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Cardiovascular Health of Taxi/FHV Drivers in the United States: A Systematic Review

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Abstract

Background: Taxi/for-hire vehicle (FHV) drivers are a predominantly immigrant, male, and growing population in large, metropolitan cities in the U.S. at risk for cardiovascular conditions.

Objective: This review sought to systematically investigate the literature given mounting evidence of poor taxi/FHV driver health.

Methods: A systematic search of peer-reviewed journal articles that included a range of cardiovascular risks and conditions among taxi/FHV drivers in the U.S. was conducted.

Results: 8800 journal articles were initially found. 14 eligible articles were included: 3 mixed methods articles, 1 qualitative article, and 10 quantitative articles. Articles spanned 13 cardiovascular risks and conditions, including tobacco, nutrition, physical activity, stress, depression, body mass index/waist circumference, cholesterol, blood glucose/diabetes, air pollution, sleep, blood pressure/hypertension, heart disease, and stroke. The majority of studies were cross-sectional and utilized convenience samples.

Conclusions: Rigorous and high quality research is needed to further investigate rates of cardiovascular health in this population. The complexity of data collection in this group presents challenges to this endeavor. The high prevalence of poor nutrition, limited physical activity, diabetes, and blood pressure across studies indicates an urgent need to address low rates of health care access at a policy level and to design targeted workplace interventions.

Keywords

tobacco; physical activity; stress; BMI; hypertension

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INTRODUCTION

In the United States (U.S.), there are over 689,000 taxi and for hire vehicle (FHV) drivers (1), a large proportion of whom are immigrants (2). Mounting evidence, though limited and unsystematic, has indicated that taxi drivers globally are at risk for developing cancer and cardiovascular disease (CVD) due to unfavorable work conditions such as long work hours, irregular shift work, sedentary lifestyles, stress, and exposure to various forms of pollution (3–6).

In other countries, researchers have described the extensive health risks that taxi drivers face. A cross-sectional study assessing the CVD risk factors among Iranian taxi drivers indicated an increased prevalence of obesity, vision problems, hypertension, diabetes, and dyslipidemia (7). In Singapore, drivers reported driving long hours and having high rates of cardiovascular risk factors including self-reported obesity, hypertension, diabetes mellitus, and high cholesterol (8). A Japanese study found higher rates of myocardial infarction and CVD risk factors among taxi drivers than in age-adjusted non-drivers (9).

While there may be differences in the experiences of taxi drivers in the U.S., a taxi driver study in Los Angeles found that work-related stress and sedentary work were associated with an elevated risk of developing hypertension, obesity, vision problems, and musculoskeletal pain in the back, legs, and shoulders (10). U.S. taxi drivers face compromised health care access because of their status as independent contractors (11, 12), with its resultant lack of employer-based insurance, and because of their low incomes, and because of potential linguistic and cultural discordance with their providers.

Taxi drivers display health behaviors and exposures with well-accepted links to CVD, such as tobacco use, limited physical activity (PA), poor nutrition (13), and the more recently linked air pollution (14, 15). Mental health issues, including excessive stress (16) and depression (17, 18), have also been associated with CVD. In addition, diabetes/blood glucose, body mass index (BMI)/waist circumference, metabolic syndrome, and hypercholesterolemia present CVD risk (13). Given the CVD risk profile evidence of the large and growing taxi driver population in the U.S., we conducted a systematic review of the literature to examine the presence of CVD risks and conditions of the taxi/FHV driver population in the U.S., and to determine gaps in the available research that should be addressed.

METHODS

Existing research on the CVD health of the U.S. taxi driver population includes quantitative, qualitative, and mixed methods studies. To conduct this review, we compiled all of the available scientific literature that assesses the CVD risk and conditions that U.S. taxi and FHV drivers face. Given the dearth of available literature, our scope was broad and encompassed any research article that provided data on CVD risks and conditions, as opposed to including only articles whose sole focus was on cardiovascular risk or presence of disease. We chose the Mixed Methods Appraisal Tool (MMAT) (19) to determine the quality of the papers examined in this review because it enables the provision of assessment

ratings for varied study designs, utilizing criteria specific to each study type, as opposed to quality assessment tools which typically focus on one specific study design. This work was performed at Memorial Sloan Kettering Cancer Center. No ethics review was conducted as no human subjects were involved in this research.

Search Strategy

With the assistance of a research librarian, systematic searches were conducted for articles originally published online or in print before February 2018 that assessed taxi, cab, livery, and other for hire vehicle drivers' CVD risk and conditions. We were interested in the following cardiovascular risks and conditions: tobacco use, stress, depression, sleep, air pollution, physical activity (PA), nutrition, diabetes/blood glucose, BMI/waist circumference, metabolic syndrome, overall cholesterol, hypertension/high blood pressure, angina, atherosclerotic heart disease, myocardial infarction, stroke, CVD-related hospitalization, and CVD-related death.

Five databases were searched: PubMed, Cochrane, Embase and CINAHL and Web of Science. Search terms on the population of interest included the following: taxi cab, taxi driver, livery driver, cab driver, professional driver, vehicle operator, hire drivers, automobile driving, taxi, cab, hired vehicles, for hire drivers, for hire vehicles. Search terms on the outcomes of interest included: cardiovascular disease, cardiovascular risk, high blood pressure, hypertension, stroke, cardiomyopathy, arrhythmia, atherosclerosis, atrial fibrillation, cardiac arrest, heart attack, heart failure, heart valve problems and disease, peripheral artery disease, diabetes, obesity, stress, sleep apnea, sleep issues, cholesterol, heart diseases, BMI, body mass index, physical activity, physical inactivity, sedentary, sleep, smoking, smoke, obesity, diet, food, nutritional status, nutritional disorders, lifestyle, exercise, sedentary lifestyle, fatigue, diabetes mellitus, diabetic, stress/psychological, tobacco, depression, habits, and mental health.

Exclusion Criteria

Exclusion criteria included the following article characteristics: research participants were children, motorcycle drivers; articles were on vehicle design; the publications were non-English publications, case reports, books, book chapters, newspaper articles, conference abstracts, review papers, commentaries, organizational and governmental reports, or unpublished dissertations/theses. We did not exclude articles based on study design given the limited number of papers published on this population.

