variables were created and included smoking, alcohol consumption, overweight status, vegetable consumption, fruit consumption, and, health coverage. Three different outcome variables were used and included CHD, stroke, and CVD (CHD or stroke). Logistic regression was used to examine the relationship between PA and each CVD outcome while controlling for healthy lifestyle factors and sociodemographic variables. Population attributable risk (PAR) percentages were computed substituting PA odds ratio (OR) values into Levin's formula. **Results**: Prevalence of reported CHD, stroke, and CVD were 6.7%, 3.1%, and 8.7%, respectively. Additionally, prevalence of each CVD outcome was significantly (*p*s < .05) higher in adult groups not meeting PA guidelines, as compared to their more active counterparts. PA was significantly related to CHD (OR = 1.36, 95% CI: 1.04 – 1.79) and CVD (OR = 1.32, 95% CI: 1.02 – 1.71) in fully adjusted models and suggestively related to stroke (OR = 1.24, 95% CI: 0.81 – 1.91). PAR analyses indicated that approximately 12.1%, 8.4%, and 10.8% of CHD, stroke, and CVD cases (respectively) could be prevented in Montana with PA intervention. **Conclusion**: This study found that after controlling for several healthy lifestyle factors, not meeting PA guidelines independently contributes to a sizable number of CVD cases in Montana. Health promotion programming leaders should use such PAR statistics to drive the needs assessment process and plan for PA interventions.

Keywords: *Physical activity (PA), healthy lifestyles, Population attributable risk (PAR), Montana health promotion*

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1. Introduction

Coronary heart disease (CHD) is the leading cause of death in the United States (U.S.), killing over 650,000 people in 2018 alone [1]. CHD is the most prevalent type of heart disease and relates to the inability of the coronary arteries to supply oxygen to the myocardium [2,3]. Stroke, or cerebrovascular disease, is the fifth leading cause of death in the U.S., responsible for over 145,00 deaths in 2018 [1]. Stroke is defined as sudden brain cell death due to lack of oxygen either by artery blockage (ischemic stroke) or artery rupture (hemorrhagic stroke) [4,5]. The social and health-related consequences from these cardiovascular diseases (CVD) include increased years lost due to disability (YLD), increased years of life lost (YLL) and increased disability-adjusted life years (DALY) [6]. Additionally, CVD inflicts a financial liability on the health care system. Specifically, in 2016 costs due to CVD were approximately $500 billion and are projected to reach over $1.1 trillion by 2035 [7].

To combat such burdens, The U.S. Department of Health and Human Services' *Healthy People* framework created objectives specifically targeting CVD and includes reducing CHD and stroke deaths from 88.0 to 71.1 (per 100,000) and 37.0 to 33.4 (per 100,000), respectively, by year 2030 [8]. These goals have greater likelihood of being met with widespread attention and adoption of the American Heart Association's (AHA) 2020 Strategic Impact Goals [9]. Briefly, adults should achieve "ideal" levels of both the health behavior metrics of smoking, body mass index (BMI), physical activity (PA), and diet as well as health factor metrics of cholesterol, blood pressure, and blood glucose. Although each AHA cardiovascular health metric (aka, *Life's Simple 7*) is known to have a positive impact on heart health, the extent to which PA specifically relates to CVD in light of other healthy lifestyle factors is less understood. Therefore, the purpose of this research was to assess the proportion of CVD cases that can be attributed to not meeting PA guidelines in a specific adult population.

2. Materials & Methods

2.1. Study Procedures

The 2019 Behavioral Risk Factor Surveillance System (BRFSS) was used for this research [10,11]. The BRFSS is a state-based annual telephone survey designed to collect data on adult health risk behaviors that lead to premature morbidity and mortality. The BRFSS samples noninstitutionalized U.S. individuals 18+ years of age. Only Montana participants of the BRFSS were used for this study.

2.2. Physical Activity (PA) Guidelines Variable

A dichotomous PA variable was constructed where participants were classified as either those that "met" or "did not meet" PA guidelines. Meeting PA guidelines was determined from a series of questions asking participants about their PA and exercise during the previous month. After reporting the types of activities, the usual frequency, and typical duration, a total minutes of PA per week was computed for each respondent. Those reporting 150+ minutes of total PA per week were considered those that "met" PA guidelines. Those reporting less than 150 minutes of total PA per week were considered those that "did not meet" PA guidelines [12].

