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EXERCISE IS MEDICINE® ON CAMPUS: A NATIONAL ANALYSIS AND ASSESSMENT OF COMMUNITY IMPACT

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A NATIONAL ANALYSIS AND ASSESSMENT OF COMMUNITY IMPACT

By

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Abstract

Introduction: The American College of Sports Medicine (ACSM) founded the Exercise is Medicine® on Campus (EIM-OC) initiative, which calls upon colleges and universities to promote physical activity on their campuses. The distribution of EIM-OC programs across the U.S. has not been reported. In addition, the impact that EIM-OC programs have on community-level physical activity prevalence is unknown. The purpose of my thesis was to evaluate and enhance the EIM-OC initiative to promote physical activity and overall health in the U.S. **Methods:** Recognized EIM-OC programs in the U.S. (n=131) were described based on local, county, state, and regional-level variables. Local variables included recognition level, school population, presence of a kinesiology-related degree, type of on-campus health care services, presence of a medical school on campus, as well as city population. County-level variables included population and designation of metro or non-metro county. The state and ACSM region that the program was in was also collected. Using a cross-sectional study design, physical activity prevalence of 1,296 eligible U.S. counties was predicted by the presence of an EIM-OC program among other health factors using multivariate linear regression. **Results:** Thirty-seven U.S. states had an EIM-OC program, while 27 states had a gold level program. Eighty-six percent of EIM-OC programs had a kinesiology-related degree program, with 76% of programs having student centered health services. School (p=0.21), city (p=0.14), and county (p=0.32) populations did not differ between recognition levels. Nearly 90% of total and gold EIM-OC programs were in metropolitan counties and 10% were in non-metropolitan counties. Adjusted multivariate regression modelling indicated that bronze (p=0.89), silver (p=0.07), and gold (p=0.67) level EIM-OC programs were not significant predictors of county-level physical activity prevalence. However, when accounting for other health factors (e.g., smoking, education, rurality), the model explained 78% of the variability in county-level physical activity prevalence ($p<0.001$). **Discussion:** Collectively, these results indicate that colleges and universities of all sizes can use EIM-OC to successfully promote physical activity on their campuses. Further promotion to help increase frequencies of participating EIM-OC campuses in states, regions, and non-metro areas across the U.S. is warranted.

Thesis Overview

The overarching goal of this thesis project was to evaluate and enhance the impact of the Exercise is Medicine® on Campus initiative to promote physical activity and overall health in the U.S. In this thesis I start by providing a review of the literature. I then discuss physical inactivity as a public health problem, as well as the accompanied risks of a physically inactive lifestyle. Furthermore, I discuss the benefits of regular aerobic and muscle strengthening exercise regarding the prevention of chronic disease. Next, I discuss the Exercise is Medicine® and Exercise is Medicine® on Campus initiatives, which identifies supporting literature and leads towards gaps in the literature, as well as the rationale for this thesis. Subsequently, I then provide a concise two-page double-spaced introduction that sets up my three aims: 1) perform a national analysis of the recognized EIM-OC programs across the U.S., 2) examine the impact of EIM-OC programs on their surrounding communities, and 3) promote the EIM-OC initiative through infographic creation. I then discuss the methodology that I used to conduct my study, which includes descriptions of data collection and statistical analyses for each of my aims. Following this, I share ensuing results before interpreting the findings from my project. I end by discussing some notable implications of this work and share some limitations of the study. An overview of this thesis project can be viewed in Figure 1.

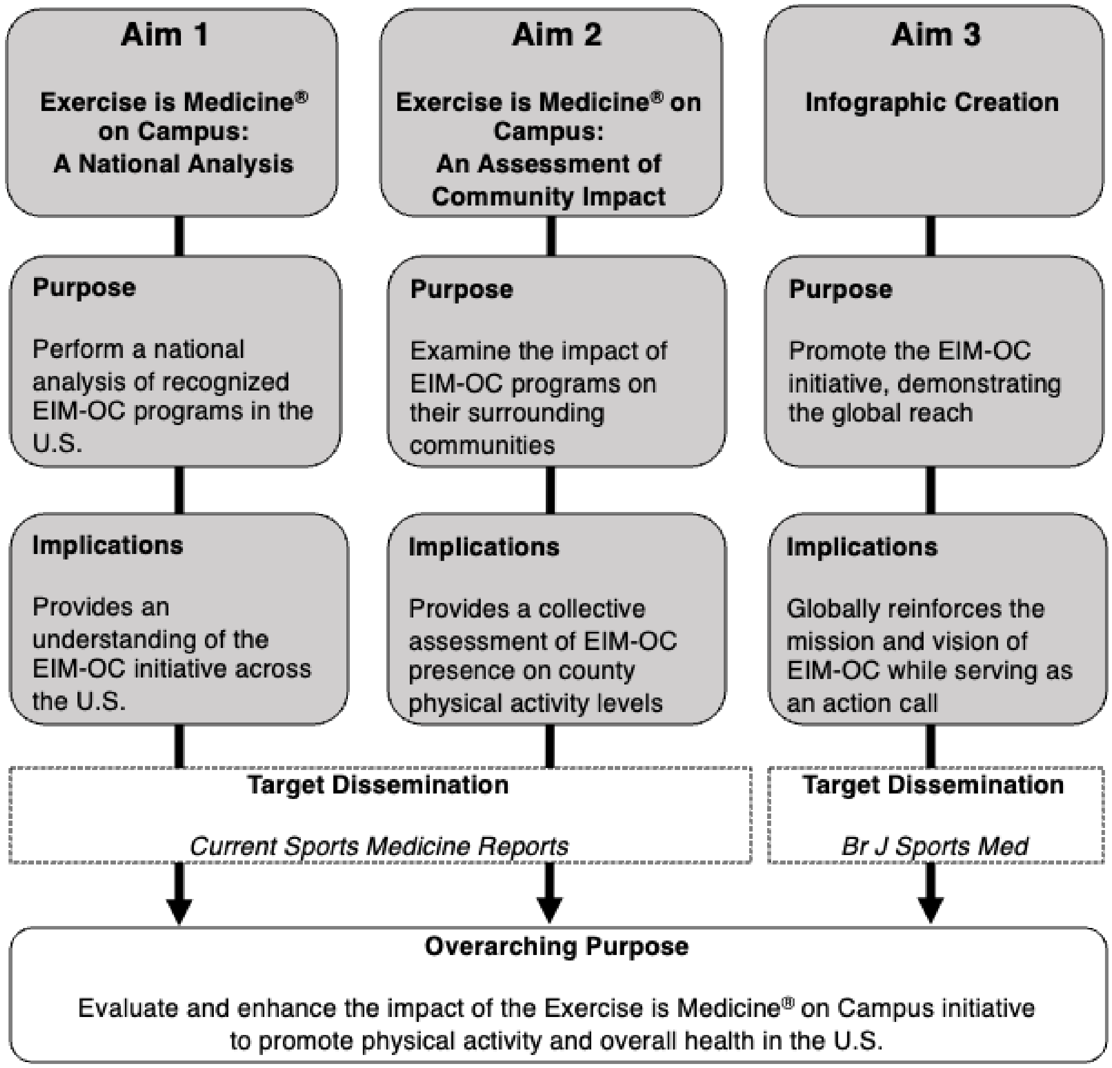

Figure 1. Thesis project overview

1 Review of Literature

This review of literature provides evidence of physical inactivity as a major public health problem, as well as the detrimental health effects of a physically inactive lifestyle from individual and community perspectives. The current physical activity guidelines and resulting health benefits of aerobic and muscle strengthening exercise are discussed. Additionally, the Exercise is Medicine® on Campus (EIM-OC) initiative and recognition program are introduced. Lastly, examples of collaborative campus and community health promotion initiatives are discussed, as well as physical activity advocacy examples in highly cited publications. The literature search was conducted using PubMed and Google Scholar from 1869 to present. Articles in English were included in the literature search. The search was conducted using the following keywords: “physical activity”, “physical inactivity”, “social determinants of health”, “muscle strengthening”, “rural”, “exercise is medicine”, “exercise is medicine on campus”.

1.1 Physical Inactivity as a Public Health Problem

Physical inactivity is defined by the World Health Organization[1] as achieving less than 150 minutes of moderate-intensity activity per week. Physical inactivity is the fourth leading risk factor for worldwide mortality, contributing to over three million deaths annually[2]. Globally, self-reported estimates have approximated that ~28% of adults[3] and ~80% of adolescents[4] worldwide do not receive adequate physical activity. In the U.S., ~80% of adults do not meet both aerobic exercise and muscle strengthening guidelines[5], which include a minimum of 150 minutes of moderate intensity aerobic exercise per week (e.g. brisk walking, cycling, swimming), and two days per week of muscle strengthening activity (e.g. calisthenics, lifting weights).

The detrimental effects of physical inactivity are not novel phenomena. In the early 1950's, Morris and colleagues[6] published a landmark study investigating the incidence of coronary heart-disease among bus drivers (less active) and conductors (more active). These authors reported that age-standardized rates of annual coronary heart-disease incidence were 2 / 1,000 men in the conductors, but 2.7 / 1,000 men in the less active drivers indicating that the conductors had fewer than half the heart attacks of their sedentary colleagues. In 2009, Blair[7] described physical inactivity as one of the most important public health problems of the 21st century. At this time, physical activity was undervalued and overshadowed in comparison to other health issues. In 2012, *The Lancet* was the first major medical journal to highlight the importance of physical activity through a series[8] of papers focused on this topic. For instance, Kohl and colleagues[9] stated that given the prevalence of physical inactivity, and the widespread health, economic and social concerns, physical inactivity should be described as pandemic. In related work, Reis and colleagues[10] discussed updates and challenges of physical activity implementation as a supplement to the 2012 series. A sense of urgency was brought forward, and in this instance, all sectors of government and community were tasked to take immediate action to help make healthy active living a more affordable, accessible, and available choice across all population groups.

1.1.1 Risks Associated with Physical Inactivity

Physical inactivity is associated with the development of a multitude of chronic conditions, such as cardiovascular disease, breast, colon and lung cancers, type-two diabetes, obesity, hypertension, and anxiety and depression[11-13]. It was estimated that approximately 11% of annual health care costs from 2006-2011 in the U.S. were attributable to inadequate aerobic physical activity, which totaled ~$117 billion[14]. Furthermore, estimated healthcare costs within U.S. adults aged 65 or above that are attributable to the progressive loss of muscle mass and strength reach ~$19 billion[15]. As a collective nation, physical inactivity impacts national security. In a fact sheet presented by the Centers for Disease Control and Prevention[16], it was estimated that ~70% of young adults in the U.S. would be ineligible to join the military if they wanted to, due to being overweight or obese. This leaves the national security of the U.S. at risk. Thus, physical inactivity burdens our society from multiple perspectives.

1.1.2 Physical Inactivity and COVID-19

Stay at home orders, shelter in place, and business closures imposed during the COVID-19 pandemic resulted in decreased rates of physical activity and increased sitting time[17] due to social isolation and indoor confinement. In a ground breaking study, Sallis and colleagues[18] compared hospitalization rates, intensive care unit admissions, and mortality incidence for over 48,000 COVID-19 patients with differing physical activity levels. Electronic health record data from Kaiser Permanente Healthcare System were used to examine self-reported physical activity parameters in the two years prior to the COVID-19 pandemic. The data were categorized into three separate physical activity levels: consistently meeting physical activity guidelines (>150 minutes / week), some activity (11-149 minutes / week), and consistently inactive (0-10 minutes / week). A positive association was found between meeting physical activity guidelines prior to COVID-19 and reduced odds for severe COVID-19 outcomes. A physically inactive lifestyle served as the third strongest independent risk factor for COVID-19 hospitalization (OR 2.26; 95% CI 1.81 to 2.83) other than advanced age (OR 2.30; 95% CI 2.10 to 2.52) or history of organ transplant (OR 2.78; 95% CI 1.88 to 4.10).

These conclusions were reinforced by Ezzatvar and colleagues[19] who conducted a systematic review and meta-analysis, with a sample size exceeding 1.8 million adults. The main finding was that physically active individuals had lower relative risk of infection (RR 0.89; 95% CI 0.84 to 0.95), hospitalization (RR 0.64; 95% CI 0.54 to 0.76), severe illness (RR 0.66; 95% CI 0.58 to 0.77), as well as COVID-19 related death (RR 0.57; 95% CI 0.46 to 0.71) in comparison to their physically inactive counterparts. The largest protective benefits were observed when physical activity guidelines were met. Through objective measurement, evidence suggests[20] that increased rates of estimated cardiorespiratory fitness (i.e., volume of oxygen consumption) measured through sub-maximal cycle ergometry were suggested to have protective effects against severe COVID-19 infection. It was found through approximately 275,000 adults, patients with severe COVID-19 infection had significantly lower cardiorespiratory fitness, as well as a higher body mass index than healthy controls. With each milliliter of cardiorespiratory increase, a graded decrease in severe COVID-19 odds risk was observed (OR 0.98; 95% CI 0.970 to 0.998). In related work, Cunningham[21] examined the association of county-level physical activity with COVID-19 cases and deaths. The findings from this study indicated a negative association between physical activity and county-level COVID-19 cases and deaths. Accordingly, physical activity serves as a protective buffer against COVID-19 at both an individual as well as community level. Taken together, the physical inactivity and COVID-19 pandemics have yielded a synergistic effect[22], and as a result of this, the incorporation of physical activity as a daily living habit is currently of uttermost importance.

1.1.3 Social Determinants of Health

The World Health Organization[23] defines social determinants of health as conditions that individuals are born in, that continue through lifespan development to residence and occupation. Major social determinants of health include neighborhoods and built environments, health care access, social and community context, education, and economic stability[24]. In rural areas, lower educational attainment, higher levels of poverty, less infrastructure, and increased distances between health promoting resources are frequently observed[25]. There are reported associations between environmental attributes that support healthy living behaviors and physical activity that differ between urban and rural environments. For instance, neighborhood walkability[26] has been reported to benefit physical activity prevalence among urban residents. The prevalence of meeting aerobic, muscle-strengthening, and combined aerobic and muscle-strengthening guidelines are lower in rural areas[27]. Currently, more than 60 million Americans live in rural areas[28], where rural residents are more prone to having more than one chronic health condition (i.e., hypertension, arthritis, coronary heart disease)[29]. Rural residents experience higher rates of social determinants of health such as poverty, smoking, and uninsured prevalence than their urban counterparts[30]. Knowing the negative effects of physical inactivity, the promotion of physical activity can be leveraged especially in rural communities to bridge the gap between the observed rural and urban health disparities.

1.2 Benefits of Physical Activity on Prevention of Chronic Disease

It is well established that physical activity is a key component for the prevention and treatment of chronic disease. With considerable evidence supporting whole-body physical activity benefits, this affordable, accessible treatment is considered to be one of the best buys in public health[31]. Arem and colleagues[32] reported decreased hazard ratios for mortality across a wide range of physical activity levels. Compared to a baseline of zero reported leisure-time physical activity, a dose-response association found a mortality risk that was 20% decreased (HR 0.8; 95% CI 0.78 to 0.82) among the group that was below recommended guidelines (i.e., 150 minutes per week), 31% (HR 0.69; 95% CI 0.67 to 0.70) decreased mortality risk among the group that was 1-2x above the minimum guidelines, and a 37% (HR 0.63; 95% CI 0.62 to 0.65) decreased mortality risk amongst the group that were 2-3x above the minimum guidelines. A maximum threshold for dose-response benefits were observed at 3-5x above the minimum recommendations, as a decreased risk of 39% (HR 0.61; 95% CI 0.59 to 0.61) was observed. Warburton and colleagues[33] conducted a systematic review that identified the beneficial health effects of physical activity on chronic conditions (cardiovascular disease, stroke, hypertension, colon cancer, breast cancer, and type-two diabetes). When comparing physically active and inactive individuals, it was observed that active individuals experience a 33% risk reduction towards experiencing cardiovascular disease, as well as a 32% risk reduction in hypertension. Colon and breast cancer experience 30% and 20% risk reductions, respectively. As already stated, physical activity has protective effects against severe COVID-19 outcomes among those who are infected[18-20]. Therefore, it is suggested that physical activity has preventative effects against heart disease, cancer, and COVID-19, which were the three leading causes of death in 2020[34] and 2021[35].