All publications were exported into EndNote, a bibliographic management tool, and uploaded into Covidence, a systematic review program. Duplicates were eliminated. Two research staff members later conducted a hand search of references from included articles and included potentially relevant publications into EndNote.

Article Selection for Inclusion in the Analysis

Using the Covidence platform, all titles and abstracts were reviewed for inclusion by two research team members, one of whom was a senior research team member (SM, KT). Reviewers' determinations were compared for consensus. Discrepancies were then resolved

by discussion among two senior research team members (SM, KT). The research team then reviewed full text articles to determine whether they met the inclusion criteria using the review metrics described above. Articles were coded for exclusion criteria based on the predetermined list of categories delineated above. Studies which did not merit inclusion because they possessed multiple exclusion criteria were categorized as excluded based on the first exclusion criterion, in line with the Covidence platform characteristics (see Figure 1). The team again assessed their coding for consensus and two senior research team members (SM, KT) resolved discrepancies.

Assessment of Study Quality

Two authors (SM, KT) independently assessed the included articles for quality using the MMAT (19) and Covidence software. Study types were qualitative (qualitative analyses of focus groups or in-depth interviews), quantitative descriptive (e.g., surveys without a comparison group, no inferential analyses conducted), quantitative non-randomized (e.g., non-randomized trials, cohort studies, and cross-sectional analytic studies), quantitative randomized controlled trials (participants were assigned to an intervention or control groups via randomization), and mixed methods (a combination of qualitative and quantitative components).

Articles were then independently rated (SM, KT) for study quality: reviewers provided “Yes”, “No”, or “Can’t tell” responses to the relevant MMAT criteria for each article (see Table 1 for responses to each MMAT criterion). When there were differences in responses, authors SM and KT discussed the ratings to achieve consensus. When consensus could not be reached, the articles were then discussed with a third author (FG) until consensus was reached. As the MMAT recommends, for mixed methods studies, quality assessments were made for mixed methods criteria and for qualitative and quantitative criteria. MMAT tool authors discourage the calculation of an overall quality score and suggest instead that qualitative assessments within each category may be more informative (2018). Therefore, we provide assessments for individual criterion in lieu of overall quality scores (Table 1).

Data Extraction and Synthesis

A data extraction form, designed in collaboration with the senior author (FG), consisted of categories that included: primary study aims and outcomes, type of study, sample information, and CVD risk factors and outcomes. Two authors (SM, KT) independently extracted data using the extraction form. The data were then exported into a spreadsheet. Each category was discussed by SM and KT, who compared independent ratings, with consensus achieved on all extracted data.

RESULTS

Included Articles

8800 potential research articles were screened by title and abstract. Of these, 8402 either did not fit the inclusion criteria or fit the exclusion criteria, leaving 398 full texts. We excluded 384 of these articles, for the following reasons: 148 did not include the correct population (i.e., not taxi drivers), 115 were not based in the U.S., 83 utilized an excluded study design

(i.e., non-empirical, conference proceedings), 16 were not in English, 14 did not include a CVD risk or condition, 5 were duplicates that had not been previously identified, and 3 did not have accessible full texts. During a hand search of references from included articles, 35 potential additional articles were identified. Upon full text screening, all were excluded. A total of 14 articles met the study inclusion criteria (see Figure 1). Three were mixed methods articles. Of these, two incorporated quantitative and qualitative studies that examined separate sample populations (20, 21) and one studied the same sample using both a qualitative and quantitative technique (22). Thus, our review includes 14 articles, which contain 16 studies.

Of the 14 included articles, three were mixed methods articles, two of which included a quantitative non-randomized component, and one of which included a quantitative descriptive component in addition to their respective qualitative components. In total, 13 articles included a quantitative component: 10 included a quantitative non-randomized component and three included a quantitative descriptive component. Four articles included a qualitative component.

Study Quality

Each criterion per category and our assessment of whether that criterion was met is presented in Table 1. All studies met the first two criteria of having clear research questions and data to support the investigation of those research questions. Overall, mixed methods studies suffered from a lack of integration between their qualitative and quantitative components. Among the 10 quantitative non-randomized studies, issues included sampling bias or studies not adequately describing their sample representativeness, not reporting or meeting complete outcome data thresholds, and unintended exposures which may have affected results. Among the three quantitative descriptive studies, none had a low risk for nonresponse bias. We were unable to make assessments for three out of the five criteria for one study (22) due to lack of information presented in the article. Among the four qualitative studies, three met all the assessment criteria, while one study only met one criterion, on the appropriateness of using a qualitative approach to address the research question (21).

Findings

As described above, three of the 14 articles utilized mixed methods: each included a qualitative and quantitative component. In two of these articles, different samples were used for the qualitative and quantitative components and thus we will discuss them as separate studies below (20, 21). The remaining mixed methods article utilized the same sample for both components and will be discussed as one study below (22).

The 16 studies predominantly conducted data collection in large cities: New York City ($n = 6$), Los Angeles ($n = 3$), San Francisco ($n = 3$), San Diego ($n = 2$), Las Vegas ($n = 1$), and Chicago ($n = 1$). Study sample sizes varied greatly ($n = 13$ – 751). With the exception of one study which utilized a stratified random sampling approach (Choi et al., 2016), all employed convenience sampling methods. Fourteen studies were cross-sectional, one study was a 12-week intervention to increase PA among drivers with follow-ups at 4, 8, and 12 weeks (23), and one study was a health fair screening which included follow-ups for

insurance, primary care, and additional screenings as appropriate over a six-month period (24). One study's survey was solely in English (25). Two studies offered surveys in English and other languages: drivers' preferred South Asian language (Hindi, Urdu, Punjabi, or Bengali) (23), and Chinese, Bengali, Arabic, Hindi, Punjabi, Urdu, or Spanish (26). Most studies indicated some level of translation or interpretation, with four focus groups in English and one described by the authors as with concurrent Arabic translation (22), focus group facilitators fluent in English and language preferred by the group (5), focus group participants being divided by language (21), multilingual staff surveying participants in their preferred language (27), focus group facilitators fluent in English and Somali (20), questionnaires verbally administered by bicultural research team members (20), and surveys administered orally primarily conducted in English with some partially conducted in Arabic by one of the authors fluent in Arabic (28). Other studies did not report on any translations (4, 21, 24, 29–31).