2.3. Healthy Lifestyle Variables

Six other binary ("high risk" vs. "low risk") healthy lifestyle variables were created and used as independent variables. A smoking variable was created from questions asking participants if they smoked at least 100 cigarettes in their entire life and if they currently smoke every day, some days, or not at all. Participants reporting having ever smoked 100+ cigarettes and reporting currently smoking every day or some days were considered "high risk" for smoking. An alcohol consumption variable was created from questions asking participants how many days per week they consumed alcohol and how many drinks per occasion they consumed alcohol on average (in the previous 30 days). Participants who reported having more than 14 drinks per week (males) or who reported having more than 7 drinks per week (females) were considered "high risk" for alcohol consumption. A health insurance variable was created from a question asking participants if they had any kind of health care coverage. Participants who reported "no" were considered "high risk" for health insurance. A BMI variable was created from self-reported height and weight where participants were considered "high risk" for overweight if their BMI exceeded 25.0 kg/m^2. A vegetable consumption variable was created from a series of questions asking participants how often they ate dark green vegetables, potatoes, and other vegetables. Participants who reported less than 1 time per day were considered "high risk" for vegetable consumption. Finally, a fruit consumption variable was created from a series of questions asking participants how often they consumed fruit or fruit juice. Participants who reported less than 1 time per day were considered "high risk" for fruit consumption.

2.4. CVD Outcome Variables

Three different binary CVD variables were created and used as separate outcome variables. CHD was assessed from a series of questions asking participants if a doctor, nurse, or other health professional ever told them that they had a heart attack, myocardial infarction, angina, or coronary heart disease. Participants who reported "yes" to either were considered having CHD. Similarly, stroke was assessed from a single question asking participants if a doctor, nurse, or other health professional ever told them that they had a stroke. Participants who reported "yes" were considered having cerebrovascular disease. Finally, an overall CVD variable was constructed where participants having either CHD or stroke were considered having CVD.

2.5. Demographic Variables

In order to control for possible sociodemographic confounding, sex, age, race, education, income, and urban/rural status were used in this study. Sex was a categorical variable represented by two groups: males and females. Age was a categorical variable ranging from 18 to 65+ years. Race was a categorical variable and comprised the following four groups: 1) Non-Hispanic White, 2) American Indian, 3) Mexican/Hispanic, and 4) Multi-racial. Education was a categorical variable consisting of the following four groups: 1) Did not graduate high school, 2) graduated high school, 3) attended some college, and 4) graduated college. Income was a categorical variable, collected as family income, and comprised five different income brackets consisting of: < $15,000, $15,000 to 24,999, $25,000 to 34,999, $35,000 to 49,999, $50,000 and over. Finally, urban/rural status was a categorical variable indicating whether the participant resides in an urban or rural region.

2.6. Statistical Analyses

Statistical analyses included prevalence estimates (%) and standard errors (SEs) for CVD outcomes across sociodemographic characteristics and healthy lifestyle factors. Test for difference in prevalence estimates were performed using the Rao-Scott chi-square (χ^2_{RS}) test of independence. Multiple logistic regression was then used to examine the independent effects of PA on each CVD outcome while controlling for other healthy lifestyle factors. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported to evaluate the PA and CVD association. Fully adjusted regression models controlled for smoking, BMI overweight status, alcohol consumption, health care coverage, fruit consumption, and vegetable consumption, as well as sex, age, race/ethnicity, income, education, and rural/urban status. Population attributable risk (PAR) percentages were computed substituting PA odds ratio (OR) values into Levin's formula [13,14]. As follows:

$$PAR = \frac{p(RR-1)}{1+p(RR-1)}$$

Where *p* is the population prevalence of the risk factor and *RR* is the relative risk of the outcome given risk factor exposure. However, ORs were substituted for RRs in this study, as described elsewhere [13]. The PAR in this research was defined as the proportion by which the outcome prevalence in the population would be reduced if the exposure were eliminated [15,16]. Analyses were weighted to produce generalizations representative of noninstitutionalized adults in Montana. SAS version 9.4 and SPSS version 27 were used for all analyses [17,18].

