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Chronic health conditions, acute health events, and healthcare utilization among adults over age 50 in Hawai'i who use cannabis: A matched cohort study

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ABSTRACT

Background: Research on cannabis-related health outcomes in diverse older adults is limited. The current study utilized a matched cohort study design to compare older adults in Hawai'i with identified cannabis diagnoses and matched controls on chronic health conditions, acute health events, and healthcare utilization from 2016 to 2020.

Method: Patients age 50 + were identified using ICD-10 diagnostic codes for cannabis use, abuse, and dependence using electronic health record data from an integrated health system (Kaiser Permanente Hawai'i). Those with cannabis diagnoses (n = 275) were compared to matched non-using controls (n = 275; based on age, sex) on chronic health conditions (coronary heart disease, hypertension, COPD, chronic non-cancer pain), acute health events (myocardial infarction, respiratory symptoms, stroke, persistent or cyclic vomiting, injuries), and healthcare utilization (outpatient, inpatient, and emergency department visits) following case identification for two years.

Results: Participants were 19.3% Native Hawaiian/Pacific Islander, 24.4% Asian, 47.8% White, and 8.5% Other/Unknown, with an average age of 62.8 years (SD=7.3). Adjusting for covariates as possible, participants with a cannabis diagnosis had significantly greater risk of coronary heart disease, chronic non-cancer pain, stroke, myocardial infarction, cyclic vomiting, and injuries, over time, compared to controls. Cannabis use was associated with any and greater frequency of outpatient, inpatient, and emergency department visits.

Conclusions: In a diverse sample, older adults who used cannabis had worse health conditions and events and used more health services over a two-year period. Future studies should evaluate cannabis-related health outcomes, effects of cannabis problem severity, as well as implications for healthcare in aging populations.

1. Introduction

The legalization of cannabis for medical and non-medical (personal or recreational) purposes has been ongoing in the U.S. since 1996. Following all 2020–2021 ballot approvals, 16 states (plus the District of Columbia) allow medical and non-medical cannabis use and 19 states allow medical-only (DISA, 2021). With the change in laws, there has been a corresponding increase in the number of adults who report use of cannabis. Although young adults have the highest rates, cannabis use among older adults (defined as age 50 +) has increased rapidly

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(Salas-Wright et al., 2017). Currently, approximately 10–14% of those ages 50 + report past-year cannabis use, reflecting a substantial increase from 2003, when rates were reported at around 3% (Choi et al., 2021; Han and Palamar, 2018, 2020; Salas-Wright et al., 2017; Schulenberg et al., 2020). Older adults increasingly describe using a range of cannabis products and methods to ingest them, including use of edibles and vaping, although data on high potency products is not available (Haug et al., 2017; Subbaraman and Kerr, 2021). Despite increases in prevalence and use of new products, research on the health impacts of regular cannabis use is unclear, particularly in older adults, who generally have more medical comorbidities than young adults that could be exacerbated by cannabis.

Older adults are a fast-growing segment of the U.S. population and will soon outnumber those under age 18 (U.S. Census Bureau, 2018). Historically, as a generation, baby boomers had relatively high rates of substance use compared with prior cohorts (Yarnell et al., 2020), which has fueled speculation that they may carry these patterns into later life. Perceptions of cannabis as risky or potentially harmful have decreased in older adults (Salas-Wright et al., 2017), perhaps driven by the possibility of medical benefit of cannabis for some chronic health conditions, although the evidence for such is sparse (Minerbi et al., 2019; van den Elsen et al., 2014).

In spite of perceived potential health benefits, evidence for harm is also growing. In 2017, the National Academies of Sciences completed a thorough review of research on adverse health conditions associated with cannabis use (National Academies of Sciences and Medicine, 2017). Of the physical health conditions examined in adult samples, evidence supported associations between cannabis use and worsening respiratory symptoms, chronic bronchitis, and risk of motor vehicle crashes. The evidence base for other physical health conditions examined in the report was insufficient to make firm conclusions. One major gap noted by the authors was the paucity of evidence on cannabis-related health effects in under-researched populations such as older adults.