Considering the health benefits of physical activity on mental health, a systematic review reported by Mammen and Faulker[36] examined the protective effects of habitual physical activity on the onset of depression. Through an analysis of 25 studies, an inverse relationship between physical activity and depressive symptom risk was observed. A meta-analysis by Schuch and colleagues[37] supported these findings, where antidepressant effects were observed in physically active individuals when compared to a non-active control group[37]. Also, Pearce and colleagues[38] found that meeting the recommended physical activity guidelines yielded a 25% decreased relative risk of experiencing depression symptoms (95% CI 0.68 to 0.82). Given the increased rates of anxiety and depression observed during the COVID-19 pandemic[39], it is even more important to leverage physical activity as a mediator of mental health symptoms.

1.2.1 Physical Activity and Immune Function

Engaging in regular physical activity is associated with numerous health benefits from an immunological perspective. A meta-analysis by Chastin and colleagues[40] investigated the effects of regular physical activity on risk of acquiring infection, innate immune parameters, as well as historical adaptive immune cell responses following vaccination. Results indicated that regular physical activity was associated with a 31% lower risk of acquiring infectious disease (HR 0.69; 95% CI 0.61 to 0.78), as well as a 36% lower risk of infectious disease-related mortality (HR 0.64; 95% CI 0.59 to 0.70). Furthermore, physically active individuals experienced higher CD4 T cell (32 cells/uL; 95% CI 7 to 56) and salivary immunoglobulin IgA (standardized mean difference 0.142; 95% CI 0.021 to 0.262) cell counts in comparison to their inactive counterparts. These adaptive immune cells assist with immunological memory, immunosurveillance, and early inflammatory response. Higher CD4 T cell counts are especially important, as it has been reported[41] that severe COVID-19 infection is associated with dysfunctional T cell function that is frequently observed in advanced age and obese individuals. Additionally, Collie and colleagues[42] assessed the association between habitual physical activity and the protective effect of COVID-19 vaccination. When compared to vaccinated individuals with low activity levels (<60 mins / week physical activity), vaccinated individuals with moderate (60-149 mins / week physical activity), and high (>150 mins / week physical activity) activity levels had 1.4 (95% CI 1.36 to 1.51) and 2.8 (95% CI 2.35 to 3.35) times lower risk of hospital admission due to COVID-19, respectively.

Therefore, habitual physical activity can provide three levels of protection against COVID-19[43]. Primary preventative measures include the decreased risk of severe COVID-19 infection as noted above[18-20]. Secondary prevention focuses on improved vaccination response in those who are physically active[42]. Lastly, physical activity has been reported to offer prevention regarding long-COVID, which is defined as continuing symptoms for at least 28 days following infection[43].

1.2.2 Muscle Strengthening Physical Activity

In addition to the health benefits from aerobic physical activity (i.e., walking, gardening, dancing) that have been reported above, there are also benefits from muscle strengthening physical activity (i.e., resistance exercise training). Resistance exercise training is associated with increases in mitochondrial fusion-related proteins[44], which is also a molecular adaptation that is often observed during aerobic training. Aerobic and resistance exercise can synergistically work together to promote beneficial health outcomes. Independent benefits of resistance training have been observed when considering improvements in cognitive function[45], and type-two diabetes[46]. Additionally, Stamatakis[47] and colleagues reported decreased hazard ratios of all-cause mortality (HR 0.79; 95% CI 0.66 to 0.94), and cancer-related mortality (HR 0.66; 95% CI 0.48 to 0.92) when adhering to only muscle strengthening guidelines. Resistance training provides protective effects against sarcopenia, which can be defined[48] as progressive loss of skeletal muscle mass and strength, which has negative implications for quality of life. World Population Prospects[49] forecasts that by the year 2050, the percentage of the global population above the ages of 65, 85, and 100 years old will increase by 188, 551 and 1,004%, respectively. Maintaining adequate muscle mass is important throughout an individual's entire lifespan. In a landmark study, Ruiz and colleagues[50] found that after controlling for potential confounders (i.e., cardiorespiratory fitness), muscular strength had an inverse association with all-cause mortality within individuals above the age of 60, with a 2x higher risk observed within individuals with low compared to high muscle strength. Therefore, it can be concluded that resistance exercise training provides health benefits that work synergistically with aerobic exercise, as well as independently.

1.2.3 Physical Activity Guidelines

The physical activity guidelines including aerobic and muscle strengthening exercise are collectively supported through numerous organizations, such as the World Health Organization, U.S. Department of Health and Human Services, American Medical Association, and American College of Sports Medicine (ACSM). Adequate physical activity for adults is defined as attaining at least 150 minutes of moderate-intensity aerobic physical activity, and 2 days per week of muscle-strengthening activity for adults[51]. While the physical activity guidelines are established to guide individuals toward optimal health benefits, Warburton and colleagues[52] have reported a dose-response relationship between physical activity and beneficial health outcomes. It is important to differentiate between physical activity and exercise. Physical activity is considered a behavior, which can be broadly defined as any bodily locomotion produced by skeletal muscle that can reference any movement, including leisure time activity (i.e., walking the dog, gardening, dancing), that yields energy expenditure movement[53]. Exercise is an extension of physical activity that includes planned, structured and repetitive movement[53].

1.3 Exercise is Medicine®

To help combat the physical inactivity public health problem, the ACSM founded the Exercise is Medicine® initiative[54] in 2007. The goal of this program is to incorporate physical activity assessment and exercise prescription into medical centers, leveraging the robust health-related benefits that physical activity has to offer. The Exercise is

Medicine® initiative began in the U.S., before later expanding globally. To leverage the most recent evidence-based research supporting physical activity, the World Congress on Exercise is Medicine® was added to the ACSM Annual meeting. Furthermore, notable expansions include collaborating with health care providers to establish continuing medical education courses regarding Exercise is Medicine®, as well as an Exercise is Medicine® Credential for fitness professionals.

1.3.1 Physical Activity Vital Sign

A commentary published by Manini[55] stated that there is not a single medication available that can replicate the beneficial, whole-body effects of physical activity. In 2009, Blair[56] advocated that primary care providers should promote habitual physical activity (e.g., 30-minute moderate to vigorous intensity physical activity) at the same frequency as they do for maintaining healthy body weight through the use of a physical activity vital sign. A vital sign (e.g., blood pressure) is used in health care to assess notable quantitative variables that are repeatedly demonstrated through literature to underlie health and disease[57]. A main pillar of Exercise is Medicine® is that physical activity should be assessed as a vital sign of health in every routine health care visit along with other common vitals such as blood pressure, pulse, respiration, and body mass index[54]. With an already-existing well-supported body of literature reporting physical activity health benefits, it would be irresponsible if primary care providers did not regularly assess physical activity, inform patients of the harms of sedentary lifestyles, and provide proper exercise programming[58]. The physical activity vital sign is a self-reported measure where the healthcare provider asks the patient to recall the frequency and duration of physical activity in the past seven days. This is recorded in electronic health records, and the primary care provider can interpret the results in accordance with the physical activity guidelines. From a patient-centered approach, the primary care provider can decide to start, modify, or maintain physical activity levels with an exercise prescription, which includes a referral to a certified exercise professional in the community.

1.4 Exercise is Medicine® on Campus

A key expansion of the Exercise is Medicine® initiative was the introduction of Exercise is Medicine® on Campus (EIM-OC) in 2009[54], which aims to create a culture of physical activity and wellness on college and university campuses[59]. The vision of EIM-OC aims to cross departmental borders throughout campus communities by advocating for students, faculty, and staff to adopt healthy living behaviors through collaborative physical activity promotion, education, and assessment initiatives. Historically, a notable way to implement physical activity amongst college students has been through physical education courses. In the 19th century, Edward Hitchcock[60] was a faculty member in the department of hygiene and physical education at Amherst College who urged the importance of playful exercises to supplement academics. This was the first instance in the U.S. where physical activity was a requirement at a college or university. This initiative catalyzed the beginning of mandatory physical education across the nation. Towards the end of the 1920s, 97% of higher education institutions across the U.S. had a physical education requirement[61]. This is concerning, as by 2012, this value had dropped to ~40%[62] as reported through a survey of 354 U.S. colleges and universities. National survey data[63] from the American College Health Association revealed factors that stress (33%), anxiety (27%) and sleep difficulties (22%) are academic success barriers that impede students. While it has already been established that U.S. adults do not regularly meet physical activity guidelines[5], the survey also reported that only 46% of college or university students are reported to meet these same guidelines[63]. The benefits that regular physical activity can have on stress and anxiety[64] have been reported. Furthermore, anxiety and depression have been associated with sleep difficulties in college students[65]. Therefore, the EIM-OC initiative may be an opportunity to leverage physical activity promotion to improve health campus-wide."

1.4.1 EIM-OC Program Components and Recognition Levels

To officially create and register an EIM-OC program, a leadership team must be established that is composed of an academic advisor and student representatives, a licensed health fitness professional, and a health care professional[59]. This facilitates a multidisciplinary approach and an academic-clinical partnership. To further incentivize creating an EIM-OC program, a recognition program has been established that allows programs to be rewarded for their efforts. Bronze, silver, and gold level acknowledgments are awarded based on the respective efforts of programs. General requirements[66] to earn each recognition level are provided for programs as a guide to plan future efforts. However, they allow for flexibility and creative discovery using the unique campus resources that are at their disposal. The central tenet of a bronze level campus focuses on the promotion of physical activity on campus through events such as Exercise is Medicine® days, step challenges, or any campus-wide options for exercise. Silver level campuses extend from bronze level efforts by providing education initiatives on physical activity. Lastly, gold level campuses facilitate routine physical activity assessment, most commonly through a physical activity vital sign by 1) assessing physical activity during student health visits, 2) prescribing physical activity for students who are below the recommended 150-minute per week guidelines, and 3) providing exercise counseling to work with students to achieve adequate physical activity levels. Additionally, other opportunities to implement routine physical activity assessment occur through counseling services (i.e., mental health or academic counseling). There are currently 131 EIM-OC programs in the U.S. that have been acknowledged for their efforts through bronze, silver, or gold level recognition[67]. However, published reports on the distribution of these EIM-OC recognized programs are lacking. The first aim of my thesis provided a national analysis of the recognized programs to determine their distribution, as well as which factors (e.g., school population, geographical location, presence of medical school) best position programs to achieve gold level status.

1.4.2 Success Stories & Barriers to Implementation

There have been some reports describing the implementation of EIM-OC programs from institutions ranging in school population. The Pennsylvania State University leveraged their EIM-OC program[68] to host an Exercise is Medicine® week-long event with the main goal of increasing exposure to the knowledge of physical activity benefits. This aim was fulfilled through exercise stations, as well as education activities. The Exercise is Medicine® week reached ~1770 students as large numbers of students were able to engage in physical activity, as well as receive exercise education and counselling.

Furthermore, Slippery Rock University[69] presented their findings from the implementation of their gold level EIM-OC program from the communication with key university stakeholders, to quantitative data reporting facilitation of the physical activity vital sign through their campus medical center. Their program yielded 20 referred patients from the student health clinic with exercise prescriptions. Undergraduate student exercise interns (with supervision from a faculty member) met with referred patients and prescribed a patient-centered exercise program. Results indicated that all patients yielded increases in their physical activity levels, as well as self-reported improvements in self-efficacy.

McEachern and colleagues[70] provided insight towards common obstacles that programs have, and what influences overall program success. A challenge within programs was communicating with busy clinicians, which is an integral part of an EIM-OC program. Furthermore, barriers were frequently observed when communicating with administration about prospective curriculum revisions to advocate for physical activity education. Lastly, a noted observed challenge was crossing departmental barriers to advocate for physical activity benefits outside of health science disciplines. This is especially important, as other degree programs likely are less educated on physical activity in general if it is not included in their course curriculum. Peterson and colleagues[71] reported that institutions with large student bodies exhibit adequate resources, while struggling with broadcasting the benefits of the program across their entire campus. Smaller institutions on the other hand, are more successful at communicating with students about programs on their campus, however they struggle with having equitable funding and support. This same study presented their findings as a scoping review of all existing EIM-OC literature, providing an analysis of key program implementation and success themes. A comprehensive review of EIM-OC literature has yielded positive results when considering physical activity promotion, education, and physical activity vital sign assessment, however, the EIM-OC initiative has now been established for over a decade and standard metrics defining program success have yet to be established.

1.4.3 EIM-OC at Michigan Tech to Impact Health and Quality of Life

In 2018, Michigan Tech University launched their Tech Forward[72] initiative to create solutions for society's present and future challenges. Constructed around themes of developing, redefining, and preparing for the future, nine institutional initiatives were established. The Health and Quality of Life initiative is to reinforce a healthy campus culture, where students, faculty and staff engage in a healthy living environment. Prospective implications of this initiative include resilient students that can overcome stressful, adverse situations to create healthy habits, while increasing underlying student retention.

The Department of Kinesiology and Integrative Physiology contributed to the Tech Forward initiative through their EIM-OC program[73]. A specific need for a community physical activity program was identified during the COVID-19 pandemic, as fitness facilities closed due to precautionary measures, decreasing physical activity accessibility in the community. To help overcome this community obstacle, a virtual physical activity program was established that aimed to improve physical activity accessibility and availability. Over 260 virtual workouts were delivered throughout the pandemic via multiple platforms (i.e., Zoom, Facebook, YouTube, local television), which received over 4,800 views from community members. Collectively, Michigan Tech and their EIM-OC program have facilitated physical activity promotion and advocacy on their campus and their surrounding community. The second aim of my thesis will look to examine the impact of EIM-OC programs on physical activity prevalence in communities across the U.S.

1.4.4 Physical Activity Advocacy

Recently, several authors have highlighted the urgency for physical activity promotion and the need for researchers, public health officials, and clinicians to work together to facilitate physical activity in their communities. For example, Table 1 includes direct quotes from several recent papers published in high impact medical and sports medicine journals. The EIM-OC initiative offers a robust model that includes a solid mission and vision for physical activity promotion, advocacy, assessment and prescription on campuses and surrounding communities[59]. However, there are currently only 131 recognized programs in the U.S., while there are over 3,000 degree-granting higher-education institutions across the nation[74]. Together, the need for increased physical activity and EIM-OC promotion form the basis of my third aim, which includes creating an infographic that will be composed of key findings from my first two aims. Information graphics present content using minimal, concise word counts and pictures, which have been demonstrated[75] to yield 6.5 times more recall than reading plain text. Translating findings from the EIM-OC national analysis and assessment of EIM-OC program impact on community physical activity prevalence through the form of an infographic will serve as an effective way to advocate for other colleges and universities to start an EIM-OC program, or further expand on an existing program. Infographics are effective ways to communicate key messages, facilitate attitude adjustments, or even elicit behavior change[76]. For instance, Wedig and colleagues[77] recently published an infographic in the *British Journal of Sports Medicine* to advocate for physical activity as a form of medicine during COVID-19. To date, this infographic has been downloaded over 26,000 times, demonstrating that an infographic can serve as a valuable way to grab the attention of a target audience to elicit behavior change.

Table 1. Examples of physical activity promotion statements across multiple sectors

Author	Journal	Concluding Statement
Guthold et al.[3]	*The Lancet*	"Policies that support increasing activity can provide other benefits to health, local economies, community wellbeing, and environmental sustainability…"
Sallis et al.[18]	*Br J Sports Med*	"…engaging in regular physical activity may be the single most important action individuals can take to prevent severe COVID-19 and its complications, including death".
Franklin et al. [78]	*Mayo Clin. Proc.*	"Moving forward, it is imperative that clinicians, public health officials, and fitness professionals work together to promote, assess and facilitate physical activity for individuals across their communities".

1.5 Summary

To conclude, this review of literature presents substantial evidence of physical inactivity as a major public health problem, as well as the detrimental health effects of a physically inactive lifestyle on individuals and communities. Current physical activity guidelines and the resulting health benefits of aerobic and muscle strengthening exercise were discussed. The Exercise is Medicine® initiative and its accompanying mission and vision were introduced, followed by the Exercise is Medicine® on Campus (EIM-OC) expansion. Lastly, examples of collaborative campus and community health promotion initiatives were discussed, as well as examples of physical activity advocacy in highly cited publications.

2 Introduction

Physical inactivity is the fourth leading risk factor for mortality worldwide, contributing to over three million fatalities annually[1]. Currently, 80% of U.S. adults do not meet recommended physical activity guidelines set by health organizations around the world (i.e., U.S. Department of Health and Human Services, American Heart Association, World Health Organization, American College of Sports Medicine)[5]. Physical inactivity is associated with the increased risk for a wide range of chronic diseases such as cardiovascular disease, type-two diabetes, obesity, cancer, among others[11-13]. Specific to COVID-19, physical inactivity has been associated with higher risk of hospitalization, intensive care unit admission, and death in those individuals who become infected. Physical inactivity is associated with 11% of annual healthcare expenditures, equating to an estimated $117 billion[14]. Given the prevalence of physical inactivity and widespread health, economic and social consequences, physical inactivity has been described as a pandemic[9].