3. Results

A total of 6,444, 6,469, and 6,434 participants had complete CHD, stroke, and CVD data with 5,952, 5,977, and 5,945 having complete outcome and PA data, respectively. Table 1 contains prevalence estimates of CVD outcomes by sociodemographic characteristic along with significance tests. With few exceptions, sociodemographic differences were similar across all three CVD outcomes. Specifically, adults that were male, older, of lower income, and lower education saw significantly (*ps* < .0001) greater CVD prevalence, as compared to their respective counterparts. Significant differences were not observed across race/ethnicity groups or urban/rural status but trended toward greater CVD prevalence in multiracial and rural adults, as compared to their respective counterparts. Table 2 contains prevalence estimates of CVD outcomes by healthy lifestyle factor. Of primary interest, prevalence of each CVD outcome was significantly (*ps* < .05) greater in adults not meeting PA guidelines, as compared to their more active counterparts. Conversely, prevalence of CHD and CVD were significantly (*ps* < .05) lower in adults without health coverage, as compared to their insured counterparts.

Table 3 contains results from the logistic regression models describing the risk associated with not meeting physical activity (PA) guidelines on each CVD outcome. In the main adjusted models, adjusted for age, sex, BMI, and smoking, PA was significantly related to CHD (OR = 1.49, 95% CI: 1.17 – 1.89), stroke (OR = 1.48, 95% CI: 1.01 – 2.15) and CVD (OR = 1.47, 95% CI: 1.17 – 1.83). However, in the fully adjusted models, PA was significantly related to only CHD (OR = 1.36, 95% CI: 1.04 – 1.79) and CVD (OR = 1.32, 95% CI: 1.02 – 1.71) and suggestively related to stroke (OR = 1.24, 95% CI: 0.81 – 1.91).

Table 1. Prevalence of cardiovascular disease (CVD) outcomes by sociodemographic characteristic in Montana adults, 2019

Sociodemographic characteristic	CHD				Stroke				CVD			
	N	%	*SE*	*p*	*N*	%	*SE*	*p*	*N*	%	*SE*	*p*
Overall	6,444	6.7	0.34	< .0001	6,469	3.1	0.25	< .0001	6,434	8.7	0.39	< .0001
Sex	6,444			< .0001	6,469			.5528	6,434			< .0001
Males	3,157	8.4	0.52		3,176	3.3	0.37		3,156	10.3	0.59	
Females	3,287	5.0	0.42		3,293	3.0	0.35		3,278	7.1	0.51	
Age Group (yr)	6,444			< .0001	6,469			< .0001	6,434			< .0001
18 to 24	415	0.6	0.45		419	0.6	0.57		415	1.2	0.73	
25 to 34	656	1.8	0.62		658	0.3	0.24		656	2.0	0.66	
35 to 44	780	2.0	0.65		781	1.5	0.55		779	3.1	0.77	
45 to 54	786	5.1	0.94		784	2.9	0.82		784	6.7	1.10	
55 to 64	1,368	7.2	0.81		1,368	3.5	0.58		1,366	9.7	0.93	
65+	2,439	16.4	0.87		2,459	7.0	0.66		2,434	20.8	0.99	
Race/Ethnicity	6,244			.4060	6,268			.6863	6,234			.4916
White	5,441	6.6	0.36		5,466	2.9	0.26		5,432	8.5	0.41	
American Indian	491	7.7	1.32		491	3.1	0.81		490	9.5	1.47	
Hispanic	139	7.5	2.42		138	3.6	1.70		139	7.8	2.43	
Multiracial	173	10.9	3.28		173	4.9	1.70		173	13.0	3.39	
Income ($)	5,474			< .0001	5,492			< .0001	5,468			< .0001
<15,000	480	9.6	1.45		481	8.7	1.65		477	14.9	1.94	
15,000 to 24,999	870	9.1	1.03		871	4.5	0.75		867	11.7	1.16	
25,000 to 34,999	617	5.6	0.97		624	2.7	0.80		615	8.0	1.24	
35,000 to 49,999	876	8.0	1.08		879	4.9	0.90		878	11.0	1.26	
50,000+	2,631	5.1	0.46		2,637	1.1	0.19		2,631	5.8	0.48	
Education	6,428			< .0001	6,453			< .0001	6,418			< .0001
Did not graduate high school	321	12.6	2.07		320	8.8	1.97		319	18.0	2.55	
Graduated high school	1,748	6.5	0.58		1,770	2.7	0.41		1,746	8.3	0.66	
Attended some college	2,010	6.8	0.58		2,008	3.3	0.41		2,003	8.8	0.66	
Graduated college	2,349	5.2	0.47		2,355	1.8	0.26		2,350	6.6	0.52	
Rural Status	6,444			.1460	6,469			.0695	6,434			.0675
Urban	3,420	6.3	0.42		3,435	2.8	0.31		3,417	8.2	0.49	
Rural	3024	7.3	0.55		3,034	3.7	0.45		3,017	9.7	0.64	