It is well-established that older adults are more susceptible to a range of health conditions compared to younger adults, including cardiovascular conditions and events (e.g., hypertension, myocardial infarction [MI]) and respiratory illnesses (e.g., chronic obstructive pulmonary disorder [COPD]; National Center for Health Statistics, 2021). Older adults are also more likely to take medications that may interact with cannabis (Brown, 2020; Brown and Winterstein, 2019). Although there is scant research on interactions between publicly-available cannabis and specific medications in older adults, accumulating evidence shows that certain medications may increase cannabinoid levels, that cannabinoids can impact the levels of other medications, that additive effects are possible, and serious interactions may exist with particular drugs, such as warfarin and clobazam (Antoniou et al., 2020; Mahvan et al., 2017). Cannabis may trigger MI in persons at high risk for cardiovascular disease, as well as in otherwise healthy adults, due to its cardiostimulatory and inflammatory effects (Chetty et al., 2021; National Academies of Sciences and Medicine, 2017). However, some studies have not demonstrated higher rates of cardiovascular disease and hypertension in those using cannabis as compared to non-users (Matson et al., 2021). Inhaling cannabis smoke, regardless of tobacco use status, has been shown to significantly increase the risk of respiratory disease, such as asthma and COPD (Winhusen et al., 2019).

Falls are the leading cause of fatal and nonfatal injuries among older adults (Centers for Disease Control [CDC], 2020). Because cannabis-related intoxication effects can include cognitive-motor skill impairment (Solowij and Pesa, 2010), risk of falls and other injuries (e.g., traffic crashes) may be particularly problematic for older adults following cannabis consumption (Latif and Garg, 2020; Lum et al., 2019; Workman et al., 2021). Work by Choi et al. (2019) shows that as many as one-third of older adults who used cannabis self-reported driving under the influence (DUI) of substances in the past year. In a different sample, higher cannabis use frequency was associated with increased odds of self-reported DUI (Choi et al., 2016).

Given these health effects, it is likely that cannabis use also impacts utilization of health care by older adults. Recent studies have shown that cannabis use or cannabis use disorder (CUD) is associated with greater health service utilization (Bahorik et al., 2018; Campbell et al., 2017; Choi et al., 2021, 2018; Matson et al., 2020), but the evidence is limited and mixed, particularly for older adults (Choi et al., 2021, 2018). Using data from a U.S. epidemiological survey, Choi et al. (2018) found that older adults who used cannabis in the past year had a higher rate of injury, which led to greater emergency department (ED) visits, as compared to non-users. Using data from the National Survey on Drug Use and Health, Choi et al. (2021) found that older adults using cannabis in the past year had a lower proportion of outpatient visits, but a higher proportion of ED visits and hospitalization, compared to non-using controls.

Electronic health record (EHR) studies have shown that adults with CUD had greater documented ED and inpatient visits compared to matched controls (Bahorik et al., 2018; Campbell et al., 2017). Adult primary care patients who used cannabis less than monthly or daily had a greater risk of ED, urgent care, or hospital admission utilization (Matson et al., 2020). A study examining data from the Nationwide Inpatient Sample dataset found that inpatient admissions for CUD grew 2-fold from 2002 to 2011, with substantial increases among older, more ill patients (Charilaou et al., 2017). Contradictory findings based on self-report found that cannabis use (Bhandari et al., 2016) or frequency (Fuster et al., 2014) was not associated with increased healthcare utilization. The legalization of non-medical cannabis in particular U.S. states, such as Colorado, has been associated with increased ED visits and/or hospitalization for cannabis exposure and cannabinoid hyperemesis syndrome (nausea/vomiting; Kim and Monte, 2016).