To help combat this public health problem and promote increased physical activity, the Exercise is Medicine®[54] initiative was established in 2007 by the American College of Sports Medicine (ACSM), with the goal of integrating physical activity assessment and prescription into medical practice. A key expansion of Exercise is Medicine® occurred in 2009, when the Exercise is Medicine® on Campus (EIM-OC)[59] initiative was introduced. Specifically, this program aims to promote physical activity benefits on campus communities worldwide. Currently, there are over 130 colleges and universities recognized in the U.S. by EIM-OC for their efforts to promote campus health and wellbeing through physical activity promotion. Three different levels of recognition can be achieved by EIM-OC programs (i.e., bronze, silver, and gold), each corresponding to the type of physical activity promotional efforts implemented[66]. Colleges and universities that communicate the benefits of regular physical activity through campus related activities earn bronze level recognition. Those programs that implement physical education and resources such as campus educational seminars earn silver level recognition. Lastly, programs that implement the physical activity vital sign in their student health clinic earn gold level recognition. To the best of my knowledge, there are no published reports on the distribution of EIM-OC programs by recognition level across the U.S., as well as which factors (e.g., school population, geographical location, health services on campus) best position programs to achieve gold level status. Therefore, a national analysis of the distribution of EIM-OC programs is warranted.

Colleges and universities are key stakeholders in their communities, with many institutions having public engagement as part of their overall mission. It is important to point out that the majority of EIM-OC programs have primarily focused their efforts towards on-campus physical activity advocacy[71] and individual health behavior change for students, faculty and staff. Some programs[73] have extended off-campus to include adults living in the community as well. The extent to which EIM-OC impacts not only individual but also community-level health (e.g., county-level physical activity prevalence), however, is unknown. Understanding the link between EIM-OC and community physical activity prevalence could help to further reinforce the importance of the EIM-OC initiative and motivate more colleges and universities to leverage their program to advocate for campus and community physical activity promotion.

The overarching purpose of my thesis was to evaluate and enhance the impact of the EIM-OC initiative to promote physical activity and overall health in the U.S. This objective was achieved through three specific aims: 1) I performed a national analysis of the recognized EIM-OC programs across the U.S., 2) I examined the relationship between the presence of EIM-OC programs and resulting community-level physical activity prevalence, and 3) I created an infographic to facilitate global implementation of the EIM-OC model. Collectively, the findings from this thesis serve to leverage the EIM-OC initiative, to provide beneficial health outcomes for campuses and surrounding communities.

3 Methodology

3.1.1 AIM 1: Exercise is Medicine® on Campus: A National Analysis

3.1.1.1 Data Collection

The objective of my first aim was to perform a national analysis of the 2023 recognized EIM-OC programs across the U.S. and describe any differences in characteristics that were associated with each recognition level. Recognized EIM-OC programs in the U.S. were described based on local, county, state, and regional-level variables. Local variables included recognition level, school population, the presence of a kinesiology-related degree, the type of student health care access on campus, the presence of a medical school on campus, as well as city population. County-level variables included population and designation of metropolitan or non-metropolitan county. State and regional variables included the state and ACSM region that the program was in.

The recognition level of each EIM-OC program was extracted from the official EIM-OC website (http://www.exerciseismedicine.org)[67]. School population data for each EIM-OC program were obtained by searching each school's official website. If the school population data were not readily available, fall 2020 data were obtained through Data USA (https://datausa.io/)[79], which is a database founded by Massachusetts Institute of Technology that includes collective visualizations of U.S. publicly available data. The presence of a kinesiology-relate degree program was identified through a keyword search of "kinesiology", "exercise science", "applied physiology", "athletic training" and "exercise physiology" on each school's official website. Access to student health care services on campuses were also provided through the school's official website. Data were obtained and placed into three separate categories: 1) on-campus health services that are provided by the higher education institution and have a licensed medical professional (i.e., physician, nurse practitioner, physician assistant), 2) on-campus health services are offered but are contracted by a third-party network, or student health services offered that were not provided by a licensed medical professional, and 3) no student health services were offered to students. The presence of a medical school on each campus was provided through official Association of American Medical Colleges (http://www.aamc.org/)[80] and American Association of Colleges of Osteopathic Medicine (http://www.aacom.org/)[81] websites for the presence of allopathic and/or osteopathic medical programs. Medical school presence was also cross-referenced on official school websites. City population data were obtained from the United States Census Bureau[82].

The county that the EIM-OC program was located in was classified as metropolitan or non-metropolitan. These data were obtained from the U.S. Department of Agriculture (USDA) and was assessed using the Rural-Urban Continuum Codes (RUCC)[83], which distinguish metropolitan counties by the population size of their metro area, and non-metropolitan counties by their degree of urbanization and distance to a metro area on a scale of one (most metropolitan) to nine (most non-metropolitan). A metropolitan county can be defined[84] by two criteria: 1) central counties, which have at least one urbanized area, which includes a minimum population of 50,000 with a core population density of 1,000 people per square mile, or 2) outlying counties that have 25% of their residents commuting to a central county for work, or if 25% of the county's employment comes from a central county. A county is considered non-metropolitan if it does not have either of the two criteria noted above[85]. Non-metropolitan counties are further distinguished based on population of urban clusters, as well as their adjacency to a metro county. Urban clusters are defined as areas with a population of 2,500 to 49,999 people, with a core density of 1,000 people per square mile. A rural area has a population less than 2,500[86], with a population density fewer than 500 people per square mile. The nine rural-urban continuum codes were categorized binomially into metropolitan (RUCC 1-3) or non-metropolitan (RUCC 4-9) groups. A breakdown of the rural-urban continuum codes is summarized in Figure 2. County populations that each EIM-OC program were located in were obtained from the U.S. Census Bureau[82]. The state that each EIM-OC program was located in was determined from the program's official school website, while the ACSM regional chapter that the program was in was extracted from the official ACSM website (http://www.acsm.org/)[87], which displayed the 12 regional chapters and their participating states / cities (i.e., ACSM Midwest Chapter contains Illinois, Indiana, Iowa, Michigan, Ohio, Wisconsin).

3.1.1.2 Statistical Analysis

Descriptive statistics were used to describe the recognized EIM-OC programs, stratified by bronze, silver, or gold level recognition. Shapiro-Wilk tests were used to assess the normality of school populations within each recognition level. Based on the distribution of the data, either parametric one-way analysis of variance (ANOVA) or non-parametric Kruskal-Wallis rank sum testing were then performed to assess differences between school populations of recognition levels. This process was repeated for city and county populations. A chi-squared test was performed to assess the dependence between the presence of a kinesiology-related degree program, type of access to on-campus student health services, and the presence of a medical school across recognition levels.

Frequencies of total and gold level programs that were locate in metropolitan (RUCC 1-3) or non-metropolitan (RUCC 4-9) counties were also reported. Descriptive statistics of total and gold level programs in each state and ACSM regional chapter were also reported, while normalizing the number of programs located in each ACSM region to the number of states located within each region. Alpha level was set to 0.05, and data were presented as mean ± SD. An overview of the data collection and analysis for Aim 1 is illustrated in Figure 3.

3.1.1.3 Figures

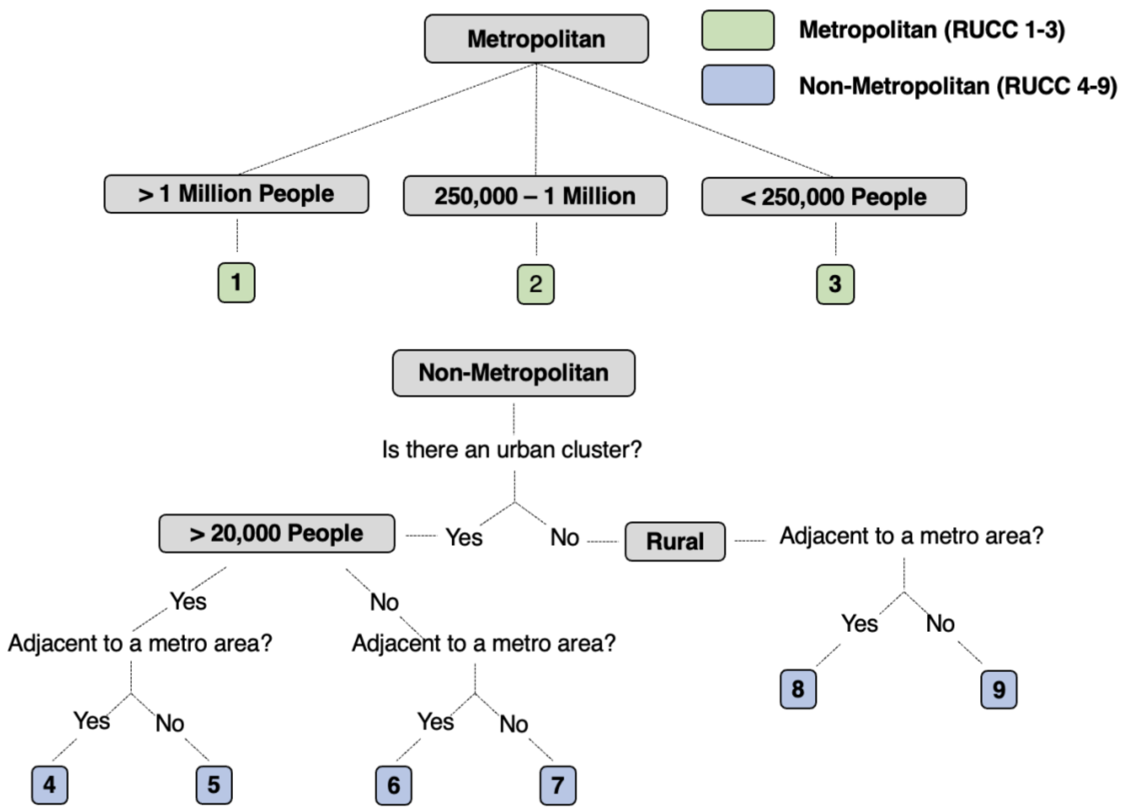

Figure 2. A summary of the Rural-Urban Continuum Codes to identify metropolitan and non-metropolitan counties in the U.S.

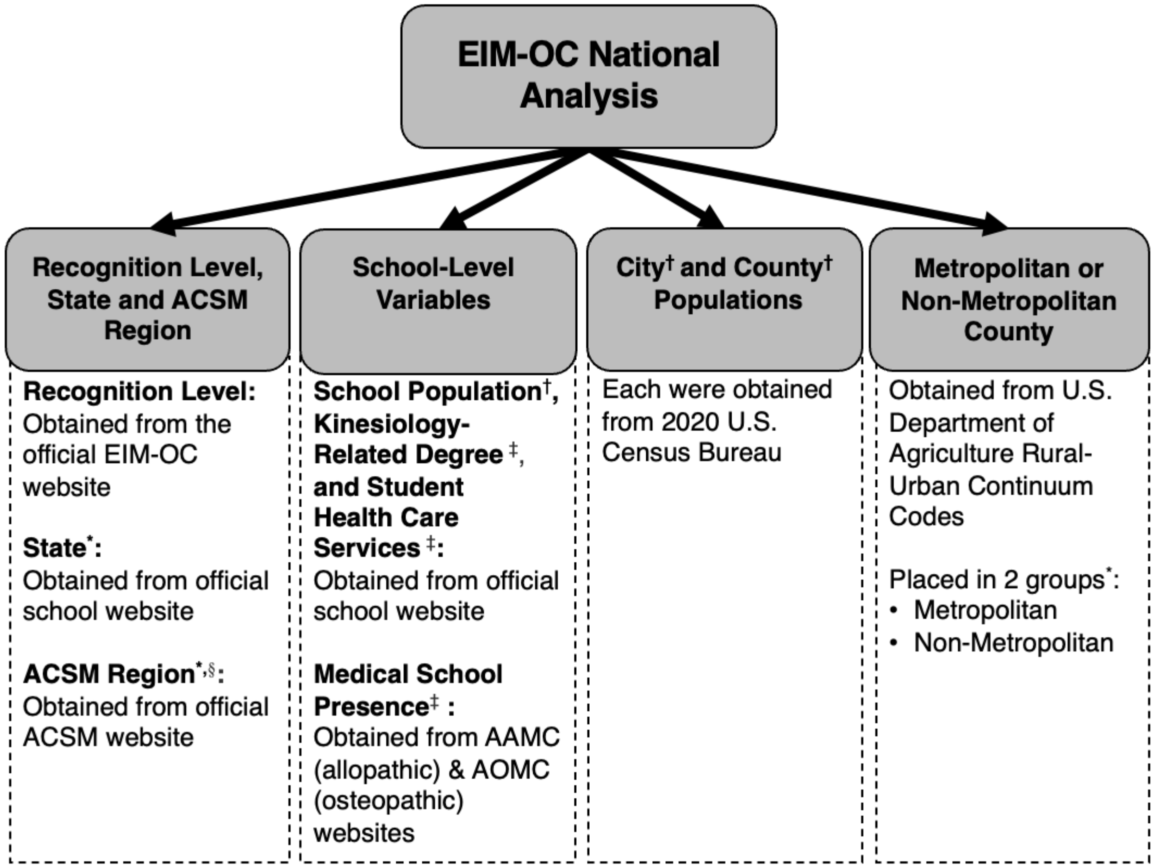

Figure 3. An overview of the data collection for Aim 1 and their specific statistical tests used. * Descriptive statistics were used. † Kruskal-Wallis tests were used (Shapiro-Wilk tests were used to assess normality). ‡ Chi-squared tests were used. §Total and gold level programs were normalized to the number of states that exist in each ACSM region.

3.1.2 AIM 2: Exercise is Medicine® on Campus: An Assessment of Community Impact

3.1.2.1 Data Collection

The objective of my second aim was to assess the impact of EIM-OC programs in their surrounding communities. To answer this question, the EIM-OC recognized programs from 2020 were first obtained from the official EIM-OC website (http://www.exerciseismedicine.org/)[67]. Note that these EIM-OC data for Aim 2 were selected such that they align with BRFSS data (described below) which were current only up through 2020. Furthermore, county-level physical inactivity prevalence data (reported as a percentage of residents that report no leisure-time physical activity) of all eligible U.S. counties were obtained from the County Health Rankings & Roadmaps website (http://www.countyhealthrankings.org/)[88], which is a Robert Wood Johnson Foundation-supported initiative that provides a multitude of county-level health metrics. The metric includes the percentage of adults aged 18 years and older that reported no leisure-time physical activity, which is a statistic obtained from the 2020 Behavioral Risk Factor Surveillance Survey (BRFSS)[89]. The BRFSS question was posed as: "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?". Potential responses include "Yes", "No", "Don't know / Not sure", or "Refused". The physical inactivity prevalence data was reversed to report physical activity prevalence in the last 30 days.

United States counties were required to contain a college or university that offered at least a two-year degree to be eligible to be included in the analysis. County Health Rankings physical activity prevalence, U.S. Department of Agriculture Rural-Urban Continuum Codes, and U.S. Census Bureau County population datasets were first amalgamated into one dataset, and counties were omitted if they were not included in the County Health Rankings dataset. To determine which counties contained a higher education institution, Carnegie Classification of Institutions of Higher Education®[90] data was used, which included a report of all higher education institutions and their resulting city locations in the U.S. (n = 3,939). The county that each higher education institution was in was Google searched, and the ensuing county was then recorded. This was repeated for each higher education institution. Counties that were not recorded were omitted from the dataset. An overview of the eligible county selection process is summarized in Figure 4.

Additional county-level health behaviors were collected that have been previously identified to influence physical activity prevalence. Specifically, county-level smoking prevalence, median household income, education level, access to exercise opportunities and health insurance, as well as RUC Codes were collected. Adult smoking prevalence data represented the percentage of the adult population in each county that "currently smoke every day, or some days and have smoked at least 100 cigarettes in their lifetime". This metric reported the percentage of adults who are current smokers, and was originally drawn from 2020 BRFSS survey data[89]. Median household income data were obtained from the Small Area Income and Poverty Estimates from 2020[91], which was a component of the United States Census Bureau. Education metrics were drawn from the American

Community Survey 5-year estimates[92], which represent the percentage of adults aged 25 and over in a resulting county with a high school diploma or equivalent. Access to exercise opportunities data were obtained from the County Health Rankings & Roadmaps website, which incorporates a combination of ArcGIS Business Analyst and Living Atlas of the World, YMCA, and U.S. Census TIGER/Line Shapefiles[93]. The data represented the percentage of individuals in a county who live reasonably close to a location for physical activity, which are defined as parks or recreational facilities. Lastly, the percentage of county residents under the age of 65 that were uninsured were obtained from data reported through the U.S. Census Bureau's Small Area Health Insurance Estimates[94].