Note. CHD is coronary heart disease. CVD is cardiovascular disease. Sample sizes (*N*s) are overall for that sociodemographic group responding to that CVD assessment. % is prevalence estimate.SE is standard error. *p*-values are for Rao-Scott chi-square χ^2_{RS} statistic.

Table 2. Prevalence of cardiovascular disease (CVD) outcomes by healthy lifestyle factor in Montana adults, 2019

Healthy lifestyle factor	CHD				Stroke				CVD			
	N	%	*SE*	*p*	*N*	%	*SE*	*p*	*N*	%	*SE*	*p*
Physical activity (PA)	5,952			.0007	5,977			.0158	5,945			.0003
Met guidelines	3,681	5.7	0.40		3,694	2.6	0.28		3,678	7.4	0.46	
Did not meet guidelines	2,271	8.1	0.65		2,283	3.9	0.53		2,267	10.4	0.76	
Body mass index (BMI)	5,998			.0021	6,021			.1006	5,990			.0001
Not overweight	1,983	5.5	0.53		1,989	2.6	0.39		1,980	6.9	0.60	
Overweight	4,015	7.8	0.46		4,032	3.5	0.36		4,010	10.1	0.54	
Smoking	6,253			.1249	6,277			.0256	6,243			.0594
Not a current smoker	5,313	6.5	0.36		5,325	2.8	0.27		5,304	8.4	0.43	
Current smoker	940	8.0	0.98		952	4.4	0.75		939	10.5	1.11	
Alcohol consumption	6,161			.4048	6,184			.5119	6,151			.6321
Not a heavy drinker	5,659	6.9	0.36		5,682	3.2	0.27		5,651	8.8	0.41	
Heavy drinker	502	5.7	1.29		502	2.4	0.99		500	8.0	1.59	
Fruit consumption	5,976			.0395	5,998			.5915	5,967			.2502
Consumes 1+ per day	3,664	6.0	0.41		3,675	3.1	0.36		3,658	8.1	0.51	
Does not consume 1+ per day	2,312	7.5	0.60		2,323	2.8	0.37		2,309	9.0	0.65	
Vegetable consumption	5,837			.2263	5,857			.1072	5,828			.1207
Consumes 1+ per day	4,855	6.3	0.38		4,866	2.7	0.26		4,847	8.0	0.43	
Does not consume 1+ per day	982	7.5	0.93		991	3.8	0.77		981	9.7	1.09	
Health coverage	6,404			.0021	6,429			.1404	6,394			.0042
Has coverage	5,956	7.1	0.36		5,978	3.3	0.27		5,946	9.2	0.42	
Does not have coverage	448	3.0	0.88		451	1.5	0.83		448	4.2	1.19	

Note. CHD is coronary heart disease. CVD is cardiovascular disease. Sample sizes (*N*s) are overall for that healthy lifestyle category responding to that CVD assessment. % is prevalence estimate.SE is standard error. *p*-values are for Rao-Scott chi-square χ^2_{RS} statistic.