The urgency to better understand cannabis use and associated health problems and utilization in older adults, particularly those from diverse ethnic/racial backgrounds, is immense. Compared to other U.S. states, Hawai'i has high numbers of multi-racial, Asian, and Pacific Islander populations (Pew Research Center, 2015, 2021; U.S. Department of Health and Human Services, 2021). As these groups are significantly understudied, we aimed to better inform the literature on cannabis by focusing solely on participants from Hawai'i. We utilized EHR data from an integrated health care system (Kaiser Permanente Hawai'i; KPHI) to identify patients age 50 + with diagnostic cannabis codes and compared them with matched non-using controls on specific chronic (coronary heart disease [CHD], hypertension, COPD, chronic non-cancer pain) and acute (MI, respiratory symptoms, hemorrhagic and ischemic stroke, persistent or cyclic vomiting, and injuries) health conditions or events and healthcare utilization (outpatient, inpatient, and ED visits) for two years following case identification. We focused primarily on health outcomes that have been infrequently studied in older adults. Though other outcomes are equally important (e.g., neurocognitive and psychiatric disorders), the current analysis focuses solely on select medical conditions. Compared to matched, non-using controls, we hypothesized that those with cannabis diagnoses would experience: (H1) greater subsequent rates of all chronic health conditions and acute health events and (H2) any and greater frequency of ED visits, outpatient visits, and hospitalizations.

2. Method

2.1. Setting

Kaiser Permanente (KP) is a federally qualified not-for-profit, group-model health maintenance organization that provides integrated, comprehensive medical care to over 240,000 individuals in the state of Hawai'i. The membership reflects the demographic/sociographic characteristics of the general population, including approximately 10% Medicaid enrollment. Demographic and clinical information is available in the EHR and includes administrative membership characteristics, inpatient admissions, outpatient visits, laboratory tests, pharmacy

dispenses and outside claims and referrals. These databases are linked through each member's unique health record number. Additionally, each member is linked to the demographic information obtained from the 2010 US Census and American Community Survey (ACS) via the associated census tract. Although medical cannabis has been allowed in the state of Hawai'i since 2000, it is not permitted for recreational, non-medical purposes (State of Hawai'i, 2021).

2.2. Study sample and design

Adult health plan members age 50 + as of October 1, 2015 were eligible for the study. A matched cohort study design was used. Cannabis cases included those who had an inpatient or outpatient cannabis diagnosis, as assessed using the International Classification of Diseases, 10th ed. (ICD-10) codes F12.x, in the two-year period of April 1, 2016 through March 31, 2018. Cases included members with any diagnostic code for "cannabis use" (ICD-10 F12.9x; 42% of sample), "CUD" (Cannabis Abuse or Dependence; ICD-10 F12.1-F12.29; 55% of sample), or both (3% of sample). We included cases with sole "in remission" CUD diagnoses (n = 2), as many clinicians use the in-remission label for patients in early remission who continue to be at-risk for relapse. All cases were combined into one group. Those with a CUD diagnosis had significantly higher rates of any behavioral health condition (not including substance use) prior to the study period (52.2% vs 36.8%, $p = .02$), but there were no other significant differences between those with CUD or cannabis use diagnoses.

Age-sex matched controls were selected among those without any diagnostic code for cannabis use at any time in their medical record. Participants in each group are subsequently referred to below as cases (i.e., those having any cannabis diagnostic code) and controls. Potential controls were matched on age (month and year of birth) and sex to cases and were selected randomly using a 1:1 ratio. We expected our outcomes of subsequent diagnosis and health care utilization to be associated with age and sex and therefore matched on these factors. Though our cannabis cohort had over 78,000 potential controls, in order to avoid reaching spurious conclusions due to large sample size, we chose to use a similarly-sized control group (Breslow and Day, 1980).

2.3. Outcomes and covariates

The date of the first cannabis diagnosis in the two-year eligibility period (4/1/2016 – 3/31/2018) was denoted the index diagnosis. The EHR was queried to identify demographics and covariates in the 6-month period prior to the index diagnosis and to assess diagnostic and health care utilization outcomes in the two years following the index diagnosis. The data collection for the controls used the index diagnosis date of the matching cannabis use case.

Outcomes evaluated during the two years post-index diagnosis included: 1) diagnosis of chronic health conditions, including CHD, hypertension, COPD, chronic non-cancer pain, and any of these conditions, 2) diagnosis of acute health events, including respiratory symptoms, hemorrhagic or ischemic stroke, MI, persistent or cyclic vomiting (symptoms of Cannabinoid Hyperemesis Syndrome), injuries (i.e., any motor vehicle crash, falls or accidental overdose/poisoning of any substance), and any of these conditions/events, and 3) any inpatient, outpatient, and ED healthcare utilization. We also examined the number of visits among those with any utilization. ICD-10 codes used to identify all diagnoses, including for cannabis, can be found in the supplementary materials (Table S1).