Drivers were predominantly male (87% – 100%), although several studies did not report gender (20, 21, 24). Drivers ranged in age from 18–80 years old, with mean ages ranging from 41–48 years old. Two studies did not report data for race/ethnicity or country of origin (20, 24). With the exception of one study in Las Vegas (31), taxi drivers in the included studies were largely immigrant or racial/ethnic minority populations.

Findings spanned a range of CVD related health variables, including CVD risk factors and conditions. One examined health and safety concerns and self-care strategies (22). While three studies focused exclusively on one CVD risk factor of interest, with one focused on air pollution (4) and two on stress (21, 31), the rest covered multiple risk factors and health conditions. Only four studies stated a primary aim of exploring CVD (5, 25, 27, 30); all other studies established other primary aims such as overall health, cancer, musculoskeletal issues, or air pollution (Table 2).

Although we did not explicitly use search terms for health insurance, this was frequently reported (8 out of 16 studies). Rates of having health insurance varied from 30% (Chicago), (25) 34% (San Francisco) (21), 42% (San Francisco) (28, 30), 43% (San Francisco) (22), 44%, 46% (NYC) (24, 27), 74% (NYC) (26), to 77% (San Diego) (20).

CVD Risk Factors

Tobacco.—Seven studies explored tobacco use among taxi drivers. Reported current rates of smoking ranged from 15% (20), (23), 18% (27), 24% (25), 36% (28), to 36% (30).

Nutrition.—Four studies examined nutrition. Apantaku-Onayemi et al. (2012) reported that only 5% ate the recommended five servings of fruits & vegetables per day, whereas Elshatarat and Burgel (2016) found that 29% ate five servings of fruits & vegetables daily. In qualitative studies, researchers found that nearly all drivers reported regularly eating unhealthy food, including fast food/junk food, with meal irregularity being typical and drivers often eating late at night (5). Drivers also reported that 'health food' was "inaccessible, expensive, and bland," although they acknowledged that their food consumption likely resulted in weight gain and heightened CVD risk (5). In another study,

drivers indicated the importance of healthy snacks (22) and connected their high caffeine consumption and inability to maintain healthy diets with job stressors (21).

Physical activity (PA).—Nine studies investigated the PA habits of drivers. Measurement methodology and rates varied across studies, making comparisons challenging. Rates of drivers never engaging in PA ran from 33% (28, 30), to approximately 40% (25), to “almost all [describing] little to no physical activity”(5). With regard to regular PA, Apantaku-Onayemi and colleagues (2012) found that only 6% engaged in PA more than five times a week for at least 30 minutes/day (i.e., recommended guideline) (32), whereas Murray and colleagues’ quantitative study found that only 14% of drivers met PA recommendations of 150 minutes of PA per week (20), compared with 74% of non-drivers. Elshatarat and Burgel (2016) indicated that 53% of drivers who engaged in PA engaged in moderate activity five days a week or more and 20% engaged in vigorous activity five days a week or more. In a small pilot study of 13, Choi and colleagues (2016) found that 31 % reported moderate or vigorous leisure-time aerobic PA twice a week or more. As part of an intervention using pedometers to increase activity among taxi drivers, Gany and colleagues (2014) found that at baseline drivers reported an average of 3,731 steps per day (SD = 1,685), with 51% increasing their steps post-intervention by an average of 217 steps per day.

In focus groups of South Asian drivers, participants indicated their belief that heart disease stemmed from a lack of PA and that barriers to PA included (in decreasing frequency) lack of time, exhaustion, not seeing value in PA, no facilities or opportunity for PA at work, and low motivation (5). Among those who reported some PA, walking was most popular, followed by yoga. PA patterns changed upon migration to the US. All participants engaged in PA in their native countries; after immigrating they became more sedentary (5). Drivers in San Diego also linked their sedentary behavior, weight gain, diabetes, and hypertension to regulations stating that they could not be more than 12 feet away from their car while in a taxi stand or passenger loading zone (20, 21). Burgel and colleagues (2012) found that drivers reported the importance of taking breaks to stretch.

Stress.—Seven studies reported on stress among drivers. Choi and colleagues (2016) found that 54% reported that their job was often stressful, whereas, in a qualitative study, Gany and colleagues (2013) found that participants in all study focus groups said that high levels of occupational stress was their greatest barrier to overall and heart health. Within the NYC setting, Mirpuri and colleagues (2018) found that East Asian drivers, older drivers, and those with higher incomes reported lower stress, whereas night shift, yellow cab, and English proficient drivers reported higher levels of stress. In a cross-sectional survey, Wang and colleagues (2014) found that 54% of drivers reported a high stress level, but that job stress and health status were not correlated (although there was a 62% decreased risk of work-related injury for drivers with combined good health and low stress). Schwer and colleagues (2010) did not report on stress directly but reported the following experiences among drivers in Las Vegas in the past year: 58% experienced fare evasion, 40% were abused or threatened, 7% were physically assaulted, 4% were robbed, 37% received false allegations. Overall, minorities were assaulted more often than non-minority drivers (31).

In qualitative studies, drivers reported that their long work hours, lack of control, discrimination, lack of bathroom access, poor ergonomic design and lack of safety features constituted job stressors, which were associated with poor health habits (fast food, caffeine, low activity levels, and smoking), and led to a variety of health problems, including obesity and hypertension (21). A NYC study reported increased stress among yellow cab drivers (5). Drivers noted taking breaks, listening to music, and socializing at the airport as stress management techniques (22).

Depression.—Using a standardized depression measure (Center for Epidemiological Studies-Depression Scale), Burgel and colleagues (2017) found an average score of 14.6 out of a possible score of 60 (SD = 8.7), with 38% of drivers over the 16 point cut-off for depression (49% of those with low back pain, 18% of those with no low back pain). Other studies showed varied rates of anxiety and depression: 8% reported ever having been diagnosed by a doctor with anxiety/depression (with night shift drivers reporting more anxiety and drivers reporting discrimination being 88% more likely to also report anxiety/depression) (26), 14% reported ever having been diagnosed by a doctor with depression (30), and 27% self-reported some depressive feelings (20% several days per month and 7% more than half the month) (20). Burgel and colleagues (2012) found that drivers mentioned the need to manage anger and find treatment for depression.