3.1.2.2 Statistical Analysis

Physical activity prevalence data and other health factors were reported for all eligible U.S. counties as mean ± SD, which were stratified by total, EIM-OC containing, metropolitan and non-metropolitan county groups. The differences between metropolitan and non-metropolitan groups for each variable were assessed via independent t-tests. Effect sizes were calculated as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) based on the benchmarks suggested by Cohen[95]. The physical activity prevalence of a county was predicted by the presence of EIM-OC bronze, silver, or gold level recognition programs using a cross-sectional study design which included the additional health factors reported above as covariates. The statistical measure used was linear, multivariate regression (Figure 5). Multi-collinearity between the predictor variables was assessed using variance inflation factor (VIF) as well as Pearson's correlations. Multi-collinearity was defined as a VIF ≥ 5 and/or Pearson's correlations of 0.80 or greater[96]. Crude and adjusted models were reported, and ANOVA was used to compare differences in adjusted R^2 between models. The effect sizes of each independent variable were estimated through standardized ß coefficients. Alpha level was set to 0.05, and all statistical analyses were completed using R programming (R: A Language and Environment for Statistical Computing, 2020, R Foundation for Statistical Computing, Vienna, Austria).

3.1.2.3 Figures

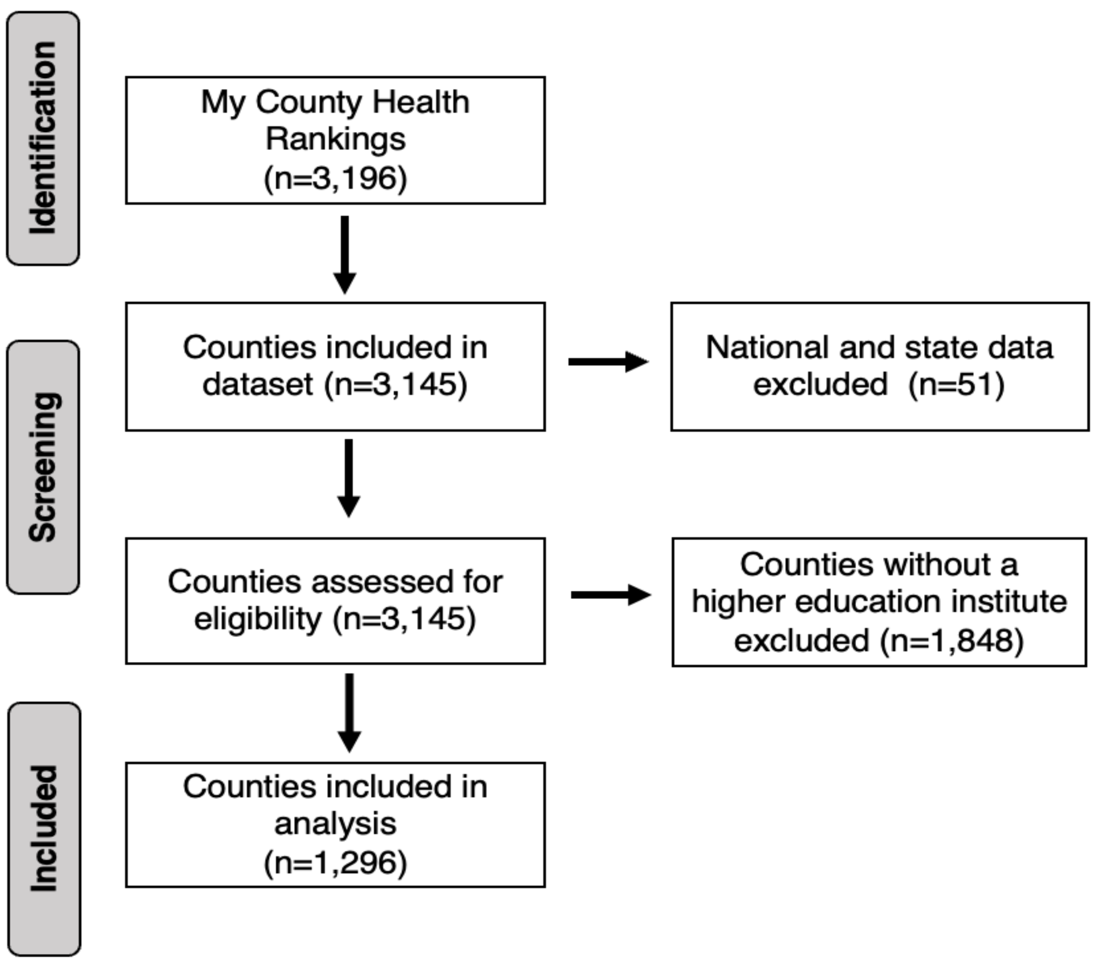

Figure 4. Eligible county selection process

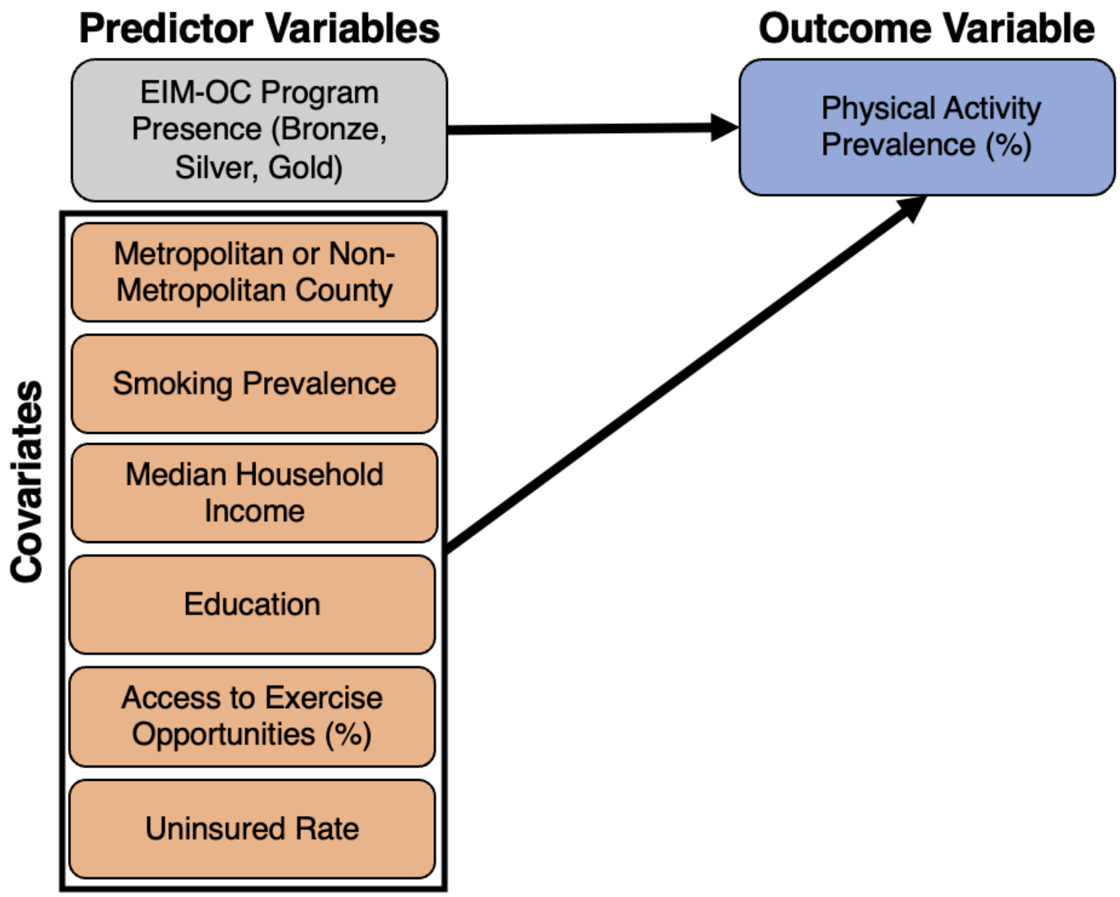

Figure 5. Multivariate linear regression model including main predictor variable (grey), covariates (orange), and outcome variable (blue).

3.1.3 AIM 3: Infographic Creation

My third aim focused on developing an infographic to call upon colleges and universities to develop an EIM-OC program. Infographics are effective ways to communicate key messages, facilitate attitude adjustments, or even elicit behavior change[76]. Therefore, when considering physical activity promotion, an infographic seemed like an effective way to do so. Design of the infographic began after the completion of Aims 1 and 2. Consultation with the co-chair of the EIM-OC National Committee prompted me to extend the action call to target colleges and universities across the world to facilitate a broader global reach. Therefore, the target journal for infographic submission was the *British Journal of Sports Medicine*. Global EIM-OC data of both registered and recognized campuses were extracted from the official EIM-OC website (http://www.exerciseismedicine.org/)[67]. The infographic was created using a combination of BioRender (Toronto, Canada, 2023), Piktochart (Malaysia, 2023) and Microsoft PowerPoint (WA, USA, 2022).

4 Results

4.1.1 AIM 1: Exercise is Medicine® on Campus: A National Analysis

Of the 131 recognized EIM-OC programs, 19 were bronze, 50 were silver, and 62 were gold level status. Thirty-seven states had at least one EIM-OC program and 27 had at least one gold level program (Figure 6). Notably, California had the most total (10) and gold level (6) programs. Several other states on the eastern side of the country had a high number of total and gold level programs, which can be observed in Appendix 7.1. The Southeast, Midwest, and Mid-Atlantic ACSM regional chapters had the most total programs (all ≥ 20) and gold level programs (all ≥ 12) (Table 2). When normalized to the number of states in each ACSM regional chapter, the Midwest, Greater New York, and Mid-Atlantic chapters had the most total and gold level programs (Table 2).

The school populations of EIM-OC programs ranged from approximately 215 (University of Wisconsin-Platteville Baraboo/Sauk County) to 68,000 students (University of Central Florida). Shapiro-Wilk testing found that school populations were not normally distributed across bronze, silver, and gold level recognition (all $p < 0.01$). Results from the Kruskal-Wallis rank sum testing indicated that school population did not differ across recognition level ($p = 0.21$, Figure 7). Eighty-six percent of EIM-OC programs had a kinesiology-related degree program on their campus. Results from the chi-squared analysis indicated that dependence between the presence of a kinesiology-related degree program and recognition level did not differ ($p = 0.56$, Figure 8). Seventy-six percent of colleges and universities that had an EIM-OC program also contained on-campus student health care services that were directly affiliated with the institution.

Further, 15% of schools contained a third-party health care system, or lacked a licensed medical professional, and 9% of schools did not offer health care services to students. Results from a chi-squared analysis found that dependence between the type of student health care services and recognition level did not differ ($p = 0.11$, Figure 8). Approximately a quarter (37 out of 131) of EIM-OC programs had a medical school on their campus. Chi-squared analysis found that dependence between the presence of a medical school on campus and recognition level did not differ ($p = 0.12$).

City and county populations varied considerably across EIM-OC programs, with city populations ranging from approximately 690 (Highland Hills, OH) to 2.7 million people (Chicago, IL), while county populations ranged from approximately 9,500 (Brewster County, TX) to over 10 million people (Los Angeles County, CA). Shapiro-Wilk testing revealed that both city and county-level populations were not normally distributed across bronze, silver, and gold recognition levels (all $p < 0.01$). Kruskal-Wallis rank sum testing found that city ($p = 0.14$) and county-level ($p = 0.32$) populations did not differ (Figure 7). The location of each EIM-OC program in the U.S. relative to county rurality is illustrated in Figure 9. Out of 131 recognized programs, 90% were in metropolitan counties and 10% were in non-metropolitan counties. Similarly, 89% of gold level programs were in metropolitan counties and 11% were in non-metropolitan counties.

4.1.1.1 Tables and Figures

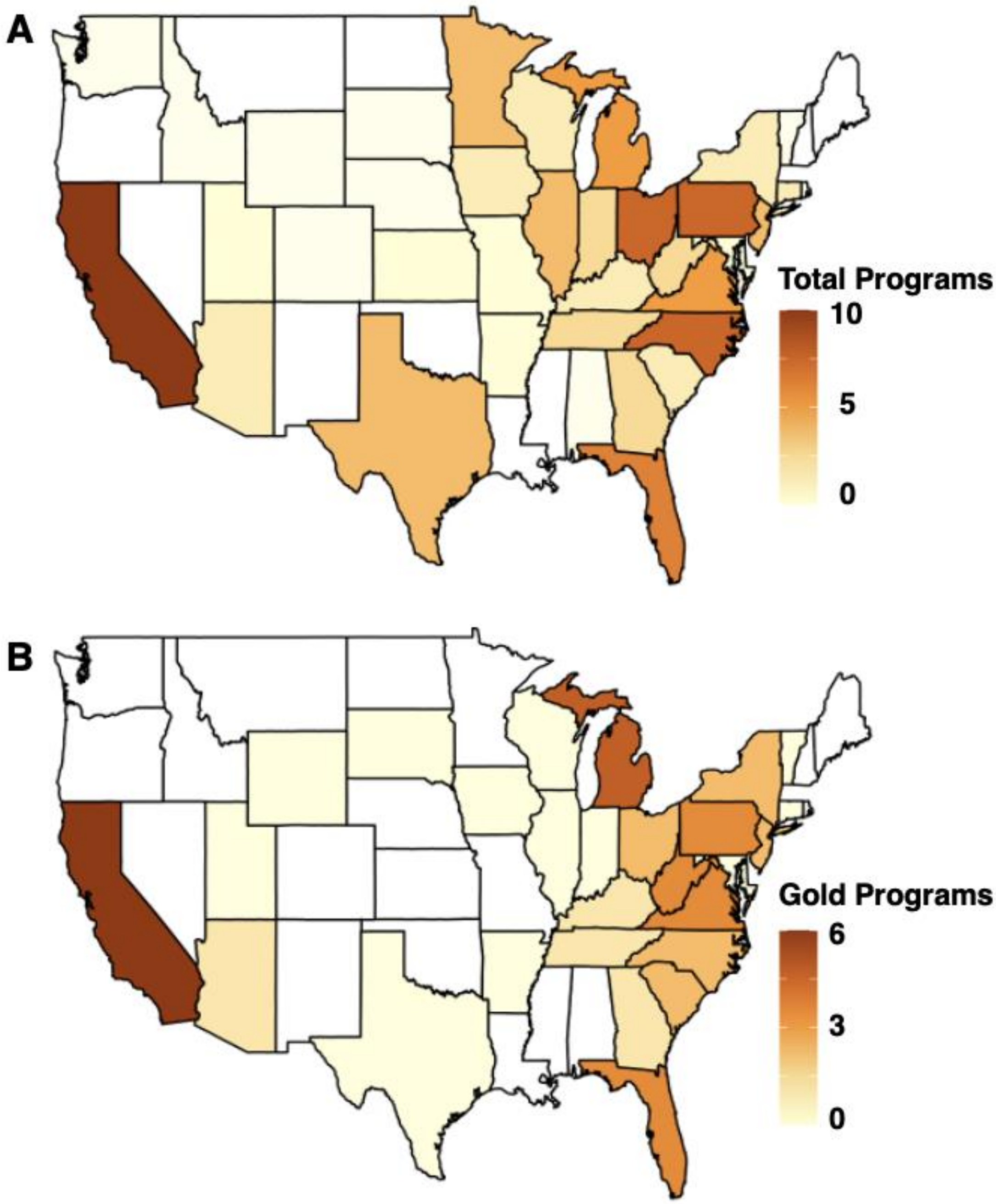

Figure 6. Total (A) and gold level (B) EIM-OC programs in the U.S.

Table 2. Number of total and gold level programs (left columns) and normalized programs (right column) for each ACSM region.