The following comorbid conditions diagnosed in the six months prior to the index date were included as covariates when appropriate: comorbid substance use disorder (SUD) (alcohol, opioids, sedatives, cocaine, other amphetamines, tobacco, inhalants or other); chronic health conditions and acute health events noted above that occurred six months prior to the index cannabis diagnosis; major depressive episode or disorder; anxiety disorder.

Race and ethnicity were self-reported at the time of initial membership enrollment and obtained from the EHR. Members have an opportunity to report up to 5 different races. For classification purposes we report the first listed non-white race. If white is the only reported race then the member is classified as white. Latinx classification is indicated when members select "Hispanic" ethnicity in a separate question. Body mass index (kg/m^2) was based on height and weight measurements closest to the index diagnosis date. Tobacco use was obtained during outpatient visits. We captured tobacco use status (i.e., never, former, or current use) recorded at the time closest to the index diagnosis. The proportion of households in the patient's neighborhood on public assistance was obtained from the ACS and based on the patient's address.

2.4. Data analyses

All statistical analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC). Descriptive statistics were used to summarize sample characteristics. Group comparisons (cases vs. controls) for demographic and baseline conditions were evaluated using McNemar and paired t-tests as appropriate. Conditional logistic regression was used to estimate adjusted odds ratios comparing dichotomous outcomes (chronic health conditions, acute health events, and any utilization) between cases and controls (H1 and H2). Frequency of healthcare utilization, measured as the number of events among those individuals with at least one event, was evaluated using a conditional poisson regression model, adjusting for covariates (H2). Due to low numbers for certain health conditions or events (hemorrhagic and ischemic stroke, MI, persistent or cyclic vomiting, motor vehicle crashes and falls), adjusted odds ratios could not be estimated validly. As some individuals died (25 cases, 8 controls) or left the health plan (36 in each group) during the 2-year follow-up, we conducted sensitivity analyses adjusting for person-months of eligibility (mean=21; median=24 months for both groups). These yielded similar results and are not reported.

3. Results

3.1. Participant characteristics

Study participants were, on average, 62.8 (SD=7.3; range 51–87) years old, predominantly male (69.5%), and were White (47.8%), Asian (24.4%), Native Hawaiian or Pacific Islander (NHPI; 19.3%), or an unknown or other race (8.5%) not documented in the EHR; and 5.6% Latinx. Cases and controls differed significantly by race/ethnicity (Table 1). Cases were more likely to be White (54.2% vs 41.5%) or NHPI (23.3% vs 15.3%) and controls were more likely to be Asian (34.5% vs 14.2%). Cases had a lower BMI (27.5 vs 28.7) and were more likely to live in a neighborhood with a higher proportion of households on public assistance (4.2% vs 3.1%) than controls. Cases were also more likely to be current (25.7% vs 13.4%) or former smokers (48.5% vs 35.8%) and have a history comorbid SUD (30.6% vs 10.2%), chronic health conditions (66.9% vs 46.2%), acute health events (32% vs 11.6%), and behavioral health disorders (45.8% vs 16%) in the six months before the index diagnosis.

3.2. Association between cannabis diagnosis and chronic health conditions and acute health events

3.2.1. Chronic health conditions

Both overall (i.e., any of the specified chronic health conditions) and specific chronic health conditions (i.e., CHD, hypertension, COPD, and chronic non-cancer pain) occurred at higher rates among cases compared to matched controls (Table 2). After adjusting for covariates, differences in rates were significant for overall (any) chronic condition ($aOR = 3.41$, $p = .001$), CHD ($aOR = 3.92$, $p < .001$), and chronic non-cancer pain ($aOR = 2.48$, $p < .001$). Rates of hypertension and COPD did

Table 1
Baseline characteristics by group and total ample. Cell entries are mean (± SD) or n (%).