BMI.—Seven studies examined BMI. Typically, a BMI of 25–29.9 is considered overweight and above that threshold is considered obese. Adjusted rates have been recommended for specific ethnic/racial groups, such as Asian Indians, with a BMI of 23 considered overweight and 25 considered obese (33–35). Studies reported variable but high rates of overweight/obese BMI: 23% at obese levels (29), 44% overweight and 25% obese (30); results from the same dataset were later reported as 68% overweight or obese (28). Other studies found rates of 77% overweight or obese (24, 27), and 81% overweight or obese (23). Yet, Murray and colleagues (2019) found an average BMI of 26 kg/m² (SD = 4).

Gany and colleagues (2016) measured waist circumference, finding that 35% had high CVD-risk waist circumference of over 102 cm for men and 88 cm for women. Bivariate analyses indicated that Caribbean drivers and immigrant drivers with over 10 years in the US had increased odds of high CVD-risk waist circumference, while those who had been driving for over 10 years had increased odds of both high CVD-risk waist circumference and overweight/obese BMI. In multivariate analyses adjusting for years driving a taxi, age, region of birth, and marital, health insurance, primary care provider, and exercise status, no single demographic factor was significantly associated with overweight/obese BMI; however, region of birth remained a significant predictor of high CVD-risk waist circumference, with drivers born in the Caribbean or Middle East at higher risk than African-born drivers (27).

Cholesterol.—Five studies examined cholesterol. One reported that 22% of drivers had hyperlipidemia (30). Rates of self-reported history of high cholesterol/hypercholesterolemia ranged from 28% (20), 36% (23), to 39% (26). Further, Gany and colleagues (2014) found that 50% of drivers had elevated total cholesterol values. Gany and colleagues (2015) found that 28% of screened drivers reported a history of cholesterol issues, with 52% of these

drivers on cholesterol medication, while 33% of drivers who received further follow-up for health or health care access needs reported a prior diagnosis of hyperlipidemia.

Blood glucose/diabetes.—Six studies examined blood glucose/diabetes. Elshatarat & Burgel (2016) found in their study that 9% had a self-reported history of diabetes. Mirpuri and colleagues (2018) found that had a self-reported history of diabetes; South Asian drivers were three times as likely than African/Afro-Caribbean drivers, and East Asian drivers were five times less likely, to have diabetes. In another study, 24% reported a history of diabetes and of these drivers, 45% had random blood glucose levels above or equal to 200mg/dL, in comparison to 3% of drivers who did not report a prior diabetes diagnosis (6% average) (23). At a 5-day health fair screening event, Gany and colleagues (2016) identified that 14% of drivers had a self-reported history of diabetes. Of those drivers whose blood glucose was measured, 36% of drivers with a history of diabetes had levels over 200mg/dl and 4% of those without a history of diabetes had levels over 200mg/dl, 9% of drivers overall (27). Drivers reporting a history of diabetes were 12 times as likely to have elevated blood glucose at screening (27). In a related paper assessing drivers who were classified as requiring follow-up at the same screening event, Gany and colleagues (2015) found that 19% of drivers requiring follow-up for health or healthcare access needs had a prior diagnosis of diabetes. In a mixed methods study, 25% of drivers reported having diabetes compared to 16% of non-drivers, and drivers in focus groups raised diabetes as a health concern, with one driver indicating that he got diabetes one year after becoming a taxi driver (20). The overall rates of diabetes presented in these studies are based on convenience samples, which necessitate caution as they may not be representative of the entire taxi/FHV driver population.

Air pollution.—Three studies examined air pollution. Choi and colleagues (2016) examined in-cabin air pollution, finding average PM_{2.5} (fine particulate matter) rates (21.5±7.9µg/m³) to be below contemporary standard exposure limits. Gany and colleagues (2017) found elevated PM_{2.5} (4–49 µg/m³) and black carbon concentrations (up to >10µg/m³) in-cab compared with ambient (central site) monitoring levels, with large variability in PM_{2.5} across sites (4). In focus groups, drivers noted that they asked their customers not to smoke inside the vehicle to avoid air pollution (22).

Sleep.—Three studies examined sleep. In one of the mixed methods studies, the qualitative component found that sleep deprivation was the second most cited occupational health concern, with drivers indicating that their long hours and financial insecurity contributed to the problem (20). Drivers further reported sleeping an average of 6 hours a night (SD = 2) and reported less sleep and higher fatigue than a non-driver comparison group (20). In a qualitative study, drivers indicated the importance of getting adequate sleep before driving (22).

CVD Conditions

Blood pressure/hypertension.—Previously, normal blood pressure values were considered to be those below a systolic blood pressure (SBP)/diastolic blood pressure (DBP) of 140/90, and pre-hypertensive values 120–139 (SBP) and 80–89 (DBP). However, recent

2017 guideline changes have shifted this range so that normal blood pressure is below 120/80, elevated blood pressure is readings of 120–129 (SBP) and less than 80 (DBP), high blood pressure/hypertension Stage 1 is readings of 130–139 (SBP) or 80–89 (DBP), high blood pressure/hypertension Stage 2 is readings of 140 or higher (SBP) or 90 or higher (DBP), and a hypertensive crisis is readings higher than 180 (SBP) and/or higher than 120 (DBP). All the articles in this review were published prior to the guideline change.

Seven studies included self-reported blood pressure. Of these, rates of high and/or hypertensive self-reported blood pressure history varied from 15% (29), 18% (30), 21% (26), 24% (25), 26% (20), 28% (24), to 38% (23). Five studies reported on measured blood pressure. Murray and colleagues (2019) found that drivers and non-driver comparisons reported similar rates of hypertension diagnoses and had similar measured blood pressure values, although they did not provide these values. Gany and colleagues (2014) reported that 65% of drivers had elevated blood pressure readings; 76% of drivers with a history of hypertension had elevated blood pressure values in comparison to 60% of drivers without a history of hypertension. In one study, 48.5% of drivers had pre-hypertensive level values (SBP: 120–139, DBP: 80–89), 20.8% had stage 1 hypertensive level values (SBP: 140–159 or DBP: 90–99), and 11.5% had stage 2 hypertensive level values (SBP: 160 or DBP:

100) (30). Gany and colleagues (2015, 2016) found that 48% (2015) to 52% (2016) of drivers had hypertensive level values (SBP: >140 or DBP: >90), and 46% of drivers with no prior diagnosis of hypertension had high blood pressure readings (27). Bivariate analyses also indicated that drivers with over 10 years of driving and aged 40–59 had a higher risk of hypertensive level readings, and immigrants living in the US for over 10 years had twice the odds of having hypertensive blood pressure readings; participants unaware of their hypertension diagnosis were more likely to be uninsured. Using multivariate analyses adjusting for years driving a taxi, age, region of birth, and marital, health insurance, primary care provider, and exercise status, years in the U.S. remained the only predictor of screening positive for high blood pressure readings (27). However, with the exception of Choi and colleagues (2016), who utilized a stratified random sampling approach to obtain their 13 participants, all other studies that indicated rates of self-reported high blood pressure/hypertension and screened for high blood pressure readings were convenience samples and may not be representative of the target population. These rates should be noted with that caveat.

