Linear association between number of modifiable risk factors and multiple chronic conditions: Results from the Behavioral Risk Factor Surveillance System

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ABSTRACT

Multiple (≥ 2) chronic conditions (MCCs) are responsible for a large fraction of healthcare costs. Our aim was to examine possible associations between MCCs and composite measures of behavioral risk factors (RFs). Data were publicly available 2013 Behavioral Risk Factor Surveillance System and included 483,865 non-institutionalized US adults ages ≥ 18 years. Chronic conditions included asthma, arthritis, chronic obstructive pulmonary disease, cognitive impairment, heart disease, stroke, cancer, and kidney disease. RFs included obesity, current smoking, sedentary lifestyle, inadequate fruit and vegetable consumption, and sleeping other than 7–8 h, while depression, hypertension, high cholesterol, and diabetes were considered in each category. Stata was used to study associations between 2 different MCCs and 2 composite measures of RFs in both unadjusted and adjusted analysis. Over 96% of respondents reported ≥ 1 of the 9 RFs and 71.5% reported ≥ 1 of the chronic conditions. For each combination there was a linear increase (with similar slopes) in MCC rate with more RFs and a statistically significant increase in adjusted odds ratios (ORs) for the MCC with each additional RF. For the MCC based on 8 chronic conditions, ORs were 1.3 (95% CI 1.1, 1.6) for 1 RF, 2.3 (1.9, 2.7) for 2, 3.7 (3.1, 4.4) for 3, 5.7 (4.8, 6.8) for 4, 9.1 (7.6, 10.8) for 5, 14.6 (12.2, 17.4) for 6, 24.0 (19.7, 29.2) for 7, 38.1 (29.6, 48.9) for 8, and 100.0 (56.3, 177.8) for all 9, each vs. zero RFs. Findings highlight the need for effective integrated programs to address multiple RFs and chronic conditions.

1. Introduction

Adults with multiple (≥ 2) chronic conditions (MCCs) account for about two-thirds of all healthcare costs in the U.S. (Anderson, 2010). MCCs are a major factor in the rise in Medicare spending (Thorpe et al., 2010), estimated to be responsible for 93% of those costs (Centers for Medicare and Medicaid Services, 2012). There is no standard definition of chronic conditions included in MCCs (Willadsen et al., 2016; Goodman et al., 2013) but chronic diseases, risk factors, mental health problems, and cognitive impairment can be among them (CMS: Centers for Medicare and Medicaid Services, n.d.; U.S. Department of Health and Human Services, n.d.). More attention is starting to be focused on MCCs as their contribution to health care costs is recognized (Centers for Medicare and Medicaid Services, 2012; Goodman et al., 2013; U.S. Department of Health and Human Services, n.d.; Gupta, 2016). While a recent review (Willadsen et al., 2016) of 163 MCC studies found that 85% included risk factors (RFs) in their definitions of MCCs, apparently none studied possible associations between MCCs and RFs. Behavioral risk factors such as hypertension, obesity, and smoking have been shown to be associated with many separate chronic conditions (Brownson et al., 2010). Risk factors can also occur concurrently and are sometimes studied using composite measures. For example, Adams et al. (2016) and Liu et al. (2016) studied slightly different combinations of 5 RFs and both found that 92%–94% of all adults reported at least one RF. Addressing RFs collectively may help in understanding how they might predict MCCs, which in turn could inform clinical and

Table 1

Components of composite measures of risk factors and chronic conditions, 2013 Behavioral Risk Factor System, 50 states + DC, adults ages 18 +, N ~ 400,000.

Measures	Percent	95% CI	Missing	(%)
Risk factors				
Obesity[*]	28.3	28.0, 28.6	26,378	(5.5)
Smoking[*]	18.2	18.0, 18.5	15,215	(3.1)
Sedentary lifestyle[*]	26.3	26.0, 26.6	33,772	(7.0)
Eat < 5-a-day[*]	82.8	82.5, 83.0	56,993	(11.8)
Sleep other than 7–8 h[*]	43.6	43.3, 43.9	7260	(1.5)
Hypertension[a]	32.4	32.1, 32.7	1387	(0.3)
High cholesterol[a]	38.6	38.3–38.9	70,116	(14.5)
Diabetes[a]	10.2	10.1, 10.4	805	(0.2)
Depression diagnosis[a]	17.7	17.5, 17.9	2267	(0.5)
Measure with all 9 risk factors above			139,683	(28.9)
Have none of above risk factors	3.6	3.5, 3.8		
Any 1	16.0	15.7, 16.2		
Any 2	22.5	22.2, 22.8		
Any 3	21.8	21.5, 22.1		
Any 4	16.3	16.1, 16.6		
Any 5	10.9	10.7, 11.1		
Any 6	5.8	5.6, 5.9		
Any 7	2.4	2.3, 2.5		
Any 8	0.7	0.7, 0.8		
All 9	0.1	0.1, 0.1		
Measure with only 5 RFs (those with [*])			83,454	(17.2)
Have none of [*] risk factors	6.4	6.2, 6.5		
Any 1	29.5	29.2, 29.8		
Any 2	33.7	33.4, 34.0		
Any 3	21.5	21.2, 21.7		
Any 4	7.8	7.6, 8.0		
All 5	1.1	1.1, 1.2		
Chronic conditions (see also[a])				
Asthma	9.0	8.8, 9.1	3405	(0.7)
Arthritis	25.0	24.8, 25.3	2909	(0.6)
Heart disease	6.6	6.5, 6.7	4562	(0.9)
Stroke	2.9	2.9, 3.0	1451	(0.3)
Cognitive impairment	10.7	10.5, 10.8	12,904	(2.7)
Chronic obstructive pulmonary disease	6.5	6.3, 6.6	2697	(0.6)
Cancer other than skin	6.5	6.4, 6.7	1140	(0.2)
Kidney disease	2.6	2.5, 2.7	1678	(0.3)
Number of chronic conditions (out of 12)			93,804	(19.4)
Have 0 chronic conditions	28.5	28.2, 28.8		
Any 1	23.6	23.3, 23.9		
Any 2	18.1	17.9, 18.4		
Any 3	12.7	12.5, 12.9		
Any 4	8.0	7.8, 8.2		
Any 5	4.6	4.5, 4.7		
Any 6	2.4	2.3, 2.5		
Any 7 or more of the 12	2.1	2.0, 2.1		