Group				
Variable	Sample (N = 550)	Case (n = 275)	Control (n = 275)	p-value[a]
Age	62.8 (± 7.3)	62.8 (± 7.3)	62.8 (± 7.3)	NA
Sex (male)	382 (69.5)	191 (69.5)	191 (69.5)	NA
Race				< 0.0001
Asian	134 (24.4)	39 (14.2)	95 (34.5)	
White	263 (47.8)	149 (54.2)	114 (41.5)	
Native Hawaiian or Pacific Islander	106 (19.3)	64 (23.3)	42 (15.3)	
Other	47 (8.5)	23 (8.4)	24 (8.7)	
Latinx (Yes)	31 (5.6)	21 (7.6)	10 (3.6)	0.0435
BMI (kg/m^2)[b]	28.1 (± 6.6)	27.5 (± 6.1)	28.7 (± 6.9)	0.0451
Percentage of households in geocode on public assistance[b]	3.7 (± 4.0)	4.2 (± 4.5)	3.1 (± 3.4)	0.0020
Tobacco use[b]				< 0.0001
Never	195 (37.5)	70 (25.7)	125 (50.8)	
Former	220 (42.3)	132 (48.5)	88 (35.8)	
Current	103 (19.8)	70 (25.7)	33 (13.4)	
Diagnoses prior to index diagnosis				
Comorbid substance use disorder	112 (20.4)	84 (30.6)	28 (10.2)	< 0.0001
Chronic health condition	311 (56.6)	184 (66.9)	127 (46.2)	< 0.0001
Acute health event	120 (21.8)	88 (32.0)	32 (11.6)	< 0.0001
Behavioral health disorder	170 (30.9)	126 (45.8)	44 (16.0)	< 0.0001

[a] p-values are based on paired t-test for continuous measures and McNemar's test for categorical measures.
[b] Missing data for 3–4 cases and 32–33 controls, depending on the variable.

not differ significantly between cases and matched controls ($p > .05$).

3.2.2. Acute health events

Rates of acute health events, including overall events (i.e., any of the specified acute health events), MI, respiratory symptoms, hemorrhagic and ischemic stroke, persistent or cyclic vomiting, and injuries (a composite of motor vehicle crashes, falls, and poisoning) were higher among cases as compared to controls (see Table 2). After covariate adjustment, differences between groups remained significant for overall (any) acute event ($aOR = 2.01, p = .004$) and injuries ($aOR = 2.90, p = .003$). Due to few events among controls, adjusted odds ratios could not be estimated for stroke, MI, and persistent or cyclic vomiting, yet cases had significantly higher rates of all three compared to controls in unadjusted analyses ($p < .0001$ for all). Although more cases (59.3%) than controls (37.8%) experienced respiratory symptoms, differences were not significant after adjusting for covariates ($p = .076$).

3.3. Association between cannabis diagnosis and subsequent healthcare utilization

Associations between cannabis diagnosis and subsequent healthcare utilization are shown in Table 3. Cannabis diagnosis was significantly associated with having an ED visit ($aOR = 1.89, p = .001$). Among those with any ED visit, cannabis use was associated with more frequent visits ($aRR = 1.93, p = .002$). Cannabis diagnosis predicted risk of inpatient hospitalization ($aOR = 3.83, p = <0.001$), as well as more frequent hospitalizations ($aRR = 1.41, p = .025$). Cannabis diagnosis was also associated with any future outpatient visit ($aOR = 4.71, p = <0.001$), as well as number of visits ($aRR = 1.74, p = .006$).

4. Discussion

This study examined the association between cannabis diagnosis and select health outcomes among diverse adults age 50 + in an integrated health system in Hawai'i. Overall, we found that those with a cannabis

Table 2
Association between cannabis diagnosis and subsequent chronic health conditions and acute health events.