Heart disease.—Elshatarat and Burgel (2016) found that 4% reported atherosclerotic heart disease.

Stroke.—Two qualitative studies explored stroke. Participants believed that stress increased their stroke risk (5). Participants also linked their sedentary behavior to issues with blood clotting and stroke, and noted that within the local taxi force, “three Somali men have died in the last two years because of strokes” (20).

DISCUSSION

Taxi /FHV drivers in the U.S. are a primarily immigrant (10, 36) and underinsured population (24), with a sedentary work environment (5). In this systematic review of the

literature, we assessed a range of CVD risks and conditions, including lifestyle behaviors, environmental exposure, and health indicators. The existing literature suggests that taxi drivers in the U.S. face significant CVD risk factors and conditions. We reviewed the (1) quality of research articles examined, and (2) prevalence and understanding of CVD risk factors and conditions. The 14 articles/16 studies on CVD risks and outcomes among taxi drivers in the U.S. suggest collectively that there are substantial reasons to be concerned about the cardiovascular health status of drivers.

The majority of studies were quantitative. Most samples were not representative. None of the mixed methods articles were considered to have effectively integrated qualitative and quantitative components. In our quality assessment, we determined that studies assessing CVD risk factors and outcomes utilizing one-item (as opposed to validated measures) or self-reported health (as opposed to objective measures) were adequate. As such, most articles in this review met this standard; however, objective measurements of the CVD risks we covered in the review were lacking in this literature. Further, measurement instruments for demographics and disease history varied across studies. This review underscores the need for high quality and rigorous research in this area and tempers the syntheses and conclusions drawn from the available research.

With regard to CVD risk, there was a wide range of 10 health and lifestyle behaviors reviewed, with many studies including multiple risk factors. Studies reporting tobacco use ranged from rates of 15% – 36%, whereas approximately 15% of adults in the U.S. are smokers (37). Poor nutrition was reported, with low consumption of fruits and vegetables and high consumption of caffeinated beverages and fast food. The majority of studies included measures of PA and found low rates. Drivers reported high stress, with a relationship between stress and poor health behaviors. There were variations in reports of depression, and one study found an association with lower back pain. However, assessing mental health, including stress, anxiety and depression, could have posed challenges, as mental health may be stigmatized in ethnic/racial minority groups (38).

There were high rates of overweight and obese drivers across studies, although studies largely included non-representative samples. Considering the newly reduced threshold for overweight/obese BMI's for Asian Indians (33–35), it is likely that the rates of overweight/obese BMIs are even higher in this population than reported in the included studies. Studies reported approximately 28%–39% of drivers with a history of high cholesterol and 22%–33% of drivers with hyperlipidemia (24, 30); one study measuring cholesterol found that 50% of drivers had elevated rates (23). There was a range of rates of drivers with self-reported diabetes, 9–25% (20, 23, 24, 26, 27, 30), and 6–9% of drivers overall had elevated blood glucose levels, with higher percentages among those with previously diagnosed diabetes (23, 24, 27). With regard to air pollution, one Los Angeles-based study found that PM_{2.5} levels were better than the cutoff for acceptable limits (29), whereas in New York City, Gany and colleagues (2017) found elevated in-cab PM_{2.5} and black carbon levels. Only one study examined sleep and it found that sleep deprivation was a significant concern, and that drivers had higher rates of fatigue and obtained less sleep than a non-driver population (20).

Fewer CVD conditions were studied; seven studies included blood pressure/hypertension and two studies examined stroke. Self-reported hypertension rates (15%–38%) were lower than indicated by objective readings; 32%–65% of drivers had high blood pressure readings, with one study finding that over 80% of drivers had blood pressure conditions when pre-hypertensive values were included (30). This underscores the disparity in awareness of high blood pressure in comparison to objective measurements, although these measurements often included just one set of blood pressure readings, which does not enable a diagnosis of hypertension. There were low self-reported rates of atherosclerotic heart disease (3.8%). Finally, qualitative study participants linked their stress and health behaviors to a high risk of stroke and CVD, indicating an awareness of the relationship between their occupational health and lifestyle factors and their cardiovascular health.

Additionally, although health insurance coverage was not our primary outcome of interest, given its importance in contextualizing access to care which impacts drivers' cardiovascular health, we noted that there was a wide range of health insurance rates across cities, although these may have fluctuated by year and with the rollout of the Affordable Care Act (39).

Limitations of Studies and Recommendations for Future Research

The studies available are limited in both number and quality. Many studies utilize self-reported health status, which may be unreliable, particularly in an underinsured population with low rates of engagement with primary care (27). There were only two studies that were not cross-sectional (23, 24), and there were no randomized controlled trials. With the exception of one small study which employed a stratified random sampling approach (29), researchers primarily used convenience samples. It is therefore difficult to interpret as generalizable the rates of CVD health risks and conditions that were found. For example, the opportunity for a free health screening may have led to more drivers being screened who suspected that they might have high blood pressure or diabetes, inflating rates in these studies. Alternatively, these drivers may have avoided these screenings. While this population is highly mobile and ascertaining reliable rates of health conditions is challenging, stratified sampling approaches to approximate a representative sample is imperative.

We found measurement variation in everything from age and demographics to health condition rates. There is a critical need for rigorous, high quality studies in this area that can provide comparable data and consensus on measurement tools. There were also only four qualitative studies. While objective measurements are necessary to accurately ascertain the prevalence of CVD risks, qualitative methodologies may be best suited to capturing nuances with regard to preventive strategies.

While many studies acknowledged the diversity of their samples, few accounted for cultural and language barriers present between researchers and participants or explicitly discussed available translations and/or efforts to adapt research design and methods for populations consisting predominantly of racial/ethnic minority and immigrant drivers. It has been well documented that fear and mistrust of medical and research institutions (40, 41), language barriers, and issues related to legal immigration status are significant barriers to recruitment and retention of racial/ethnic minority and immigrant communities (40).