Table 3. Logistic regression models describing the risk associated with not meeting physical activity (PA) guidelines on cardiovascular disease (CVD) in Montana adults, 2019

CVD outcome	Not Adjusted				Main Adjusted				Fully Adjusted			
	N	*OR*	*LL*	*UL*	*N*	*OR*	*LL*	*UL*	*N*	*OR*	*LL*	*UL*
CHD	5,952	**1.47**	1.17	1.84	5,642	**1.49**	1.17	1.89	4,570	**1.36**	1.04	1.79
Stroke	5,977	**1.54**	1.08	2.20	5,667	**1.48**	1.01	2.15	4,586	1.24	0.81	1.91
CVD	5,945	**1.46**	1.19	1.79	5,637	**1.47**	1.17	1.83	4,564	**1.32**	1.02	1.71

Note. Odds ratios (ORs) in bold are significant (*p*s < .05). LL and UL are the lower limit and upper limit for the 95% confidence interval estimating population OR. Main adjusted model adjusted for age, sex, smoking status, and overweight status. Fully adjusted model included main covariates plus adjusted for race, education, income, rural/urban status, alcohol consumption status, health care coverage, fruit consumption, and vegetable consumption.

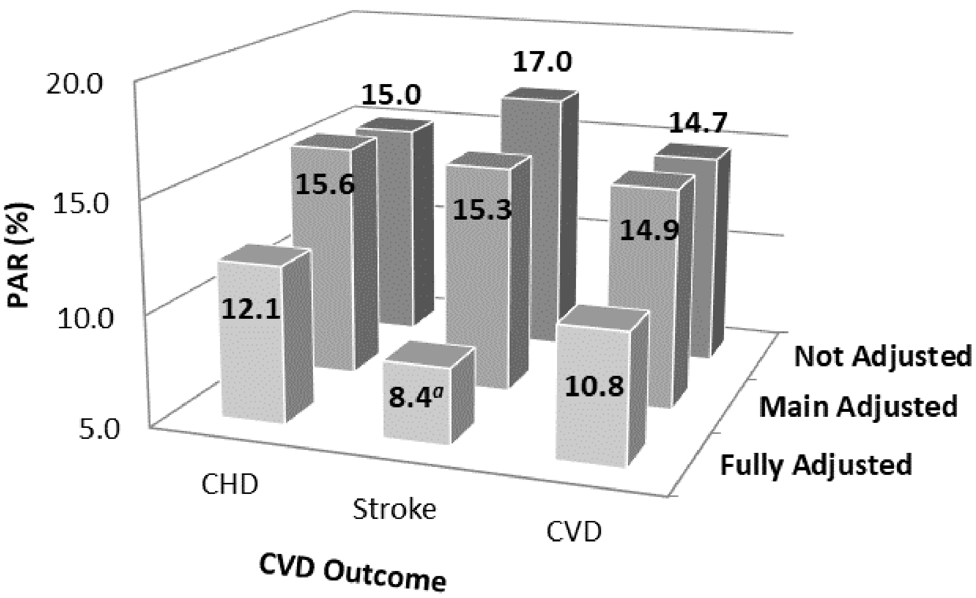

Figure 1. Isometric chart of population attributable risk (PAR) associated with not meeting physical activity (PA) guidelines on cardiovascular disease (CVD) in Montana adults, 2019. (Note. Sample sizes displayed in Table 3. All PARs computed substituting PA odds ratio (OR) from logistic regression into Levin's formula. Main adjusted model adjusted for age, sex, smoking status, and overweight status. Fully adjusted model included main covariates plus adjusted for race, education, income, rural/urban status, alcohol consumption status, health care coverage, fruit consumption, and vegetable consumption. Fully adjusted OR for PA and stroke was not significant, however, could be considered suggestive.)