Abbreviations: CI: confidence interval; RF: risk factor.
[*] Indicates one of the 5 risk factors.
[a] Can be risk factor or chronic conditions.

public health practice.

Our objective for this current work was to study MCCs based on different definitions and their associations with composite measures of up to 9 risk factors. The chronic conditions chosen were asthma, arthritis, heart disease, stroke, chronic obstructive pulmonary disease (COPD), cognitive impairment, cancer other than skin, and chronic kidney disease. The RFs were current smoking, sedentary lifestyle, inadequate fruit and vegetable consumption, sleeping other than 7–8 h, and obesity. Because diabetes, hypertension, high cholesterol, and depression can be considered either chronic conditions (Willadsen et al., 2016; Goodman et al., 2013) or RFs (Brownson et al., 2010) they would be included in the study in each category. Prevalence rates of the composite measures plus their associations with each other would be studied. We would also test the hypothesis that there is a linear association between the number of RF's and MCC rates as was found for other outcomes (Adams and Grandpre, 2016). The hope was that results might aid in the development and targeting of integrated prevention

programs addressing multiple RFs aimed at reducing rates of MCCs and lowering associated health care costs.

2. Methods

2.1. Data

We used publicly available (Behavioral Risk Factor Surveillance System (BRFSS) (Atlanta, Georgia), n.d.) Behavioral Risk Factor Surveillance System (BRFSS) data from 2013 in order to include sleep as a RF. The BRFSS is a large, representative, state-based telephone survey of non-institutionalized U.S. adults (Behavioral Risk Factor Surveillance System. Atlanta (GA), n.d.) and our data included 483,865 respondents ages ≥ 18 years in the 50 states and DC. In general, data have been shown to be comparable to results from national surveys based on self-reported behaviors (Nelson et al., 2013; Pierannunzi et al., 2013). For all measures described below, responses of "don't know" or refusal to answer were excluded from analysis. The median response rate for cell phone and land line surveys combined was 46.4%, ranging from 29.0% in Alabama to 58.0% in Colorado (Behavioral Risk Factor Surveillance System, 2013).

2.2. Risk factor measures

Survey questions are available on-line (Behavioral Risk Factor Surveillance System. Atlanta (GA), n.d.) and only potentially modifiable risk factors were included. Current smokers were respondents who smoked 100 cigarettes and now smoked every day or some days. Respondents who did not participate in any leisure time physical activity in the past month were considered to have a sedentary lifestyle. Obesity was a body mass index ≥ 30 based on self-reported height and weight. Inadequate fruit and vegetable consumption was defined as consuming the combination < 5 times per day based on responses to six separate questions. Hours of sleep in a 24-hour period were reported as round numbers and dichotomized into 7–8 h vs. any other number of hours, as both too little and too much sleep have been associated with adverse outcomes (Gallicchio and Kalesan, 2009). RFs that could also be chronic conditions included hypertension, high cholesterol, depression, and diabetes, each defined as "ever told", except diabetes excluded women who were told only when pregnant.

Once unknowns were removed, final N's for the 9 separate RFs ranged from 426,872 for fruit and vegetable consumption to 483,060 for diabetes. Composite measures were generated which included all 9 RFs and the 5 RFs that were just RFs, by counting the number of RFs, with totals that ranged from 0 to 9, or 0 to 5, respectively. Unknowns were removed from the composite measure if any of its components were unknown, resulting in final sample sizes of 344,182 for the measure including all 9 and 400,411 for the measure that included only the 5 RFs. Alternate measures were created that represented respondents who reported any vs. none of the RFs for that measure.

2.3. Chronic conditions, MCCs

With the exception of cognitive impairment (CI) all chronic conditions were defined as "ever told" and included heart disease, stroke, current asthma (ever told and still have it), COPD, arthritis, cancer other than skin, and kidney disease. Cognitive impairment was defined as a "yes" response to "Because of a physical, mental, or emotional problem, do you have difficulty remembering, concentrating, or making decisions?" This question has been asked since 2008 by the census bureau and is now a standard disability question on federal surveys (US Census Bureau, n.d.). This measure is consistent with other measures of CI but should not be considered cognitive decline because the question lacks a time frame (Jessen et al., 2014; Rabin et al., 2015). Our measures of MCCs included respondents who reported ≥ 2 of the component chronic conditions. MCC8 included asthma, arthritis, heart