Addressing these barriers, and engaging documented facilitators of research participation, such as culturally congruent study designs (40) and altruism related to community benefit of research participation (40, 42), may help to improve the quality of data collected and recruitment and retention of this population.

At the same time, we recognize the challenges of data collection; taxi drivers are a difficult to reach population (they are constantly on the move), which may result in retention challenges and low response rates with high chances of missing data. Creative approaches to retention have been modeled by various research projects and include enhanced training of research staff and strategic development of follow-up procedures utilizing detailed participant tracking, search, and contact protocols (43, 44).

We found that few studies reported on the involvement of community organizations, community advisory boards, and industry governing bodies in shaping their research aims, research design, and data collection tools or detailed reciprocity efforts, that is if and how they disseminated findings to stakeholders or made recommendations for driver health. Development of Community Advisory Boards (CABs), and engagement with Community Based Participatory Research (CBPR) methods more broadly, may further address the aforementioned challenges of cultural and linguistic barriers and mistrust of medical and research institutions.

The rules governing taxis/FHVs vary from city to city and, as such, data might not be generalizable from one locale to another. Additionally, the rapid shifts in the driving industry, including the rise of ride-sharing apps, and the recently documented financial struggle of taxi drivers (45–47) will likely impact the health of the various groups of drivers. Responsive research is needed.

Implications and Conclusion

Further rigorous research is warranted to develop actionable policy changes. There are many challenges to gathering data from this population that lead to missing data, and low rates of follow-up, among others. These research challenges inevitably lead to poor publication rates; there may indeed be much more available unpublished data on this population that could be useful for moving the field forward. Whereas randomized controlled trials, longitudinal, and experimental designs would be enormously beneficial, they may not always be feasible. As such, researchers should strive for random stratified samples to the extent possible, even when conducting cross-sectional research. Additionally, creative approaches to recruitment and retention, and the cultural and linguistic relevance of recruitment and assessment tools, may address these challenges and improve the quality of research in this field.

Despite these research limitations, the evidence is compelling that chronic disease risks and cardiovascular conditions are present among the large and growing taxi/FHV driver populations in U.S. metropolitan areas. Comprehensive programs and policies are needed to address this risk. These include structural changes to address low driver incomes, accessible health insurance coverage, education around utilizing the health care system and about health, PA and nutrition programs, including facilitating the availability of space for PA, and

fresh fruits and vegetables, and other nutritious foods, and stress management programs at areas at which taxis congregate and at other convenient locations.

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Figure 1.
PRISMA Chart

Table 1.

Study Quality

Criteria	Burgel et al., 2012	Wang et al., 2014	Murray et al., 2019	Choi et al., 2016	Elshatarat & Burgel, 2016	Gany et al., 2015	Gany et al., 2016	Gany et al., 2014	Schwer et al., 2010	Burgel et al., 2017	Mirpuri et al., 2018	Gany et al., 2017	Apantaku-Onayemi et al., 2012	Gany et al., 2013
ALL														
1. Are there clear research questions?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Do the data allow to address the research questions?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MIXED METHODS (MM)														
1. Is there an adequate rationale for using a mixed methods design to address the research question?	X	✓	✓											
2. Are the different components of the study effectively integrated to answer the research question?	X	X	X											
3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	X	X	X											
4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	X	✓	X											
5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	X	X	X											
QUANTITATIVE NON RANDOMIZED (QNR)														
1. Are the participants representative of the target population?		X	X	✓	X	X	X	X	X	X		X		
2. Are the measurements appropriate regarding both the outcome and intervention (or exposure)?		✓	✓	✓	✓	✓	✓	✓	X	✓	✓			
3. Are there complete outcome data? (70% *)		?	?	✓	?	✓	✓	X	✓	?	?			

Criteria	Burgel et al., 2012	Wang et al., 2014	Murray et al., 2019	Choi et al., 2016	Elshatarat & Burgel, 2016	Gany et al., 2015	Gany et al., 2016	Gany et al., 2014	Schwer et al., 2010	Burgel et al., 2017	Mirpuri et al., 2018	Gany et al., 2017	Apantaku-Onayemi et al., 2012	Gany et al., 2013
4. Are the confounders accounted for in the design and analysis?		✓	X	✓	✓	✓	✓	✓	✓	✓	✓			
5. During the study period, is the intervention administered (or exposure occurred) as intended?		✓	✓	X	✓	X	✓	X	✓	✓	X			
QUANTITATIVE DESCRIPTIVE (QD)														
1. Is the sampling strategy relevant to address the research question?	✓										✓	✓	✓	
2. Is the sample representative of the target population?	✓										X	X	✓	
3. Are the measurements appropriate?	?										✓	✓	✓	
4. Is the risk of nonresponse bias low?	?										X	X	X	
5. Is the statistical analysis appropriate to answer the research question?	?										✓	✓	✓	
QUALITATIVE (QL)														
1. Is the qualitative approach appropriate to answer the research question?	✓	✓	✓											✓
2. Are the qualitative data collection methods adequate to address the research question?	✓	X	✓											✓
3. Are the findings adequately derived from the data?	✓	X	✓											✓
4. Is the interpretation of results sufficiently substantiated by data?	✓	X	✓											✓
5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	✓	X	✓											✓

Note: ✓ = Yes, X = No, ? = Can't tell.

* We established 70% complete outcome data as our threshold by reducing accepted outcome thresholds of 80%, to account for the highly mobile nature of the population (Thomas, 2004; Zaza, 2000).

Table 2.

Data Extraction.