Outcome	Group		Adjusted OR (95% CI)[a]	p-value
	Case, n (%)	Control, n (%)		
Chronic health conditions				
Any	252 (91.6)	193 (70.2)	3.41 (1.64, 7.09)	0.0010
Coronary heart disease (CHD)	65 (23.6)	19 (6.9)	3.92 (1.97, 7.80)	0.0001
Hypertension	155 (56.4)	113 (41.1)	1.46 (0.94, 2.28)	0.0921
Chronic obstructive pulmonary disorder (COPD)	75 (27.3)	42 (15.3)	1.29 (0.81, 2.05)	0.2897
Chronic non-cancer pain	206 (74.9)	151 (54.9)	2.48 (1.62, 3.79)	< 0.0001
Acute health events				
Any	187 (68.0)	108 (39.3)	2.01 (1.26, 3.21)	0.0036
Respiratory symptoms	163 (59.3)	104 (37.8)	1.50 (0.96, 2.35)	0.0756
Hemorrhagic and ischemic stroke	28 (10.2)	2 (0.7)	N/A[b]	< 0.0001
Myocardial infarction (MI)	23 (8.4)	3 (1.1)	N/A[b]	< 0.0001
Persistent or cyclic vomiting	15 (5.5)	2 (0.7)	N/A[b]	< 0.0001
Injuries (all)	47 (17.1)	12 (4.4)	2.90 (1.42, 5.87)	0.0033
Motor vehicle accidents	1 (0.4)	0	N/A[b]	<0.0001
Falls	14 (5.1)	1 (0.4)	N/A[b]	< 0.0001
Accidental overdose/poisoning of any substance	35 (12.7)	11 (4.0)	3.40 (1.68, 6.88)	0.0007

[a] Models are adjusted for the following covariates as appropriate: body mass index; tobacco use status; proportion of households in the patient's neighborhood on public assistance; any co-morbid SUD; any chronic health condition; and any acute health event. The following covariates were not statistically significant (and therefore not included as covariates) in any model: race/ethnicity; prior diagnosis of a major depressive episode or disorder; and prior diagnosis of any anxiety disorder.
[b] Due to few events, adjusted odds ratios could not be accurately estimated. For these events, the p-values are based on McNemar's test for matched pairs.

Table 3
Association between cannabis diagnosis and subsequent healthcare utilization.

Outcome	Adjusted OR (95% CI)[a]	p-value	Adjusted RR (95% CI)[a]	p-value
	Risk of any utilization		Risk for number of visits[b]	
ED visits	1.89 (1.29, 2.79)	0.0012	1.93 (1.44, 2.59)	0.0017
Outpatient encounters	4.71 (2.09, 10.66)	0.0002	1.74 (1.14, 2.65)	0.0055
Inpatient visits	3.83 (2.20, 6.65)	< 0.0001	1.41 (1.07, 1.87)	0.0247

[a] Models are adjusted for race/ethnicity (any inpatient visit and number of outpatient visits) and a prior diagnosis of co-morbid SUD (any ED visit, any inpatient visit, and number of ED visits), as appropriate. The following covariates were not statistically significant (and therefore not included as covariates) in any model: body mass index; tobacco use status; proportion of households in the patient's neighborhood on public assistance; prior diagnosis of selected chronic health conditions; prior diagnosis of selected acute health events; prior diagnosis of a major depressive episode or disorder; and prior diagnosis of selected anxiety disorders.
[b] among those with at least one visit.

diagnosis had two to three times higher rates of any acute or chronic health condition or event compared to non-using controls, as assessed in the two-year period following case identification. Compared to matched controls, those with a cannabis diagnosis had significantly higher rates of CHD, chronic non-cancer pain, stroke, MI, persistent or cyclic vomiting, and injuries. Though those with a cannabis diagnosis had higher rates of all health conditions and events, we found no significant differences for hypertension, COPD, and respiratory symptoms. Findings related to healthcare utilization demonstrated that having a cannabis diagnosis was associated with any and the number of future ED visits, outpatient visits, and hospitalizations.