ACSM Region	Total	Gold	Total	Gold
Southeast	36	20	1.5	0.3
Midwest	29	12	4.8	2.0
Mid-Atlantic	20	12	2.9	1.7
Southwest	15	9	2.5	1.5
Northland	7	1	1.8	0.1
Central States	6	1	1.5	0.3
New England	6	2	1.0	0.3
Texas	5	1	5.0	1.0
Greater New York	3	3	3.0	3.0
Northwest	2	0	0.5	0
Rocky Mountain	2	1	1.0	0.5
Alaska	0	0	0.0	0.0

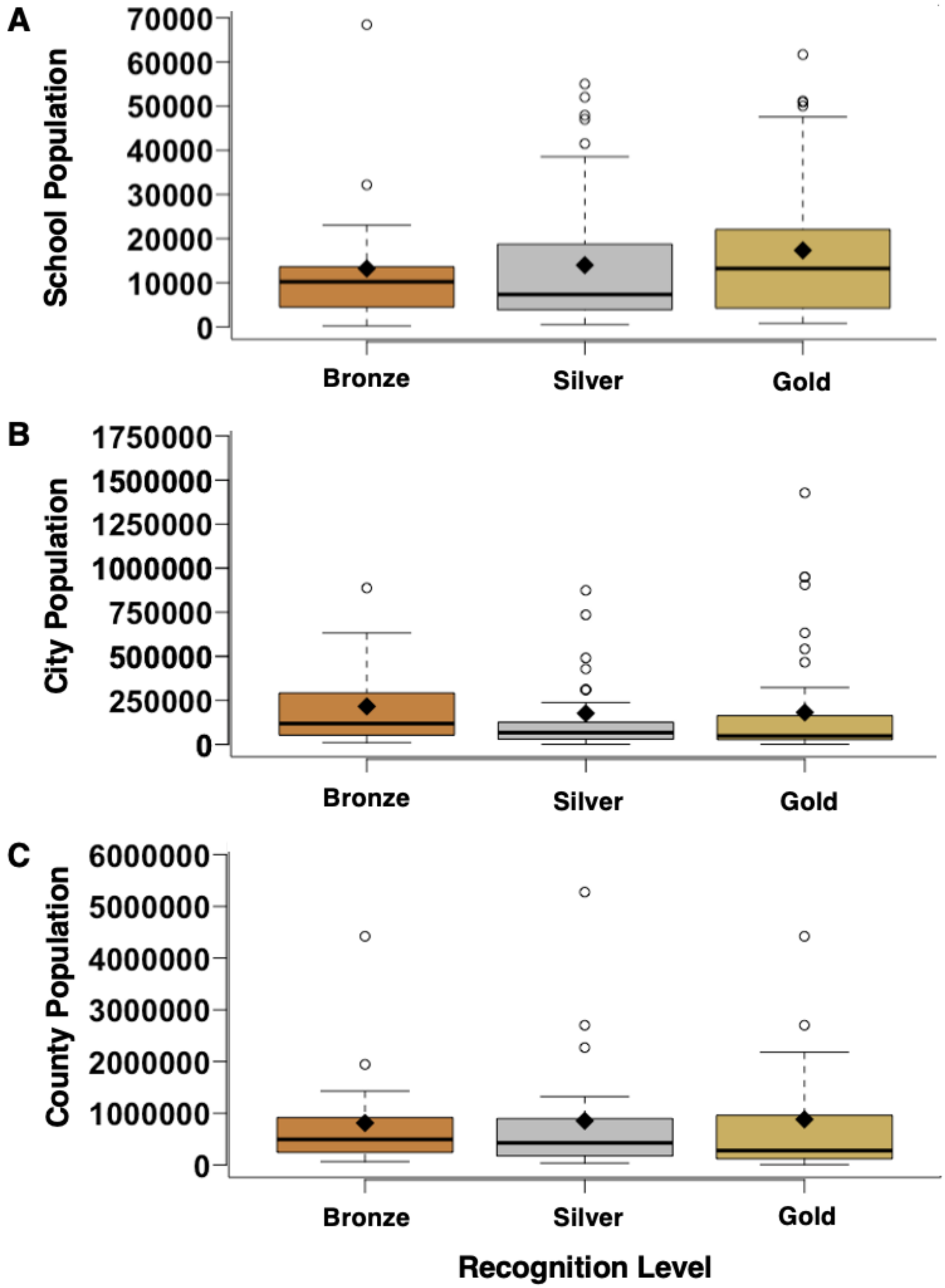

Figure 7. Box plots illustrating the distribution of school population (A), city population (B), and county populations (C) across three levels (EIM-OC bronze, silver and gold level recognition). Each box represents the interquartile range with the median indicated by the thick line and means indicated by the black diamond.

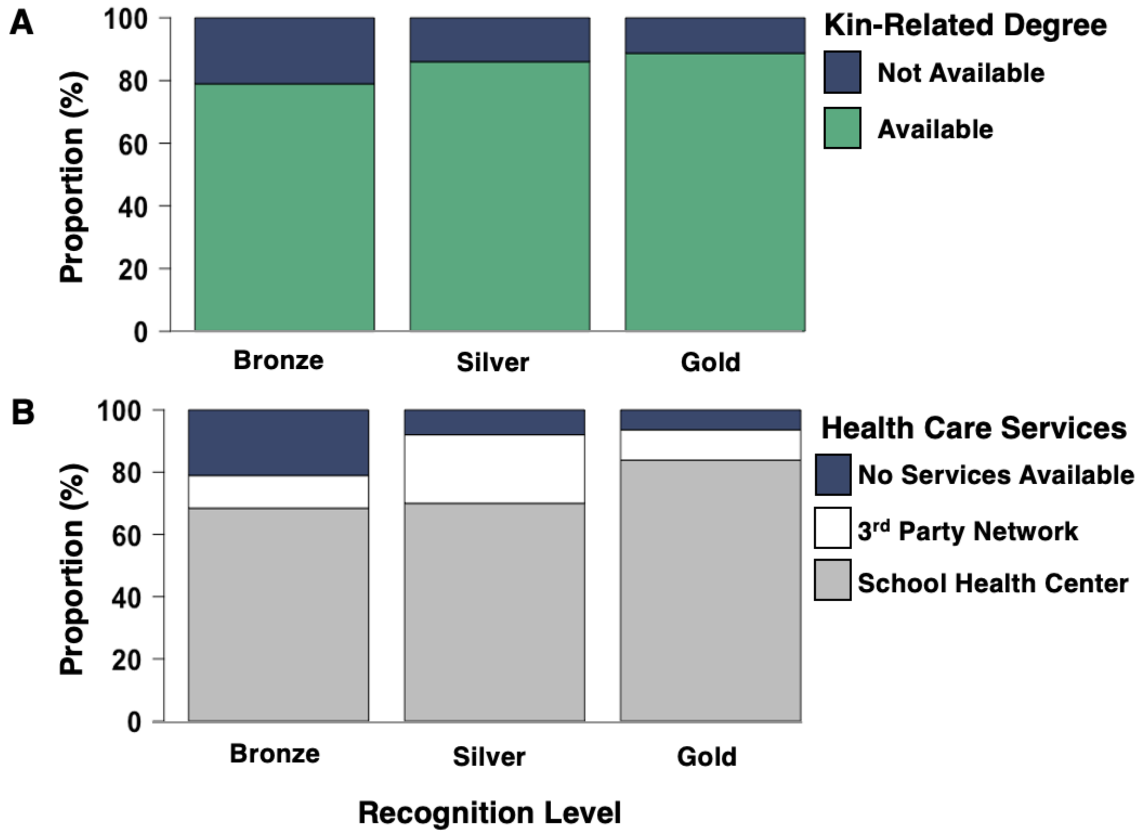

Figure 8. Proportions of EIM-OC program institutions that had kinesiology-related degree programs (A) and health care services (B). The proportions of each variable across each recognition level are illustrated.

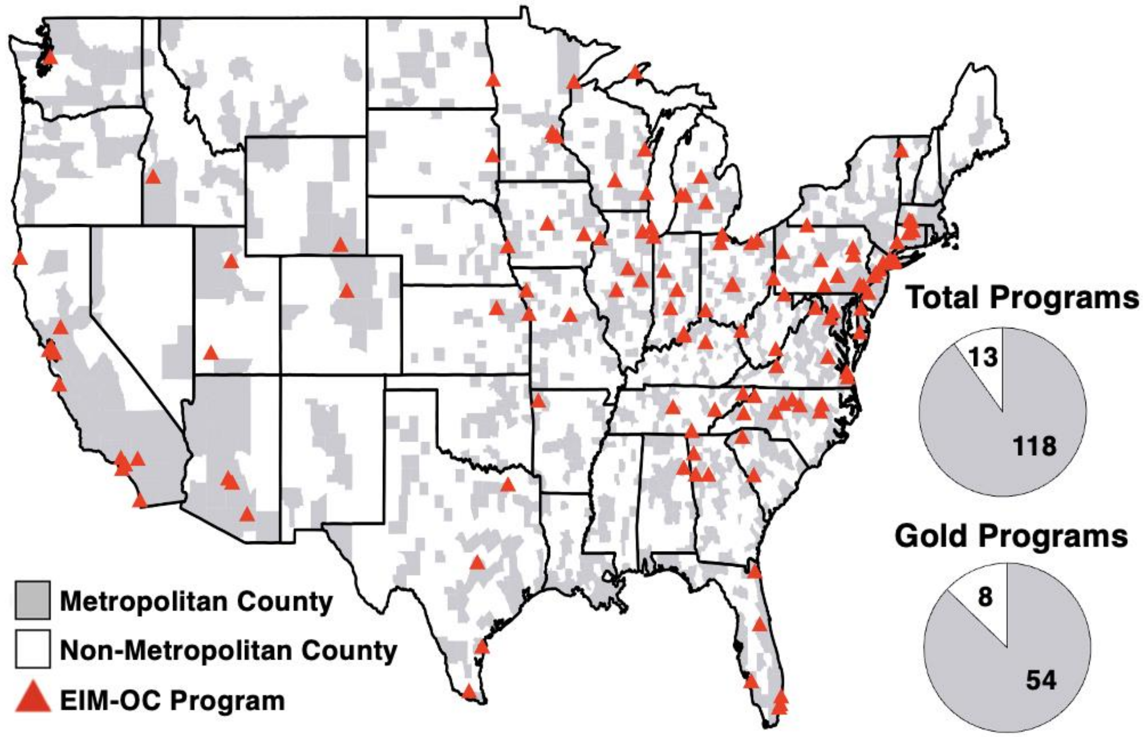

Figure 9. Recognized EIM-OC program superimposed on metropolitan (RUCC 1-3) and non-metropolitan (RUCC 4-9) U.S. counties. Pie charts represent proportions of total and gold level programs stratified by metropolitan or non-metropolitan county.

4.1.2 AIM 2: Assessment of Community Impact

4.1.2.1 Overview of Data

After screening for the presence of a higher education institution, a total of 1,296 eligible U.S. counties were included in the analysis. Of the eligible counties, 721 were metropolitan and 575 were non-metropolitan. A total of 117 counties contained an EIM-OC program. County-level health parameters for these counties are presented in Table 3. Results from the independent t-tests indicated that all county-level health factors (physical activity prevalence, county population, education, smoking, access to exercise, percent uninsured and median household income) differed between metropolitan and non-metropolitan U.S. counties ($p < 0.001$, Table 3.).

Table 3. County-level health factors of eligible U.S. counties, stratified by rurality. Data are reported as means ± SD.

Variable	Eligible County Stratification				Test Statistics	
	Total Eligible (n = 1,296)	EIM-OC Counties (n = 117)	Metro (n = 721)	Non-Metro (n = 575)	p value	Effect Size
Physical Activity %	75 ± 5%	77 ± 4%	77 ± 5%	74 ± 5%	<0.001	0.55
County Population	223,493 ± 498,639	698,018 ± 1,188,863	368,929 ± 631,558	41,129 ± 27,477	<0.001	0.70
Education	89 ± 5%	91 ± 4%	90 ± 4%	88 ± 5%	<0.001	0.41
Smoking %	19 ± 4%	16 ± 3%	17 ± 4%	21 ± 4%	<0.001	-0.92
Access to Exercise	73 ± 18%	86 ± 11%	80 ± 15%	63 ± 18%	<0.001	1.05
% Uninsured	11± 5%	9 ± 4%	10 ± 4%	12 ± 5%	<0.001	-0.38
Household Income	62,469 ± 16,754	70,374 ± 17,543	69,344 ± 17,610	53,580 ± 10,510	<0.001	1.04

*p < 0.01

4.1.2.2 Multicollinearity and Linear Modelling

Pearson's correlations for each continuous predictor variable are reported in Table 4 and demonstrate no violations of multicollinearity in accordance to thresholds that were established in the study design. Each iteration of the linear model can be observed in Appendix 7.2. Results from the crude linear regression model (Table 5) indicated that 1.5% of the variability in county-level physical activity prevalence could be explained through the general presence of an EIM-OC program. Specifically, the presence of an EIM-OC silver (ß = 0.082, $p < 0.01$), and gold level programs (ß = 0.099, $p < 0.001$) were significant predictors whereas bronze level recognition programs were not significant (ß = 0.033, p = 0.24). When adjusted for other health factors, the multivariate regression model (Table 6) explained 77.5% of the variability in county-level physical activity prevalence. Model comparison ANOVA indicated a significant difference between the crude and adjusted models (F-statistic = 730.3, $p <0.001$). Smoking prevalence (ß = -0.491), education (ß = 0.437), percent of residents uninsured (ß = -0.06), median household income (ß = 0.147), and categorical RUC code (ß = 0.089) were all significant predictors in the model ($p < 0.001$). Access to exercise opportunities (ß = -0.025, p=0.172) and EIM-OC bronze (ß = 0.001, p = 0.887), silver (ß = -0.026, p = 0.067), and gold level (ß = -0.007, p = 0.667) recognition levels were all not significant predictors.

Table 4. Pearson's r correlation coefficients [upper bound, lower bound 95% confidence interval] for other health factors.

Health Factor	Education	Smoking %	Access to Exercise	% Uninsured	Household Income
Education	X	-0.43 [-0.48, -0.38]*	0.39 [0.34, 0.44]*	-0.53 [-0.57, -0.49]*	0.49 [0.44, 0.53]*
Smoking %	-0.43 [-0.48, -0.38]*	X	-0.62 [-0.66, -0.59]*	0.29 [0.23, 0.34]*	-0.76 [-0.79, -0.74]*
Access to Exercise	0.39 [0.34, 0.44]*	-0.62 [-0.66, -0.59]*	X	-0.31 [-0.36, -0.26]*	0.52 [0.48, 0.56]*
% Uninsured	-0.53 [-0.57, -0.49]*	0.29 [0.23, 0.34]*	-0.31 [-0.36, -0.26]*	X	-0.40 [-0.45, -0.35]*
Household Income	0.49 [0.44, 0.53]*	-0.76 [-0.79, -0.74]*	0.52 [0.48, 0.56]*	-0.40 [-0.45, -0.35]*	X

*$p < 0.01$

Table 5. Crude linear regression model.

Variable	ß Coef.	Estimate	Std. Error	t value	p value
(Intercept)	N/A	0.753	0.001	538.1	<0.001**
EIM-OC Bronze	0.033	0.015	0.012	1.184	0.237
EIM-OC Silver	0.082	0.021	0.007	2.987	<0.01*
EIM-OC Gold	0.099	0.024	0.007	3.583	<0.001**
		R^2	Adj. R^2	F-statistic	
		0.017	0.015	7.329 on 3 and 1292 DF	

* $p < 0.05$, ** $p < 0.001$

Table 6. Adjusted multivariate linear regression model.

Variable	ß Coef.	Estimate	Std. Error	t value	VIF	p value
(Intercept)	N/A	0.455	0.018	24.76		<0.001**
EIM-OC Bronze	0.002	8.52^{-4}	0.006	0.142	1.01	0.887
EIM-OC Silver	-0.025	-0.006	0.003	-1.841	1.01	0.067
EIM-OC Gold	-0.006	-0.001	0.003	-0.430	1.01	0.667
Smoking %	-0.491	-0.590	0.027	-21.85	2.91	<0.001**
Education	0.437	0.440	0.017	25.87	1.65	<0.001**
Access to Exercise	-0.025	-0.006	0.005	-1.34	1.87	0.172
% Uninsured	-0.060	-0.064	0.017	-3.81	1.46	<0.001**
Household Income	0.147	4.23^{-7}	6.383^{-8}	6.66	2.82	<0.001**
RUCC: Non-Metro	0.089	0.009	0.001	6.31	1.43	<0.001**
			R^2	Adj. R^2	F-statistic	
			0.777	0.775	497.6 on 9 and 1286 DF	

** $p < 0.001$

4.1.3 AIM 3: Infographic Creation

The infographic can be observed in Figure 10. The infographic begins with a broad description of the mission and vision of EIM-OC, with the main component demonstrating the three-step process of the physical activity vital sign. Furthermore, the infographic ties together the main pillars of the EIM-OC initiative with the recognition program, introducing physical activity promotion, education initiatives, and assessment. Furthermore, the infographic ends with the current global representation of EIM-OC. It was found that globally, there are currently over 200 registered EIM-OC programs, with 149 of these programs being part of the recognition program. These programs are represented by 13 countries, which are located on 4 different continents. The infographic ends with a global action call to utilize the EIM-OC model on their campus. Furthermore, ways to further leverage EIM-OC are provided, including collaborative efforts to communicate with neighboring institutions to do the same.