Author	Loc	N	Age	% Male	Race/Ethnicity/ Country of Origin	Primary Study Aims	CVD Risk	CVD Conditions
Apantaku-Onayemi et al. (2012)	Chi	751	Medi: 37y R: 29% 18–24y 40% 25–44y 26% 45–59y 5% 60y+	99	50% Black 24% Asian 14% White 3% Hispanic/Latino 9% Other 10% US Born	CVD, GH, Can To survey health and risk factors with a focus on cancer risk factors	PA: 6% obtain PA more than 5x/week for at least 30 min/day; ~40% never obtain PA Nut: 5% eat 5 servings of fruits & veg/day Tob: 24% current smokers	BP: 24% of those who knew their blood pressure stated it was high
Burgel et al. (2012) Study 1 (Qual) ⁺	SF	36 (FG)	M: 47.4y SD: 10y R: 32–66y	87	43% US Born	OHS, SCS To identify health and safety concerns and self-care strategies	PA: Take breaks to stretch Nut: Healthy snacks Str: Taking breaks, music, and going to the airport to socialize as stress management Dep: Necessity for anger management and treatment for depression Slp: Necessity for adequate sleep AP: Not allowing customers to smoke in vehicles	
Burgel et al. (2017) Study 2 (Quant) ⁺	SF	37 (survey)	M: 47y SD: 10y R: 32–66y	87	43% US Born			
Burgel et al. (2017) *	SF	129	M: 45y SD: 11y R: 25–71y	94	24% Arabic heritage 45% US Born (32 countries of origin not spec.)	Mus, PS To identify the association between psychosocial work factors and lower back pain	PA: 67% reported some PA BMI: 68% overweight or obese Dep: 38% CES-D 16 Tob: 36% use tobacco	
Choi et al. (2016)	LA	13	M: 43y R: 24–67y	100	“Mostly Asian or Black”	AP, OHS To investigate worksite physical hazards inside taxi cabs, with a focus on drivers’ ambulatory heart rate	PA: 31% reported moderate or vigorous leisure-time aerobic PA 2x/week AP: in-cabin PM _{2.5} below contemporary standard exposure limits BMI: 23% BMIs > 30 kg/m ² Str: 54% reported job was often stressful	BP: 15% had hypertension (self-report)
Elshatarat & Burgel (2016) *	SF	130	M: 45y SD: 11y R: 5% 20–29y 29% 30–39y 30% 40–49y 22% 50–59y 13% 60–70y	94	40% White 24% Arabic 9% Latino/Hispanic 7% Black/African Am 5% Chinese 2% Indian Am 23% Other 45% US Born	CVD To describe CVD risk factors and health profiles	PA: 33% no regular PA, 53% participate in moderate activity: 5 days/week, 20% participate in vigorous activity: 5 days/week BMI: 32% normal, 44% overweight, 25% obese Cho: 22% Hyperlipidemia, 9% currently on meds for elev. cholesterol Dep: 14% reported depression, 10% visited healthcare professional for emotional or mental distress in last year Glu: 9% Diabetes Mellitus, 6% currently on medication for diabetes Nut: 29% eat 5 cups of fruits & veg/day Tob: 36% current tobacco use	BP: 18% hypertension, 19% normal BP, 49% pre-HTN, 21% Stage 1 HTN, 12% Stage 2 HTN, 11% on hypertension medication AHD: 4% Heart Disease

Author	Loc	N	Age	% Male	Race/Ethnicity/ Country of Origin	Primary Study Aims	CVD Risk	CVD Conditions
Gany et al. (2013)	NYC	31	R: 26% 18–40y 74% 41y+	100	100% South Asian 42% India 32% Pakistan 19% Bangladesh 6% refused	CVD, GH To investigate the knowledge, attitudes, and beliefs of South Asian taxi drivers about general health and CVD risk	PA: Almost all described little to no PA. Nut: Nearly all drivers regularly ate unhealthy food at work. Str: All groups reported high levels of stress as barrier to health.	
Gany et al. (2014)	NYC	74 (start) 47 (finish)	M: 48y R: 11% 30–39y 45% 40–49y 34% 50–59y 6% 60–69y 4% 70–79y	100	100% South Asian 47% India 38% Pakistan 15% Bangladesh	Act, IS To assess feasibility, acceptability, and potential impact of a pedometer-based PA intervention. (Pilot)	PA: Baseline steps M=3,731.9 (SD 1,685) Step change: M=+217. 51% drivers had a net increase in their number of steps/day. BMI: 81% were overweight or obese Cho: 36% hx of hypercholesterolemia, 50% had elevated total cholesterol values (200 mg/dL) at intake Glu: 24% hx of diabetes, 45% who self-reported a hx of diabetes had intake levels >200 mg/dL, 6% overall Tob: 17% reported current use	BP: 65% had elevated blood pressure (n=32), 38% had hx of HTN, 76% of drivers with hx of HTN had elevated BP values compared to 60% of drivers with no hx of HTN HD: 11% hx of CVD
Gany et al. # (2015)	NYC	466 (survey) 384 (screen) 242 (FU)	R (n=242): 51 40y 143 >40y			HCA, IS To describe impact of intervention for health insurance enrollment and primary care navigation	BMI: 23% <25 (n=332) Cho: 28% of screened drivers reported hx of cholesterol problems, 52% of whom reported cholesterol meds. 33% of drivers who received further follow up reported prior diagnosis of hyperlipidemia. Glu: 19% of drivers who received further follow up reported hx of diabetes, 9% abnormal random glucose values (n=329)	BP: 28% hx of HTN (self-report), 48% BP<140/90 (screening)
Gany et al. # (2016)	NYC	466 (survey) 413 (screen)	R: 100 18–39y 209 40–59y 33 60y	100 (1F)	2% US Born 47% South Asian Region of Birth: 181 South Asia 92 Africa 57 Caribbean 13 Latin Am. 11 Europe 23 Middle East 4 East Asia 7 US	CVD To assess CVD risk factors	BMI: (n=332) 77% were either overweight or obese, 35% had high risk waist circ (n=317), 10y driving had greater odd of overweight or obese BMI>25. Glu: (n=375) 14% previous dx of diabetes, (n=326) 9% had random plasma glucose >200 mg/dL (36% of those with prior dx of diabetes [12 OR of high random glucose values], 4% with no prior diabetes dx). Tob: 30% used tobacco in their lifetime, 18% current tobacco users	BP: 52% of drivers (n=368) had >140 sys and/or >90 dia (screening), 46% of drivers with no prior dx of HTN had high BP reading, Years in US (immigrants who lived in the US>10y) was sole significant predictor of high BP (multivariate analyses adjusting for other predictors)
Gany et al. (2017)	NYC	100 (survey) 7 (air quality tested)	Survey R: 17% 18–30y 24% 31–40y 26% 41–50y 29% 51–65y 3% >65y	100	Region of birth: 27% Africa 24% South Asia 13% Caribbean 12% US 8% Cen./S. Am 6% Mid East 5% East Asia 4% Europe 1 Refused	AP To monitor air quality in taxi cabs and stands and assess drivers' knowledge, attitudes, and beliefs on health risks of air pollution	AP: <i>In-Cab</i> Elevated PM _{2.5} and BC cone, compared with ambient monitoring levels, BC levels elevated, reached >10 µg/m ³ <i>Roadside:</i> Rush hour ambient PM _{2.5} levels near or greater than EPA 24h NAAQS of 35 µg/m ³ for PM _{2.5} . Avg BC and avg PM _{2.5} levels were comparable between stands and their roadside control sites. Avg taxi stand BC and PM levels were significantly higher than levels at the closest NYSDEC's air monitoring site.	