Our findings present new evidence of possible adverse health outcomes related to cannabis use in older adults. Considering differences between those with a cannabis diagnosis and matched controls for specific health conditions, the odds of subsequent CHD were the greatest. Past reviews have demonstrated mixed evidence for CHD risk among those who use cannabis (Richards et al., 2019). Other cardiovascular outcomes examined in this study included hypertension, MI, and hemorrhagic and ischemic stroke. No significant differences were found between groups for hypertension. Though we found that risk for MI and stroke differed significantly between cases and controls, the numbers were too low to get appropriate estimates of risk. Limited data based on case reports suggests that cannabis use may induce MI immediately following use (Chetty et al., 2021). A recent systematic review and meta-analysis found that stroke prevalence was slightly higher among those who used cannabis compared with non-users, but the average age of participants who used cannabis across studies was 26.2 years (Swetlik et al., 2021). In trying to understand potential cardiovascular mechanisms, past work has shown that those who use cannabis experience increases in heart rate and blood pressure immediately after use, possibly from sympathetic nervous system activation and parasympathetic nervous system inhibition (Chetty et al., 2021; Richards et al., 2019). More evidence is needed to fully understand risk in older adults, who are generally at higher risk for cardiovascular conditions and events than younger adults (National Center for Health Statistics, 2021).

Patients with a cannabis diagnosis in our study had higher rates of respiratory symptoms (59% vs 38%) and COPD (27% vs 15%) compared to matched controls, but these differences were not statistically significant. Past work generally supports a link between cannabis and bronchitis, but less commonly for cannabis and serious respiratory conditions such as COPD (Gracie and Hancox, 2021; National Academies of Sciences and Medicine, 2017). One limitation associated with past work is that studies have not consistently controlled for tobacco smoking in analyses, making it difficult to separate out the effects (National Academies of Sciences and Medicine, 2017). It is possible that tobacco co-use may be contributing to mixed findings and could lead to an additive risk for COPD and other respiratory diseases in older adults. Currently, available evidence for risks related to cannabis alone is limited (Tan et al., 2009; Tashkin, 2009).

Additional health outcomes examined in this study include chronic non-cancer pain, persistent or cyclic vomiting, and injuries. Cannabis use is common among individuals with chronic non-cancer pain and past research remains mixed as to the extent that cannabis may improve chronic and non-cancer pain symptoms (Campbell et al., 2018; National Academies of Sciences and Medicine, 2017). Though we cannot verify with our data, we suspect that higher rates of pain may have been at least partially due to participant use of cannabis for medical purposes. When asked about conditions for which they use cannabis medically, older adults consistently identify pain as the predominant condition (Reynolds et al., 2018; Yang et al., 2021). Additionally, current research shows that regular, ongoing cannabis use can produce significant nausea and vomiting (aka cannabinoid hyperemesis), leading to ED visits, particularly when cannabis is inhaled (Monte et al., 2019; Sorensen et al., 2017). Our study provides initial evidence that older adults may also experience hyperemesis.

Though there is evidence that driving under the influence of cannabis can lead to motor vehicle crashes (National Academies of Sciences and Medicine, 2017), evidence for other injuries related to cannabis use, especially among older adults, is scant. In one recent study, Choi et al. (2018) found that cannabis use was associated with injuries in adults over age 50. Cannabis use increased the likelihood of visits to the ED via increases in injuries. Similarly, our data showed that risk of injuries in older adults who use cannabis was almost three times higher than in non-users. More research on falls and other injuries related to cannabis use in older adults is needed, as intoxication effects could influence fall risk and driving in ways that are different from younger populations.

Similar to recent EHR studies with adult populations who have used cannabis or have CUD, we found strong associations between cannabis use and any and more frequent healthcare utilization among older adults in our sample (Bahorik et al., 2018; Campbell et al., 2017; Matson et al., 2020). Due to higher rates of various health conditions in cases compared to controls, it's not surprising that cannabis use status was associated with healthcare utilization. Older adults tend to have greater healthcare needs, but limited research has focused on cannabis-related health effects in this group. A recent study with adults in a primary care setting found those aged 50–64 who used cannabis daily or almost daily utilized urgent healthcare more than non-users in the same age range (Matson et al., 2020). In future studies it will be necessary to determine how cannabis use frequency and length of time using, product potency, and route of ingestion affect utilization. Preliminary evidence suggests that more frequent use of high potency products (e.g., concentrates) may lead to increased negative consequences in younger populations, but it is unclear if concentrates impair older adults in the same manner (Bedillion et al., 2022). Recent evidence with younger adults suggests that both cannabis flower and concentrates may lead to balance impairment post-use, which could drive healthcare utilization in older adults (Bidwell et al., 2020).