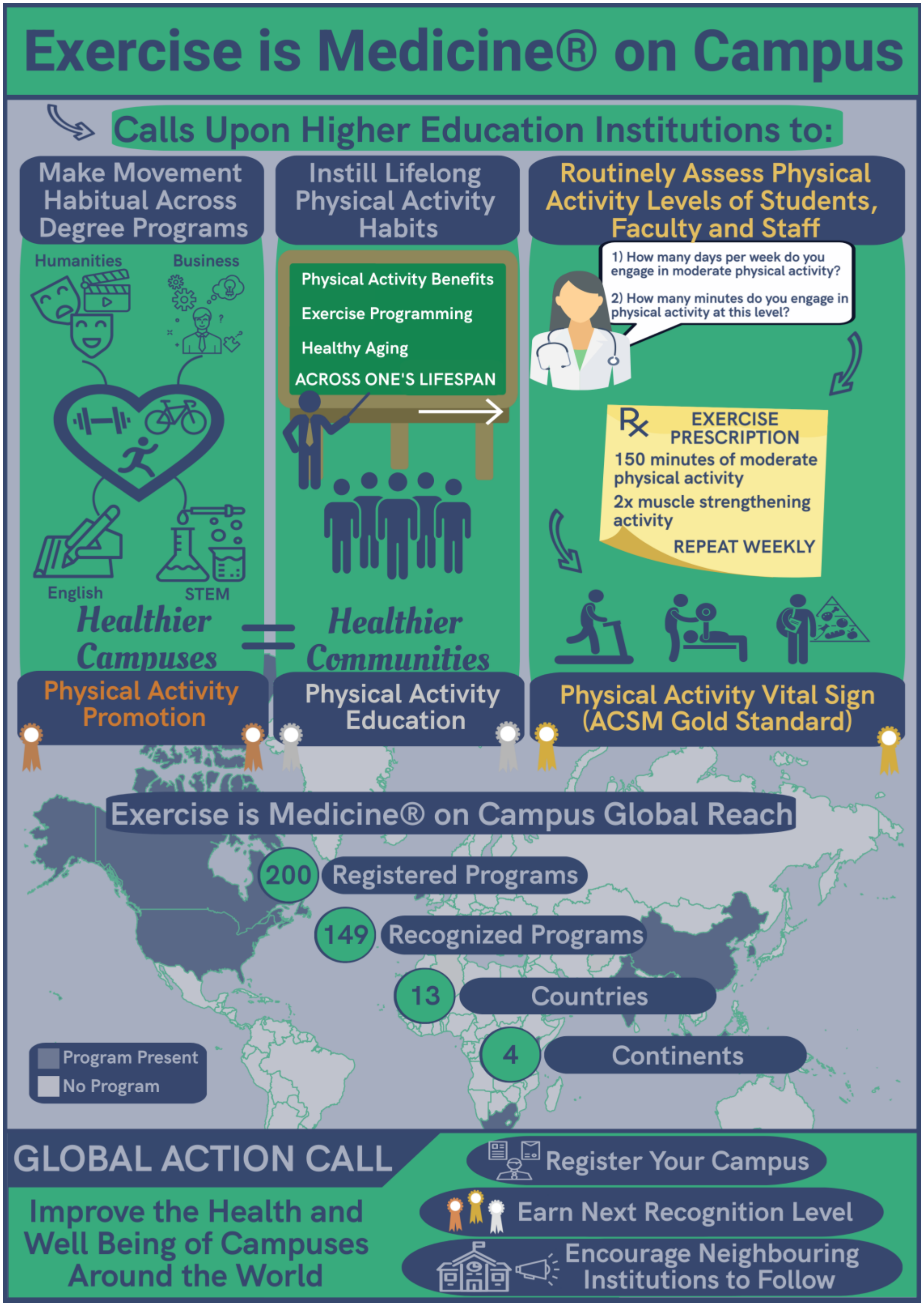

Figure 10. Aim 3 infographic

5 Discussion

5.1 Main Findings

The purpose of my thesis was to evaluate and enhance the impact of the EIM-OC initiative, which aims to promote physical activity and overall health across college and university campuses in the U.S. Results from Aim 1 indicated that ~75% of U.S. states had a recognized EIM-OC program and that ~50% had a gold level program. When considering both state and ACSM region, most EIM-OC total and gold level programs were located in the eastern half of the country. School populations ranged considerably (~275 fold), and the majority of recognized programs had a kinesiology-related degree on their campus and access to student centered health care services. While there were no significant differences in school, city, and county populations between bronze, silver and gold recognition levels, nearly all programs were located in metro counties. Results from Aim 2 indicated that the presence of an EIM-OC program did not have a significant influence on county-level physical activity prevalence when adjusted for other health factors (e.g., smoking, education, rurality). Collectively, these results indicate that colleges and universities of all sizes and infrastructure have used EIM-OC to promote physical activity on their campuses.

5.2 National and Regional Representation

To the best of my knowledge, there are no published reports that document the distribution of recognized EIM-OC programs across the U.S. Morgan and colleagues[97] evaluated the distribution of Exercise is Medicine® Canada on Campus programs through a casebook, which assessed established (n = 7) and developing (n = 5) programs from eastern provinces such as Quebec and Nova Scotia, as well as British Columbia on the west coast. The casebook served the purpose of sharing best practices, improving communication levels between the national office and existing programs. Five of the seven established programs that are reported in this casebook are from Ontario, providing insight towards their high concentration of programs. These data from Canada's Exercise is Medicine® governing body serve as a valuable tool for communication between new and established programs[97]. This suggests the importance for collaboration at local, regional, and national levels. Slippery Rock University[98] and Appalachian State University[99] are examples of promoting their gold-level EIM-OC programs through their official school websites. Intertwining EIM-OC program presence into institution websites may serve as a potential way to improve EIM-OC promotion to current and future students, as well as community members. Moreover, based on my analyses, it is clear which states in the U.S. (e.g., California, Pennsylvania, North Carolina) and ACSM regions (e.g., Southeast, Midwest, Mid-Atlantic) are leading the charge in implementing EIM-OC. Moreover, it is evident that areas to target for future EIM-OC implementation and promotion include central and northwest states, as well as Rocky Mountain and Northwest ACSM regional chapters. Finally, opportunities for expansion and collaboration may exist at ACSM regional chapter meetings which can serve as a forum for faculty and student trainees to articulate their own EIM-OC program success stories and lessons learned.

5.3 Structure of Colleges and Universities

EIM-OC programs were located on campuses ranging from small community colleges to undergraduate focused institutions to large flagship and land grant research universities. Thus, school populations of recognized EIM-OC programs ranged from approximately 200 to almost 70,000 students. These data are consistent with those from Morgan et al.[97], who described campuses that ranged from less than 10,000 to greater than 30,000 students. Over 85% of EIM-OC programs evaluated in the current study had a kinesiology-related degree program on their college or university campus. These results support and extend upon those reported by Lagally and colleagues[100]. Specifically, these authors administered surveys to EIM-OC programs to assess the characteristics of existing EIM-OC programs. Of the programs that responded (28 out of 175), 86% had a kinesiology-related department as a component of their EIM-OC program. Together, my findings as well as those by Lagally et al.[100] demonstrate the high prevalence of kinesiology-related degree programs at colleges and universities that have EIM-OC programs and thus it is likely a key asset for implementation. It is also important to consider that many biology departments offer health science courses (e.g., Anatomy and Physiology) and pre-health degree concentrations (e.g., pre-medicine, pre-physical and occupational therapy). Accordingly, it would be very illuminating to also direct EIM-OC implementation towards these departments, where many future medical professionals often start their undergraduate training.

When considering the type of student health care services offered on campus, I found that over 90% of programs had some form of health care services on their campuses, with the majority of health care services being student-centered. These values are slightly greater than those identified from survey responses[100] indicating that ~70% of responding programs had health care services on their campus. While the vast majority of programs had both a kinesiology-related degree and student health services, I did not detect any differences across EIM-OC recognition level. Nonetheless, my findings along with previous reports[100] document the extent to which these health related degree programs and medical services are present at colleges and universities that promote physical activity through EIM-OC.

Approximately a quarter of recognized programs contained a medical school on their campus. These schools were represented by both allopathic and osteopathic branches, as well as two schools that were stand-alone medical schools. Importantly, successful implementation of the physical activity vital sign (i.e., requirement to achieve EIM-OC gold level) requires a multidisciplinary team approach that includes medical professionals to ask physical activity vital sign questions during patient exams, medical professionals to interpret activity levels and prescribe exercise, as well as exercise professionals for referral processes[101]. Thus, a medical school on campus would be an important potential collaborator to consider when creating an EIM-OC program and working towards physical activity vital sign implementation. Only 10% of current U.S. medical students report proficiency in creating exercise programs for their patients, while the percentage of U.S. medical schools that incorporate exercise assessment and prescription into their core curriculum is even lower[102]. Thus, campuses that contain both EIM-OC programs and medical schools may benefit from academic-clinical collaboration to promote physical activity on campus and implement the physical activity vital sign in their campus health centers.

5.4 EIM-OC at City and County Levels

Similar to school size, both city and county population ranges varied greatly. Programs were located in all corners of the U.S., with many counties having more than one program (i.e., Los Angeles County, CA had 3 programs). Based on my preliminary findings, there are no significant differences between school, city, or county populations across EIM-OC bronze, silver, or gold level recognition. However, the descriptive ranges in school, city, and county populations indicate that the promotion and facilitation of physical activity through EIM-OC can be achieved on almost any campus located anywhere in the U.S. Interestingly, results also indicated that nearly all (~90%) total and gold level EIM-OC programs were in metropolitan counties.

Importantly, most EIM-OC programs have primarily focused their efforts towards on- physical activity advocacy strictly on-campus[71]. A few programs also extend physical activity promotion off-campus into the surrounding community[73]. For instance, Wedig and colleagues[73] promoted and provided physical activity resources to students, staff, faculty, and community members during the pandemic and beyond. The purpose of Aim 2 was to assess the community impact of EIM-OC programs through county-level physical activity prevalence data. While the difference between metropolitan and non-metropolitan counties is rather large, it is important to note that I identified that there are more metropolitan (n = 721) than non-metropolitan (n = 575) counties that contain higher education institutions (Table 3). The results from Aim 2 demonstrated that the presence of silver and gold level EIM-OC programs were a significant predictor of county-level physical activity, accounting for 1.5% of the variance in county-level physical activity prevalence. However, EIM-OC program presence was not significant when adjusting for other health factors (e.g., smoking, education, rurality). Therefore, the adjusted model provided a robust explanation of almost 80% of observed variance in county-level physical activity. Longitudinally, further nationwide EIM-OC program implementation is required for further assessment of community impact. While EIM-OC program implementation may serve to be beneficial everywhere, this thesis highlights the need for physical activity promotion towards existing colleges and universities, especially those in rural, non-metropolitan areas, where rates of health factors such as physical activity[27], education level[25], and smoking[103] were reported to be lower.

5.5 Implications

The findings from my thesis provide three notable implications. First, performing a national analysis of the recognized EIM-OC programs in the U.S. provides ACSM chapter regions along with participating and developing programs with an understanding of the distribution of the EIM-OC initiative across the country. Together, these data may help direct future implementation of EIM-OC programs at the campus, county, state, regional and/or national level. Opportunities for expansion may also exist through collaborative efforts between programs. For instance, aiding non-metropolitan schools with the development of an EIM-OC program through outreach efforts from established programs may be beneficial. Furthermore, to the best of my knowledge, this study provides the first collective assessment of EIM-OC presence on county-level physical activity prevalence. Understanding the possible link between EIM-OC and community physical activity prevalence could help to further reinforce the importance of the EIM-OC initiative. This could help to motivate more colleges and universities to leverage their

EIM-OC programs to advocate for physical activity promotion not only on campus, but in their surrounding communities. With published data from both the U.S. and Canada[97], we now have a better understanding of EIM-OC impact on countries in North America. There are approximately 20 more recognized EIM-OC programs globally[67], therefore an important next step is to better understand the characteristics of the programs that exist in other countries. Lastly, promotion of the EIM-OC model beyond the U.S. and North America reinforces the mission and vision of EIM-OC while serving as a global action call to further promote physical activity on campus and in surrounding communities.

5.6 Limitations

This study had several limitations. First, it is important to note that other EIM-OC programs exist in the U.S. that were not included in the analysis. On the official EIM-OC website, there are programs that are classified as registered, that may promote, educate, and/or assess physical activity on their campuses at a level that may earn bronze, silver, or gold level status. However, to become recognized, the EIM-OC advisor must complete the annual recognition program form. Programs that were registered but not recognized were not included in my analysis. Furthermore, data collection of school-level variables (i.e., population, degree programs, health services) were standardized to the best of my ability. However, the ease of collection varied based on the information provided on official school websites. Future studies should expand on this thesis project and the work of Lagally et al.[100] to survey all recognized programs across the U.S. While Lagally and colleagues[100] reported a survey response rate of only 16%, future direction could include surveying in collaboration with groups such as the EIM-OC national office and/or ACSM regional chapters to improve standardized reporting measurements. This aligns with future directions reported from Peterson et al.[71] in attempt to create a streamlined method to assess EIM-OC program success. Furthermore, documenting these data similar to Morgan et al.[97] in the form of a casebook may allow for increased collaborative efforts from programs to reach the common goal of increased physical activity promotion.

Considering the assessment of community impact, it is important to note that the American Collegiate Health Association has a National College Health Assessment[104], which provides a survey to allow campuses to collect physical activity level data. While this survey allows for the opportunity to collect campus-wide physical activity data through specific questioning, all recognized EIM-OC campuses do not participate in the survey. Future directions of EIM-OC may include encouraging campuses to collect campus wide physical activity data to allow for standardized assessments of program impact via pre- and post-activity levels. The county level physical activity data utilized 2019 BRFSS data as the outcome variable. It is important to note that this study was cross-sectional, and the self-reported data was not directly measured. Furthermore, a reported[105] limitation of the BRFSS question is that the nature of the question does not account for physical activity that is a component of any occupation-related activity. Fan and colleagues[106] reported differences in rural-urban physical activity disparities based on the measurements of physical activity (i.e., total activity versus leisure activity, versus activity at home). Moreover, the 2023 BRFSS county stratified physical inactivity data could not be obtained, therefore the most recent, publicly available data from 2020 had to be used. To support this and to pair data accordingly, EIM-OC recognition program data from 2020 was used. These data also contained 131 recognized programs but included slight differences in the distribution of recognition level (19 bronze, 53 silver, 59 gold). Lastly, these 2020 EIM-OC program data were from a year that was impacted by COVID-19. During this time, many worldwide extracurricular initiatives were put on hold, and perhaps many programs were halted due to pandemic measures, or EIM-OC advisors did not complete the recognition form.

5.7 Conclusion

In summary, I performed a national analysis of the 2023 recognized EIM-OC programs by evaluating local, county, state and regional-level factors (Aim 1) and examined the relationship between the presence of EIM-OC programs and resulting community-level physical activity prevalence (Aim 2). Most of the EIM-OC programs were located in the eastern half of the country, contained a kinesiology-related degree on their campus, and provided access to student centered health care services. School, city, and county populations ranged considerably, with no significant differences across bronze, silver and gold level recognition. Additionally, the presence of an EIM-OC program was not a significant predictor of county-level physical activity prevalence when adjusted for other health factors. I interpret these results to suggest that collectively, colleges and universities of varying sizes and infrastructure can promote physical activity on their campuses using the EIM-OC initiative. Further promotion of the model would be beneficial to help increase the number of participating EIM-OC campuses in specific states, and regions, and non-metropolitan areas within the U.S.

6 Reference List

1. World Health Organization. Physical inactivity. WHO. Accessed February 16th, 2023. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3416

2. World Health Organization. *Global recommendations on physical activity for health*. World Health Organization; 2010.

3. R. Guthold, Stevens G. A., Riley L. M., Bull F. C. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *Lancet Glob Health*. Oct 2018;6(10):e1077-e1086. doi:10.1016/s2214-109x(18)30357-7

4. R. Guthold, Stevens G. A., Riley L. M., Bull F. C. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. *Lancet Child Adolesc Health*. Jan 2020;4(1):23-35. doi:10.1016/s2352-4642(19)30323-2

5. D. L. Blackwell, Lucas J. W., Clarke T. C. Summary health statistics for U.S. adults: national health interview survey, 2012. *Vital Health Stat 10*. Feb 2014;(260):1-161.