Author	Loc	N	Age	% Male	Race/Ethnicity/ Country of Origin	Primary Study Aims	CVD Risk	CVD Conditions
Mirpuri et al. (2018)	NYC	535	M: 44y SD: 11y R: 21–80y	100	4% U.S. 44% South Asia 23% Africa/Afro-Carib 18% East Asia 12% Other	PS, GH To examine impact of discrimination on stress and health	Cho: 39% self-reported hx of hypercholesterolemia Dep: 8% reported anxiety/ depression. Night shift drivers suffered higher rates of anxiety. Those with more discrimination were 88% more likely to report anxiety/ depression. Glu: 18% self-reported hx of diabetes, South Asian drivers 3x as likely and East Asian drivers 5x less likely to have diabetes. Str: East Asian and higher income drivers reported lower stress. Night shift drivers, medallion yellow cab drivers, older drivers, and drivers reporting English proficiency reported more stress. MRF: Discrimination not significantly associated with type 2 diabetes, or hypercholesterolemia.	BP: 21%hx of HTN. Discrimination was not significantly associated with HTN
Murray et al. (2019) Study 1 (Qual)	SD	19	M: 41y SD: 11y	100	100% East African	OHS, IS To identify health concerns and barriers and gather intervention recommendations using community-based participatory research	PA: Drivers linked ordinance restricting them from leaving 12ft radius around their car to chronic diseases, such as diabetes and kidney disease. They felt these conditions were prevalent among drivers. Several drivers linked their increase in sedentary behavior while driving to weight gain and onset of diabetes and hypertension. Glu: Diabetes was raised in all groups as health concern that arose after starting to work as a taxi driver. Slp: Sleep deprivation was 2 nd most cited occupational health concern. Sleep deprivation frequently connected to long hours of work. Drivers reported they frequently had to work 7 days/wk and 12 hr/day in order to meet car lease costs and earn money to take home.	BP: HTN mentioned in all 3 focus groups. Participants linked sedentary behavior to increased prevalence of HTN among drivers, several drivers linked their increase in sedentary behavior after starting as a taxi driver to onset of HTN. Dea: Participants reported multiple deaths within the local taxi workforce linked to CVD. Stk: Participants linked sedentary behavior to issues with blood clotting and stroke
Murray et al. (2019) Study 2 (Quant)	SD	75 (driver) 25 (control)	M: 46y SD: 12y (driver) M: 40y (control)			OHS To identify health concerns and barriers and gather intervention recommendations using community-based participatory research	PA: 14% of drivers met rec of 150 min of PA per week, compared to 74% of non-drivers. BMI: M = 26%, SD = 4 Cho: 28.4% previous dx of high cholesterol Dep: <i>Freq. of depressive feelings:</i> 73%, not at all, 20%, several days per month, 7%, > half of the month Glu: 25% of drivers reported having diabetes, compared to 16% of non-drivers Slp: Hrs/night slept M = 6.0hrs. Drivers slept less and reported higher rates of fatigue than non-driver comparisons. Avg 1h less/night Tob: 15% current smokers, 9% former smokers	BP: drivers (27%) and control reported similar doctor-diagnosed HTN, drivers and control had similar objective measures of BP
Schwer et al. (2012)	LV	401	R: 64% >45y 11% <35y	91	69% White 10% African American	OSH, PS To describe patterns of drivers' experiences with	Str: <i>experiences of robbery, fare evasion, threats, verbal abuse over the past year were considered stress inducing activities.</i> 58% experienced fare evasion, 40% were	

Author	Loc	N	Age	% Male	Race/Ethnicity/ Country of Origin	Primary Study Aims	CVD Risk	CVD Conditions
Wang et al. (2014) Study 1 (Quant)	LA	309	24% 35–45y 35% 46–55y 29% >56y	100	8% Pacific Islander 7% Hispanic 11% American Indian 72% U.S. Born	occupational violence and stress.		abused or threatened, 7% physically assaulted, 4% robbed, 37% experienced false allegations, Minorities were assaulted more often than the white reference group.
			M: 47y SD: 10y R: 24–84y 23% 0–39y 36% 40–49y 32% 50–59y 8% 60y		46% Asian 25% White 18% Black 12% Hispanic	OHS, PS To examine the association of drivers' health status and job stress with work related injury	Str: 54% reported high stress level	
Wang et al. (2014) Study 2 (Qual)	LA	12 (FG) 53 (IDI)			Ethiopia Korea US India	OHS, PS To examine the association of drivers' health status and job stress with work related injury	Str: Drivers noted long hours required to make a living, their lack of control over job conditions, discrimination and harassment, and the indignity they experience when denied access a restroom. MRF: Drivers identified smoking, sedentary work, lack of PA, consumption of unhealthy food and caffeine, and obesity as resulting from job stressors.	

[‡]These samples were the same. One participant dropped out for the qualitative study.

^{*}These studies utilized overlapping samples.

[†]These studies utilized overlapping samples.

Note:

Primary study outcomes: CVD = cardiovascular disease. GH = general health. Can = cancer. OHS = overall health strategies. SCS = safety and self-care strategies. Mus = musculoskeletal. PS = psychosocial. AP = air pollution. Act = activity. IS = intervention strategies. HCA = health care access.

CVD risk factors: PA = physical activity. Nut = nutrition. Tob = tobacco. Str = stress. Dep = depression. Sip = sleep. AP = air pollution. BMI = body mass index. Cho = cholesterol. Glu = glucose. MRF = miscellaneous risk factors.

CVD conditions: BP = blood pressure. AHD = atherosclerotic heart disease. HD = heart disease. Stk = stroke. Dea = death.