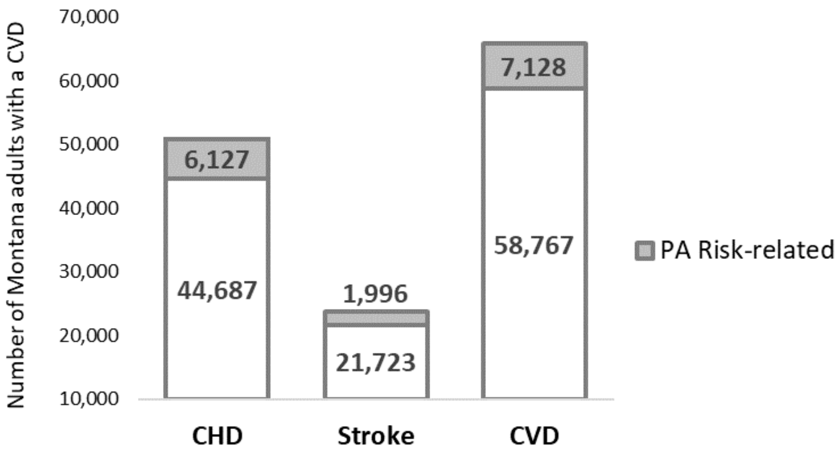

Figure 2. Bar graph displaying the number of CVD cases in the Montana population that might be prevented with widespread adherence to PA guidelines, 2019

Figure 1 displays results from the PAR analyses using unadjusted, main adjusted, and fully adjusted ORs. The graph indicates that adjustments of both sociodemographic and other healthy lifestyle factors reduces the PA and CVD relationship. Specifically, approximately 12.1%, 8.4%, and 10.8% of CHD, stroke, and CVD cases (respectively) can be attributed to not meeting PA guidelines. Thus, these respective proportions of CVD cases could be prevented in Montana with PA intervention. Figure 2 highlights these results with a bar graph indicating the raw number of CVD cases in the Montana population that might be prevented by zeroing out the prevalence of adults not meeting PA guidelines.

4. Discussion

The purpose of this study was to assess the proportion of CVD cases that can be attributed to not meeting PA guidelines among adults in Montana. The approach that was used to address this aim was computation of the attributable risk measures and specifically PAR measures. The benefit of evaluating this research using the PAR is twofold. Firstly, the PAR accounts for both the relationship between PA risk and CVD (i.e., the OR from logistic regression) as well as the amount of risk exposure in the population (i.e., prevalence estimates of PA risk). Secondly, the PAR calculation allows for the use of adjusted ORs, controlling for other healthy lifestyle factors (and sociodemographic variables). Using adjusted ORs allows this research to estimate the amount of CVD risk specifically credited to not meeting PA guidelines. Thus, this study found that PA contributes to approximately a 10^{th} of CVD among Montana adults. These findings are consistent with that of other studies in U.S. as well as foreign populations [19,20]. The lack of significant association between PA and stroke in fully adjusted analyses is worthy of mention. The associations found between PA and stroke were firstly relatively smaller in comparison and secondly lacked power due to the smaller number of stroke cases in the sample. Therefore, fully adjusted PAR values were computed for stroke but with a note of caution.

A strength regarding this study was the use of a current (2019) and representative sample of noninstitutionalized adults in Montana. As well, this study used several different healthy lifestyle variables and outcome measures that have a long established history in the BRFSS. Finally, the use of PAR measures to assess the amount of PA contribution toward CVD in Montana adults is novel and adds depth to this research.

The most concerning limitation regarding these study findings is that the BRFSS is a cross-sectional survey. Thus, only correlational interpretations can be inferred with no implied cause-and-effect associations between PA and CVD outcomes. As a consequence, this study is unable to determine the extent to which not meeting PA guidelines causes CVD or the extent to which CVD causes decreased PA behavior. Another limitation worth stating is that the BRFSS variables are assessed by interviewers and self-reported by the participants. Therefore, there may be measurement error in variable assessment that is not accounted for in this study. A final limitation regarding this research is its inability to assess all CVD-related risk factors. That is, the 2019 BRFSS only assessed PA, BMI, smoking, alcohol, fruit consumption, vegetable consumption, and health care coverage. Hence, other healthy lifestyle factors or risk factors related to CVD but not assessed could impact the adjusted PAR values. For example, a more comprehensive assessment of diet similar to the Healthy Eating Index (as in the National Health and Nutrition Examination Survey) could change the PAR values found in this study [21]. In sum, results from this research should be interpreted with caution.

5. Conclusions

This study found that after controlling for several healthy lifestyle factors, not meeting PA guidelines independently contributes to a sizable number of CVD cases in Montana. Health promotion programming leaders should use such PAR statistics to drive the needs assessment process and plan for PA interventions.

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