6. J. N. Morris, Heady J. A., Raffle P. A., Roberts C. G., Parks J. W. Coronary heart-disease and physical activity of work. *Lancet*. Nov 28 1953;262(6796):1111-20; concl. doi:10.1016/s0140-6736(53)91495-0

7. Steven N Blair. Physical inactivity: the biggest public health problem of the 21st century. *British Journal of Sports Medicine*. 2009;43(1):1-2.

8. Physical Activity Series *The Lancet* 2012;

9. H. W. Kohl, 3rd, Craig C. L., Lambert E. V., et al. The pandemic of physical inactivity: global action for public health. *Lancet*. Jul 21 2012;380(9838):294-305. doi:10.1016/s0140-6736(12)60898-8

10. R. S. Reis, Salvo D., Ogilvie D., Lambert E. V., Goenka S., Brownson R. C. Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving. *Lancet*. Sep 24 2016;388(10051):1337-48. doi:10.1016/s0140-6736(16)30728-0

11. I. M. Lee, Shiroma E. J., Lobelo F., Puska P., Blair S. N., Katzmarzyk P. T. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. Jul 21 2012;380(9838):219-29. doi:10.1016/s0140-6736(12)61031-9

12. D. E. R. Warburton, Bredin S. S. D. Health benefits of physical activity: a systematic review of current systematic reviews. *Curr Opin Cardiol*. Sep 2017;32(5):541-556. doi:10.1097/hco.0000000000000437

13. U.S. Department of Health and Human Services. *Physical Activity Guidelines for Americans*. 2nd ed. 2018.

14. S. A. Carlson, Fulton J. E., Pratt M., Yang Z., Adams E. K. Inadequate physical activity and health care expenditures in the United States. *Prog Cardiovasc Dis*. Jan-Feb 2015;57(4):315-23. doi:10.1016/j.pcad.2014.08.002

15. S. Goates, Du K., Arensberg M. B., Gaillard T., Guralnik J., Pereira S. L. Economic Impact of Hospitalizations in US Adults with Sarcopenia. *J Frailty Aging*. 2019;8(2):93-99. doi:10.14283/jfa.2019.10

16. Centers for Disease Control and Prevention. Unfit to Serve CDC. Updated June 20th, 2023. Accessed February 19th 2023. https://www.cdc.gov/physicalactivity/resources/unfit-to-serve
17. A. Ammar, Brach M., Trabelsi K., et al. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. *Nutrients*. May 28 2020;12(6)doi:10.3390/nu12061583
18. R. Sallis, Young D. R., Tartof S. Y., et al. Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: a study in 48 440 adult patients. *Br J Sports Med*. Oct 2021;55(19):1099-1105. doi:10.1136/bjsports-2021-104080
19. Y. Ezzatvar, Ramírez-Vélez R., Izquierdo M., Garcia-Hermoso A. Physical activity and risk of infection, severity and mortality of COVID-19: a systematic review and non-linear dose-response meta-analysis of data from 1 853 610 adults. *Br J Sports Med*. Aug 22 2022;doi:10.1136/bjsports-2022-105733
20. E. Ekblom-Bak, Väisänen D., Ekblom B., et al. Cardiorespiratory fitness and lifestyle on severe COVID-19 risk in 279,455 adults: a case control study. *Int J Behav Nutr Phys Act*. Oct 19 2021;18(1):135. doi:10.1186/s12966-021-01198-5
21. G. B. Cunningham. Physical activity and its relationship with COVID-19 cases and deaths: Analysis of U.S. counties. *J Sport Health Sci*. Sep 2021;10(5):570-576. doi:10.1016/j.jshs.2021.03.008
22. A. Ramirez Varela, Sallis R., Rowlands A. V., Sallis J. F. Physical Inactivity and COVID-19: When Pandemics Collide. *J Phys Act Health*. Aug 19 2021;18(10):1159-1160. doi:10.1123/jpah.2021-0454
23. World Health Organization. Social determinants of health WHO. Accessed February 16th 2023. https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1
24. W. C. Cockerham, Hamby B. W., Oates G. R. The Social Determinants of Chronic Disease. *Am J Prev Med*. Jan 2017;52(1s1):S5-s12. doi:10.1016/j.amepre.2016.09.010
25. LH Downey. Rural Populations and Health: Determinants, Disparities, and Solutions *Prev Chronic Dis* 2013;(10:E104)
26. Igor Vojnovic. Building communities to promote physical activity: a multi-scale geographical analysis. *Geografiska Annaler: Series B, Human Geography*. 2006/03/01 2006;88(1):67-90. doi:10.1111/j.0435-3684.2006.00206.x
27. C. G. Abildso, Daily S. M., Umstattd Meyer M. R., Perry C. K., Eyler A. Prevalence of Meeting Aerobic, Muscle-Strengthening, and Combined Physical Activity Guidelines During Leisure Time Among Adults, by Rural-Urban Classification and Region - United States, 2020. *MMWR Morb Mortal Wkly Rep*. Jan 27 2023;72(4):85-89. doi:10.15585/mmwr.mm7204a1
28. Agency for Healthcare Research, Quality. National healthcare quality and disparities report. 2017;
29. P. Boersma, Black L. I., Ward B. W. Prevalence of Multiple Chronic Conditions Among US Adults, 2018. *Prev Chronic Dis*. Sep 17 2020;17:E106. doi:10.5888/pcd17.200130
30. Michael Meit, Knudson Alana, Gilbert Tess, et al. The 2014 update of the rural-urban chartbook. *Bethesda, MD: Rural Health Reform Policy Research Center*. 2014;10

31. J. N. Morris. Exercise in the prevention of coronary heart disease: today's best buy in public health. *Med Sci Sports Exerc*. Jul 1994;26(7):807-14.

32. H. Arem, Moore S. C., Patel A., et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. *JAMA Intern Med*. Jun 2015;175(6):959-67. doi:10.1001/jamainternmed.2015.0533

33. D. E. Warburton, Charlesworth S., Ivey A., Nettlefold L., Bredin S. S. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *Int J Behav Nutr Phys Act*. May 11 2010;7:39. doi:10.1186/1479-5868-7-39

34. F. B. Ahmad, Cisewski J. A., Miniño A., Anderson R. N. Provisional Mortality Data - United States, 2020. *MMWR Morb Mortal Wkly Rep*. Apr 9 2021;70(14):519-522. doi:10.15585/mmwr.mm7014e1

35. F. B. Ahmad, Cisewski J. A., Anderson R. N. Provisional Mortality Data - United States, 2021. *MMWR Morb Mortal Wkly Rep*. Apr 29 2022;71(17):597-600. doi:10.15585/mmwr.mm7117e1

36. G. Mammen, Faulkner G. Physical activity and the prevention of depression: a systematic review of prospective studies. *Am J Prev Med*. Nov 2013;45(5):649-57. doi:10.1016/j.amepre.2013.08.001

37. F. B. Schuch, Vancampfort D., Firth J., et al. Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. *Am J Psychiatry*. Jul 1 2018;175(7):631-648. doi:10.1176/appi.ajp.2018.17111194

38. M. Pearce, Garcia L., Abbas A., et al. Association Between Physical Activity and Risk of Depression: A Systematic Review and Meta-analysis. *JAMA Psychiatry*. Jun 1 2022;79(6):550-559. doi:10.1001/jamapsychiatry.2022.0609

39. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet*. Nov 6 2021;398(10312):1700-1712. doi:10.1016/s0140-6736(21)02143-7

40. S. F. M. Chastin, Abaraogu U., Bourgois J. G., et al. Effects of Regular Physical Activity on the Immune System, Vaccination and Risk of Community-Acquired Infectious Disease in the General Population: Systematic Review and Meta-Analysis. *Sports Med*. Aug 2021;51(8):1673-1686. doi:10.1007/s40279-021-01466-1

41. A. Sette, Crotty S. Adaptive immunity to SARS-CoV-2 and COVID-19. *Cell*. Feb 18 2021;184(4):861-880. doi:10.1016/j.cell.2021.01.007

42. S. Collie, Saggers R. T., Bandini R., et al. Association between regular physical activity and the protective effect of vaccination against SARS-CoV-2 in a South African case-control study. *Br J Sports Med*. Feb 2023;57(4):205-211. doi:10.1136/bjsports-2022-105734

43. D. C. Nieman. Exercise Is Medicine for Immune Function: Implication for COVID-19. *Curr Sports Med Rep*. Aug 1 2021;20(8):395-401. doi:10.1249/jsr.0000000000000867

44. CHANGHYUN LIM, KIM HYO JEONG, MORTON ROBERT W., et al. Resistance Exercise–induced Changes in Muscle Phenotype Are Load Dependent. *Medicine & Science in Sports & Exercise*. 2019;51(12):2578-2585. doi:10.1249/mss.0000000000002088

45. R. C. Cassilhas, Viana V. A., Grassmann V., et al. The impact of resistance exercise on the cognitive function of the elderly. *Med Sci Sports Exerc*. Aug 2007;39(8):1401-7. doi:10.1249/mss.0b013e318060111f

46. J. Lee, Kim D., Kim C. Resistance Training for Glycemic Control, Muscular Strength, and Lean Body Mass in Old Type 2 Diabetic Patients: A Meta-Analysis. *Diabetes Ther*. Jun 2017;8(3):459-473. doi:10.1007/s13300-017-0258-3

47. E. Stamatakis, Lee I. M., Bennie J., et al. Does Strength-Promoting Exercise Confer Unique Health Benefits? A Pooled Analysis of Data on 11 Population Cohorts With All-Cause, Cancer, and Cardiovascular Mortality Endpoints. *Am J Epidemiol*. May 1 2018;187(5):1102-1112. doi:10.1093/aje/kwx345

48. A. J. Cruz-Jentoft, Baeyens J. P., Bauer J. M., et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing*. Jul 2010;39(4):412-23. doi:10.1093/ageing/afq034

49. The United Nations. Population Division World Prospects 2022. UN. Accessed January 27th, 2023. https://population.un.org/wpp/

50. Jonatan R Ruiz, Sui Xuemei, Lobelo Felipe, et al. Association between muscular strength and mortality in men: prospective cohort study. *BMJ*. 2008;337:a439. doi:10.1136/bmj.a439

51. Katrina L. Piercy, Troiano Richard P., Ballard Rachel M., et al. The Physical Activity Guidelines for Americans. *JAMA*. 2018;320(19):2020-2028. doi:10.1001/jama.2018.14854

52. D. E. Warburton, Bredin S. S. Reflections on Physical Activity and Health: What Should We Recommend? *Can J Cardiol*. Apr 2016;32(4):495-504. doi:10.1016/j.cjca.2016.01.024

53. C. J. Caspersen, Powell K. E., Christenson G. M. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep*. Mar-Apr 1985;100(2):126-31.

54. Walter R. Thompson, Sallis Robert, Joy Elizabeth, Jaworski Carrie A., Stuhr Robyn M., Trilk Jennifer L. Exercise Is Medicine. *American Journal of Lifestyle Medicine*. 2020;14(5):511-523. doi:10.1177/1559827620912192

55. T. M. Manini. Using physical activity to gain the most public health bang for the buck. *JAMA Intern Med*. Jun 2015;175(6):968-9. doi:10.1001/jamainternmed.2015.0544

56. S. N. Blair, Church T. S. The fitness, obesity, and health equation: is physical activity the common denominator? *Jama*. Sep 8 2004;292(10):1232-4. doi:10.1001/jama.292.10.1232

57. R. E. Sallis, Baggish A. L., Franklin B. A., Whitehead J. R. The Call for a Physical Activity Vital Sign in Clinical Practice. *Am J Med*. Sep 2016;129(9):903-5. doi:10.1016/j.amjmed.2016.05.005

58. Robert Sallis. Exercise is medicine: a call to action for physicians to assess and prescribe exercise. *The Physician and Sportsmedicine*. 2015/01/02 2015;43(1):22-26. doi:10.1080/00913847.2015.1001938

59. American College of Sports Medicine. Exercise is Medicine® on Campus: Action Guide ACSM. Accessed January 11th, 2023. https://www.exerciseismedicine.org/EIM-OCActionGuide

60. N. Allen. Physical culture in Amherst College. Presented to the Board of Trustees of Amherst College at their annual meeting, July 8, 1869. *Am J Public Health*. May 2003;93(5):720-2. doi:10.2105/ajph.93.5.720

61. K. J. McCristal, Miller Emil A. A Brief Survey of the Present Status of the Health and Physical Education Requirement for Men Students in Colleges and Universities. *Research Quarterly American Association for Health, Physical Education and Recreation*. 1939/12/01 1939;10(4):70-80. doi:10.1080/10671188.1939.10622514
62. B. J. Cardinal, Sorensen S. D., Cardinal M. K. Historical perspective and current status of the physical education graduation requirement at American 4-year colleges and universities. *Res Q Exerc Sport*. Dec 2012;83(4):503-12. doi:10.1080/02701367.2012.10599139
63. American College Health Association. National College Health Assessment, spring 2018. ACHA. Accessed January 26th 2023. https://www.acha.org/documents/ncha/NCHA-II_Spring_2018_Reference_Group_Executive_Summary.pdf
64. B. Singh, Olds T., Curtis R., et al. Effectiveness of physical activity interventions for improving depression, anxiety and distress: an overview of systematic reviews. *Br J Sports Med*. Feb 16 2023;doi:10.1136/bjsports-2022-106195
65. A. K. Ghrouz, Noohu M. M., Dilshad Manzar M., Warren Spence D., BaHammam A. S., Pandi-Perumal S. R. Physical activity and sleep quality in relation to mental health among college students. *Sleep Breath*. Jun 2019;23(2):627-634. doi:10.1007/s11325-019-01780-z
66. American College of Sports Medicine. Exercise is Medicine® on Campus: Recognition Levels ACSM. Accessed January 11th, 2023. www.exerciseismedicine.org//EIM-OC-Recognition-Levels.pdf
67. American College of Sports Medicine. Exercise is Medicine® on Campus ACSM. Accessed 2023, February 17th. https://www.exerciseismedicine.org/eim-in-action/eim-on-campus/
68. M. Bopp, Bopp C. M., Duffey M. L., Ganim R., Proctor D. N. Implementation and evaluation of an Exercise is Medicine™ on campus week. *Eval Program Plann*. Oct 2015;52:176-81. doi:10.1016/j.evalprogplan.2015.06.003
69. Jeff Lynn, Urda Joyan, Winters Carena S. Slippery Rock University: A Case Study of Success in Exercise is Medicine® On Campus. *ACSM's Health & Fitness Journal*. 2015;19(4):34-36. doi:10.1249/fit.0000000000000130
70. B. M. McEachern, Jackson J., Yungblut S., Tomasone J. R. Barriers and Facilitators to Implementing Exercise is Medicine Canada on Campus Groups. *Health Promot Pract*. Sep 2019;20(5):751-759. doi:10.1177/1524839919830923
71. N. E. Peterson, Zera J. N., Tompkins C. L., et al. Exercise is Medicine on Campus: A Scoping Review of Evidence 2009 to 2021 and Call to Action. *Curr Sports Med Rep*. Aug 1 2022;21(8):289-302. doi:10.1249/jsr.0000000000000978
72. Michigan Technological University. Tech Forward MTU, Office of the President. Accessed January 19th, 2023. https://www.mtu.edu/president/techforward/
73. I. J. Wedig, Phillips, J. J., Kamm, K. B., Elmer, S. J. Promoting Physical Activity in Rural Communities During COVID-19 with Exercise is Medicine on Campus. *ACSM Health and Fitness Journal* 2023;27(2):1-8.
74. Integrated postsecondary education data system. Educational institutions. U.S. Department of Education. Accessed January 25th, 2023. https://nces.ed.gov