Current literature is lacking on a wide range of negative health effects related to cannabis in non-White populations, especially for those who are Asian and NHPI. Ethnic minorities are at greater risk of health disparities, including substance use (Lê Cook et al., 2010; Hines et al., 2012; Vasilenko et al., 2017; Wu et al., 2016), but may receive

differential access to treatment resources (Chen et al., 2020). A complex set of determinants (e.g., income, education, neighborhood), including structural racism, likely play a significant role in these health disparities (Churchwell et al., 2020). The current study is the first to our knowledge to examine cannabis-related health outcomes in older adults from diverse groups that have been understudied. It will be important for future research to examine whether particular groups of older adults are more vulnerable to cannabis-related risks.

This study has a number of limitations. We predominantly selected particular health conditions/events that have been understudied in older adults; however, there are many other important medical conditions that need to be explored, including cognitive and psychiatric disorders. We utilized ICD-10 codes to identify health conditions and may have missed codes that could have increased the number of conditions assessed. Some conditions were rarely reported (e.g., motor vehicle crashes); small numbers prohibited calculation of adjusted estimates. Cannabis use was assessed via the EHR and included only instances where cannabis was recorded in the patient's health record. Practitioners do not consistently ask patients about their cannabis use and tend to record information only when it is substantial; therefore, we may not have identified all possible cases. Though we examined health outcomes following cannabis diagnosis, members could have had the conditions in the more distant past and may have been using cannabis before a formal diagnosis was assigned. Our data did not allow us to determine whether visits were specific to cannabis or treatment for SUD. In addition, information about the patient's cannabis use, including frequency, quantity, potency, and route of ingestion or form (e.g., flower, concentrates), was not available. Older adults report medical and non-medical use of cannabis and use of a wide range of products (Arora et al., 2019; Cranford et al., 2016; Kaufmann et al., 2020; Lum et al., 2019; Manning and Bouchard, 2021; Reynolds et al., 2018). This information should be captured in future work. We used a relatively young age cutoff of 50 + . While consistent with prior studies (e.g., Choi et al., 2018), future work should also examine older samples. Participants were all insured members of a KP health plan in one geographic region (Hawai'i) and may not be representative of those who are uninsured or who live in states with no access to medical cannabis or that allow recreational, non-medical use. Lastly, race/ethnicity were self-reported and this classification may be subject to error, as many people in Hawai'i are multi-racial, but may not identify as such (Kaneshiro et al., 2011).

5. Conclusions

Although the current study cannot establish a causal relationship between cannabis and specific health outcomes, it does provide evidence of possible links in older adults. Rates of particular health conditions and events were higher in those who had a cannabis diagnosis compared to matched controls and cannabis use was associated with greater healthcare utilization. Future studies should examine these health outcomes in a larger sample, across differing geographic areas with varying cannabis laws. Learning more about dose-dependent effects and co-use of cannabis with tobacco and other drugs will be important to better understand the impact of cannabis on health outcomes in older adults, particularly among those from diverse ethnic groups. These findings also highlight the importance of screening for cannabis use in older adults presenting with health conditions that may be related to cannabis. It will be important to continue learning about the therapeutic benefits and adverse health outcomes associated with cannabis in order to provide accurate information for patients.

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CRediT authorship contribution statement

All authors made significant contributions to this manuscript. Dr. Phillips took the lead role in conceptualization, methodology, writing and editing the manuscript. Ms. Pedula aided in the conceptualization of the study, curated the data, conducted the analyses, and summarized the findings. Dr. Choi aided in the conceptualization of the study and contributed to the writing and editing of the manuscript. Ms. Tawara and Drs. Simiola, Satre, Owen-Smith, Lynch, and Dickerson all played supporting roles in writing and editing the manuscript. All authors reviewed and approved the final manuscript.

Conflict of interest

None noted.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2022.109387.

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