75. Randy Krum. *Cool infographics: Effective communication with data visualization and design*. John Wiley & Sons; 2013.
76. H. Scott, Fawkner S., Oliver C., Murray A. Why healthcare professionals should know a little about infographics. *Br J Sports Med*. Sep 2016;50(18):1104-5. doi:10.1136/bjsports-2016-096133
77. I. J. Wedig, Duelge T. A., Elmer S. J. Infographic. Stay physically active during COVID-19 with exercise as medicine. *Br J Sports Med*. Mar 2021;55(6):346-347. doi:10.1136/bjsports-2020-103282
78. B. A. Franklin, Wedig I. J., Sallis R. E., Lavie C. J., Elmer S. J. Physical Activity and Cardiorespiratory Fitness as Modulators of Health Outcomes: A Compelling Research-Based Case Presented to the Medical Community. *Mayo Clin Proc*. Feb 2023;98(2):316-331. doi:10.1016/j.mayocp.2022.09.011
79. Data USA. Accessed March 19th, 2023. https://datausa.io/
80. American Association of Medical Colleges. Medical School Members AAMC. Accessed March 21, 2023. https://members.aamc.org/eweb/DynamicPage.aspx?site=AAMC&webcode=AAMCOrgSearchResult&orgtype=Medical%20School
81. American Association of Colleges of Osteopathic Medicine. Explore Medical Schools AACOM. Accessed 2023, March 21.
82. U.S. Census Bureau. 2020 Census Data USCB. Accessed February 2nd, 2023. https://www.census.gov/programs-surveys
83. U.S. Department of Agriculture. Rural-Urban Continuum Codes USDA. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes
84. Office of Management and Budget. Revised Delineations of Metropolitan Statistical Areas, Micropolitan, Statistical Areas, and Combined Statistical Areas, and Guidance on Uses of
the Delineations of These Areas. OMB. Accessed February 9th, 2023. https://www.bls.gov/bls/omb-bulletin-15-01-revised-delineations-of-metropolitan-statistical-areas.pdf
85. U.S. Department of Agriculture. Rural-Urban Continuum Codes: Documentation. USDA. Accessed February 9th, 2023. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/
86. U.S. Department of Agriculture. Rural Classifications. USDA. Accessed February 9th, 2023. https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/
87. American College of Sports Medicine. Regional Chapter Meetings. Accessed March 21, 2023. https://www.acsm.org/meetings/regional-chapters
88. County Health Rankings. County Health Rankings Model. https://www.countyhealthrankings.org/explore-health-rankings/county-health-rankings-model
89. Centers for Disease Control and Prevention. Calculated Variables in the 2019 Data File of the Behavioral Risk Factor Surveillance System CDC. Updated February 9th https://www.cdc.gov/brfss/annual_data/2019/pdf/2019-calculated-variables-version4-508.pdf

90. Carnegie Classification of Institutions of Higher Education®. Higher Education Institutions. American Council on Education. https://carnegieclassifications.acenet.edu/resource/
91. U.S. Census Bureau. SAIPE State and County Estimates for 2020. USCB. Accessed February 13th, 2023. https://www.census.gov/data/datasets/2020/demo/saipe/2020-state-and-county.html
92. U.S. Census Bureau. American Community Survey USCB. Accessed February 16th 2023. https://www.census.gov/programs-surveys/acs
93. County Health Rankings. Access to Exercise Opportunities. County Health Rankings Accessed April 14th, 2023. https://www.countyhealthrankings.org/explore-health-rankings/county-health-rankings-model/health-factors/health-behaviors/diet-and-exercise/access-to-exercise-opportunities?year=2023
94. United States Census Bureau. Small Area Health Insurance Estimates (SAHIE): 2019. Accessed March 26th, 2023. https://www.census.gov/library/publications/2021/demo/p30-09.html
95. Jacob Cohen. *Statistical power analysis for the behavioral sciences*. Academic press; 2013.
96. Ronald D. Snee. Validation of Regression Models: Methods and Examples. *Technometrics*. 1977;19(4):415-428. doi:10.2307/1267881
97. T. L. Morgan, Liscio M., Leung P., McEachern B., Yungblut S., Tomasone J. R. Exercise is Medicine® Canada on Campus Casebook: Evaluation of a novel knowledge translation tool and lessons learned. *Eval Program Plann*. Dec 2021;89:101992. doi:10.1016/j.evalprogplan.2021.101992
98. Exercise is Medicine at SRU Slippery Rock University Accessed August 1st, 2023. https://www.sru.edu/life-at-sru/health-and-wellness/exercise-is-medicine
99. Exercise is Medicine at App State Division of Student Affairs Accessed August 1st, 2023. https://eim.appstate.edu/
100. Kristen M. Lagally, Sherman Jacqueline, Amorose Anthony J., Rinaldi-Miles Anna, Winters Carena S. Exercise Is Medicine on Campus Programs: A Descriptive Study. *Recreational Sports Journal*. 2019;43(2):106-116. doi:10.1177/1558866119889898
101. K. Berra, Rippe J., Manson J. E. Making Physical Activity Counseling a Priority in Clinical Practice: The Time for Action Is Now. *Jama*. Dec 22-29 2015;314(24):2617-8. doi:10.1001/jama.2015.16244
102. A. V. Connaughton, Weiler R. M., Connaughton D. P. Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: implications for Healthy People 2010. *Public Health Rep*. May-Jun 2001;116(3):226-34. doi:10.1093/phr/116.3.226
103. National Healthcare Quality & Disparities Reports. *National Healthcare Quality and Disparities Report: Chartbook on Rural Healthcare*. Agency for Healthcare Research and Quality (US); 2021.
104. American College Health Association. About ACHA-NCHA. Accessed July 12, 2023. https://www.acha.org/NCHA/About_ACHA_NCHA/Overview/NCHA/About/About_NCHA.aspx?hkey=75eaa64f-e82c-4cfd-a19c-4e3f9bf126ee

105. County Health Rankings. Physical Inactivity County Health Rankings Accessed February 15th, 2023. https://www.countyhealthrankings.org/explore-health-rankings/county-health-rankings-model/health-factors/health-behaviors/diet-and-exercise/physical-inactivity?year=2023
106. J. X. Fan, Wen M., Kowaleski-Jones L. Rural-urban differences in objective and subjective measures of physical activity: findings from the National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Prev Chronic Dis*. Aug 21 2014;11:E141. doi:10.5888/pcd11.140189

7 Appendix

7.1 EIM-OC programs stratified by state (total and gold level)

State	Total Programs	Gold Programs
California	10	6
North Carolina	8	3
Ohio	8	3
Pennsylvania	8	4
Florida	7	4
Michigan	6	5
Virginia	6	4
Illinois	5	1
Minnesota	5	0
New Jersey	5	3
Texas	5	1
Georgia	4	2
Indiana	4	1
Tennessee	4	2
West Virginia	4	4
Arizona	3	2
Connecticut	3	1
Iowa	3	1
Kentucky	3	2
New York	3	3

South Carolina	3	3
Wisconsin	3	1
Arkansas	2	1
Kansas	2	0
Massachusetts	2	0
Maryland	2	1
Missouri	2	0
Utah	2	1
Alabama	1	0
Colorado	1	0
Delaware	1	0
Idaho	1	0
Nebraska	1	0
South Dakota	1	1
Vermont	1	1
Washington	1	0
Wyoming	1	1

7.2 Iterations of Adjusted Linear Model

Crude Model – EIM-OC presence predicting physical activity prevalence

```
lm1<-lm(paraw~eimoc,data=data2)
summary(lm1)

Call:
lm(formula = paraw ~ eimoc, data = data2)

Residuals:
       Min        1Q    Median        3Q       Max
 -0.164628 -0.030878  0.002372  0.034372  0.134372

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
 (Intercept)     0.752628   0.001399 538.067  < 2e-16 ***
 eimoc bronze    0.014772   0.012480   1.184 0.236741
 eimoc silver    0.021122   0.007072   2.987 0.002873 **
 eimoc gold      0.023946   0.006684   3.583 0.000353 ***
 ---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

 Residual standard error: 0.04803 on 1292 degrees of freedom
 Multiple R-squared:  0.01673,    Adjusted R-squared:  0.01445
 F-statistic: 7.329 on 3 and 1292 DF,  p-value: 7.14e-05
```

Beta Coefficients Crude Model

```
eimoc bronze        eimoc silver
0.03267165          0.08248432

eimoc gold
0.09894630
```

Model #2 - EIM-OC presence + smoking prevalence predicting physical activity prevalence

```
lm2<-lm(paraw~eimoc+smoking,data=data2)
summary(lm2)
```

```
Call:
lm(formula = paraw ~ eimoc + smoking, data = data2)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.152280 -0.017072  0.003033  0.021850  0.073720 

Coefficients:
               Estimate  Std. Error t value Pr(>|t|)    
(Intercept)    0.927054   0.004417 209.883   <2e-16 ***
eimoc bronze   0.003010   0.008302   0.363   0.7170    
eimoc silver  -0.008583   0.004759  -1.804   0.0715 .  
eimoc gold    -0.002450   0.004492  -0.546   0.5855    
smoking       -0.910434   0.022538 -40.395   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03193 on 1291 degrees of freedom
Multiple R-squared:  0.5657, Adjusted R-squared:  0.5643 
F-statistic: 420.4 on 4 and 1291 DF,  p-value: < 2.2e-16
```

Model #3 - EIM-OC presence + smoking prevalence + high school education predicting physical activity prevalence

```
lm3<-lm(paraw~eimoc+smoking+education,data=data2)
summary(lm3)
```

```
Call:
lm(formula = paraw ~ eimoc + smoking + education, data = data2)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.082638 -0.014738  0.000862  0.015586  0.070848 

Coefficients:
               Estimate   Std. Error t value   Pr(>|t|)    
(Intercept)     0.438408   0.015391  28.485   <2e-16 ***
eimoc bronze   -0.002651   0.006162  -0.430   0.6670    
eimoc silver   -0.008978   0.003531  -2.543   0.0111 *  
eimoc gold     -0.003961   0.003332  -1.189   0.2348    
smoking        -0.656780   0.018452 -35.593   <2e-16 ***
education       0.494117   0.015207  32.494   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02369 on 1290 degrees of freedom
Multiple R-squared:  0.7612, Adjusted R-squared:  0.7602 
F-statistic: 822.3 on 5 and 1290 DF,  p-value: < 2.2e-16
```

Model #4 - EIM-OC presence + smoking prevalence + high school education + percentage of residents uninsured predicting physical activity prevalence

```
lm4<-lm(paraw~eimoc+smoking+education+uninsured,data=data2)
summary(lm4)
```

```
Call:
lm(formula = paraw ~ eimoc + smoking + education + uninsured,
    data = data2)

Residuals:
      Min        1Q    Median        3Q       Max
-0.082338 -0.014213  0.000369  0.015173  0.070238

Coefficients:
               Estimate   Std. Error t value Pr(>|t|)
(Intercept)    0.477688   0.017591  27.156  < 2e-16 ***
eimoc bronze  -0.002593   0.006116  -0.424  0.67161
eimoc silver  -0.009139   0.003505  -2.608  0.00922 **
eimoc gold    -0.004377   0.003309  -1.323  0.18613
smoking       -0.651216   0.018358 -35.474  < 2e-16 ***
education      0.457954   0.017096  26.787  < 2e-16 ***
uninsured     -0.075724   0.016811  -4.504 7.26e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02351 on 1289 degrees of freedom
Multiple R-squared:  0.7649, Adjusted R-squared:  0.7638
F-statistic: 698.8 on 6 and 1289 DF,  p-value: < 2.2e-16
```

Model #5 - EIM-OC presence + smoking prevalence + high school education + percentage of residents uninsured + access to exercise opportunities predicting physical activity prevalence

```
lm5<-lm(paraw~eimoc+smoking+education+uninsured+exerciseaccess,data=dat
a2)
summary(lm5)
```

```
Call:
lm(formula = paraw ~ eimoc + smoking + education + uninsured + 
    exerciseaccess, data = data2)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.085357 -0.014273  0.000454  0.015176  0.072713 

Coefficients:
                Estimate   Std. Error t value Pr(>|t|)    
(Intercept)     0.489196   0.018063  27.083  < 2e-16 ***
eimoc bronze   -0.001393   0.006118  -0.228  0.81997    
eimoc silver   -0.008322   0.003509  -2.371  0.01787 *  
eimoc gold     -0.003546   0.003316  -1.070  0.28498    
smoking        -0.681986   0.021595 -31.581  < 2e-16 ***
education       0.462272   0.017131  26.985  < 2e-16 ***
uninsured      -0.080634   0.016869  -4.780 1.96e-06 ***
exerciseaccess -0.012531   0.004660  -2.689  0.00726 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02346 on 1288 degrees of freedom
Multiple R-squared:  0.7662, Adjusted R-squared:  0.7649 
F-statistic: 602.9 on 7 and 1288 DF,  p-value: < 2.2e-16
```

Model #6 - EIM-OC presence + smoking prevalence + high school education + percentage of residents uninsured + access to exercise opportunities + median household income predicting physical activity prevalence

```
lm6<-lm(paraw~eimoc+smoking+education+uninsured+exerciseaccess+income,data=data2)
summary(lm6)
```

```
Call:
lm(formula = paraw ~ eimoc + smoking + education + uninsured + 
    exerciseaccess + income, data = data2)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.084932 -0.014505 -0.000169  0.014990  0.074217 

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)    
(Intercept)      4.627e-01  1.854e-02  24.951  < 2e-16 ***
eimoc bronze    -1.466e-03  6.053e-03  -0.242 0.808683    
eimoc silver    -8.158e-03  3.472e-03  -2.350 0.018945 *  
eimoc gold      -3.006e-03  3.282e-03  -0.916 0.359917    
smoking         -5.908e-01  2.731e-02 -21.629  < 2e-16 ***
education        4.479e-01  1.716e-02  26.102  < 2e-16 ***
uninsured       -6.393e-02  1.698e-02  -3.765 0.000174 ***
exerciseaccess  -1.351e-02  4.614e-03  -2.929 0.003462 ** 
income           3.364e-07  6.273e-08   5.362 9.77e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02321 on 1287 degrees of freedom
Multiple R-squared:  0.7713, Adjusted R-squared:  0.7699 
F-statistic: 542.5 on 8 and 1287 DF,  p-value: < 2.2e-16
```

Model #7 - EIM-OC presence + smoking prevalence + high school education + percentage of residents uninsured + access to exercise opportunities + median household income + RUCC metro/non-metro predicting physical activity prevalence

```
lm7<-lm(paraw~eimoc+smoking+education+uninsured+exerciseaccess+income+r
urality,data=data2)
summary(lm7)
 Call:
 lm(formula = paraw ~ eimoc + smoking + education + uninsured +
     exerciseaccess + income + rurality, data = data2)

 Residuals:
       Min         1Q     Median         3Q        Max
 -0.085854 -0.014404 -0.000322  0.015043  0.078577

 Coefficients:
                         Estimate   Std. Error  t value  Pr(>|t|)
 (Intercept)              4.549e-01  1.837e-02  24.759  < 2e-16 ***
 eimoc bronze             8.523e-04  5.994e-03   0.142 0.886959
 eimoc silver            -6.343e-03  3.446e-03  -1.841 0.065856 .
 eimoc gold              -1.401e-03  3.255e-03  -0.430 0.666969
 smoking                 -5.896e-01  2.699e-02 -21.847  < 2e-16 ***
 education                4.400e-01  1.701e-02  25.868  < 2e-16 ***
 uninsured               -6.386e-02  1.678e-02  -3.807 0.000147 ***
 exerciseaccess          -6.454e-03  4.725e-03  -1.366 0.172234
 income                   4.231e-07  6.383e-08   6.628  5.0e-11 ***
 ruralityNon-Metropolitan  8.707e-03  1.531e-03   5.687  1.6e-08 ***
 ---
 Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

 Residual standard error: 0.02293 on 1286 degrees of freedom
 Multiple R-squared:  0.7769, Adjusted R-squared:  0.7753
 F-statistic: 497.6 on 9 and 1286 DF,  p-value: < 2.2e-16
```

Variance Inflation Factor Model #7

```
                   GVIF Df GVIF^(1/(2*Df))
 eimoc          1.089409  3        1.014375
 smoking        2.905708  1        1.704614
 education      1.645143  1        1.282631
 uninsured      1.463833  1        1.209890
 exerciseaccess 1.869075  1        1.367141
 income         2.816524  1        1.678250
 rurality       1.425978  1        1.194143
```

Beta Coefficients Model #7

```
eimoc bronze        eimoc silver
0.001884954         -0.024770832

eimoc gold          smoking
-0.005788816       -0.490501072

education           uninsured
0.437011788         -0.060664687

exerciseaccess      income
-0.024594396        0.146504751

ruralityNon-Metropolitan
0.089443640
```

Analysis of Variance Table Between Crude and Adjusted Models

```
Model 1 (lm1) : paraw ~ eimoc
Model 2 (lm7) : paraw ~ eimoc + smoking + education + uninsured +
exerciseaccess + income + rurality
   Res.Df   RSS   Df  Sum of Sq   F    Pr(>F)
 1   1292 2.98033
 2   1286 0.67623  6    2.3041 730.3 < 2.2e-16 ***
 ---
 Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```