



University of Kentucky  
UKnowledge

---

Theses and Dissertations--Public Health (M.P.H.  
& Dr.P.H.)

College of Public Health

---

2023

## Prevalence of Multimorbidity in the Atherosclerosis Risk in Communities Study at Baseline

Katie Highfill  
katiehighfill.14@gmail.com

Follow this and additional works at: [https://uknowledge.uky.edu/cph\\_etds](https://uknowledge.uky.edu/cph_etds)



Part of the [Public Health Commons](#)

[Right click to open a feedback form in a new tab to let us know how this document benefits you.](#)

---

### Recommended Citation

Highfill, Katie, "Prevalence of Multimorbidity in the Atherosclerosis Risk in Communities Study at Baseline" (2023). *Theses and Dissertations--Public Health (M.P.H. & Dr.P.H.)*. 366.  
[https://uknowledge.uky.edu/cph\\_etds/366](https://uknowledge.uky.edu/cph_etds/366)

This Graduate Capstone Project is brought to you for free and open access by the College of Public Health at UKnowledge. It has been accepted for inclusion in Theses and Dissertations--Public Health (M.P.H. & Dr.P.H.) by an authorized administrator of UKnowledge. For more information, please contact [UKnowledge@lsv.uky.edu](mailto:UKnowledge@lsv.uky.edu).

## **STUDENT AGREEMENT:**

I represent that my capstone and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

## **REVIEW, APPROVAL AND ACCEPTANCE**

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's capstone including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Katie Highfill, Student

Dr. Anna Kucharska-Newton, Committee Chair

Richard Ingram, Director of Graduate Studies

PREVALENCE OF MULTIMORBIDITY IN THE ATHEROSCLEROSIS RISK IN  
COMMUNITIES STUDY AT BASELINE

CAPSTONE PROJECT PAPER

A paper submitted in partial fulfillment of the  
requirements for the degree of  
Master of Public Health  
in the  
University of Kentucky College of Public Health  
by  
Katie Highfill, BPH  
Lexington, Kentucky

Committee Members:  
Anna Kucharska-Newton, PhD, MPH (Chair)  
Erin Abner, PhD, MPH  
Steven Browning, PhD

## Abstract

**Aim:** The aim of this study is to examine the prevalence of multimorbidity among middle-aged adults in the Atherosclerosis Risk in Communities Study at baseline by examining the demographic and socioeconomic characteristics of the participants.

### Methods

I included 15,698 participants from the Atherosclerosis Risk in Communities (ARIC) baseline visit. Participants were randomly selected from 4 different locations in the United States. Multimorbidity was defined as the prevalence of 2 or more chronic conditions in an individual. Three different multimorbidity definitions (MM1, MM2, and MM3) were created with different inclusion criterion. Prevalence of each multimorbidity definition was analyzed among participants using covariates of age, sex, race, education level, area deprivation index, and by race and sex.

**Results:** Black female participants had the overall highest prevalence of multimorbidity compared to any other demographic. Those with a low education level and high level of neighborhood deprivation also had higher prevalence among each definition. The most inclusive definition of multimorbidity had the highest prevalence within each demographic group.

**Conclusion:** The inclusion of obesity and hyperlipidemia, in addition to prevalent cancer and cardiovascular disease, increases the prevalence of multimorbidity within every demographic group. Black participants had the highest prevalence of multimorbidity within each definition.

# Table of Contents

<b>Background</b> .....	<b>4</b>
Multimorbidity: No Consensus Definition .....	6
<b>Methods</b> .....	<b>6</b>
Study Design.....	6
Inclusion/Exclusion Criteria .....	7
Multimorbidity Definition .....	7
Covariates .....	8
Analytical Approach .....	9
<b>Results</b> .....	<b>9</b>
<b>Discussion</b> .....	<b>10</b>
Age Group.....	10
Race-Sex .....	10
Individual and Neighborhood Socioeconomic position.....	11
Strengths/Limitations of Study .....	11
<b>Conclusion</b> .....	<b>12</b>
<b>References</b> .....	<b>13</b>
<b>Appendix</b> .....	<b>16</b>

## Background

Multimorbidity, commonly defined as the presence of two or more chronic conditions in an individual, is highly prevalent.<sup>1-3</sup> Chowdhury's 2021 meta-analysis of multimorbidity determined the global prevalence of multimorbidity at 37.2%.<sup>4</sup> The prevalence of multimorbidity in South America (45.7%) and North America (43.1%) was the highest estimated among the 54 countries included in the meta-analysis.<sup>4</sup> Prevalence of multimorbidity is increasing.<sup>5,6</sup> In 1988, the prevalence of multimorbidity in the United States (U.S.) was 45.7%, and it increased to 59.6% in 2014.<sup>5</sup>

As populations are getting older and mortality rates are decreasing, individuals are acquiring more chronic diseases.<sup>7</sup> Previous studies have shown that multimorbidity increases with age.<sup>7-10</sup> A Scottish cross-sectional study found that those aged 65-84 years had an average of 2.6 conditions, and those aged 85+ had an average of 3.6 conditions.<sup>1</sup> The prevalence of multimorbidity is estimated at 30.4% in those aged 45-64 years and 64.9% in those aged 65-84 years of age.<sup>1</sup> Similar to other countries, multimorbidity prevalence increases with age in the United States.<sup>9,10</sup> After adjusting for age, race, sex, poverty, education, and insurance status, a study by King et al., which used National Health and Nutrition Examination Survey (NHANES) data, estimated that multimorbidity, age-standardized to the 2010 census population of adults aged 20+, was 91.8% among those 65 years or older compared to 70.6% of those 45-64 years of age.<sup>5</sup>

Other possible risk factors associated with multimorbidity have been researched. Previous studies suggest that those who were 65 years or older and have identified as having little to no education were more likely to have two or more chronic conditions, and therefore multimorbidity.<sup>7,8</sup> Multimorbidity tends to be highest among African

American populations.<sup>9,10</sup> Historically, those with a lower socioeconomic status, little to no education, and lack of access to care or treatment are at higher risk of chronic conditions and multimorbidity.<sup>10,11</sup> Disparities and health inequalities in healthcare and access to healthy lifestyles lead to an increased risk of prevalence of multimorbidity.<sup>11</sup>

Multiple studies have assessed risk factors among individuals with multimorbidity across the world including Scotland, Australia, Denmark, and Finland,<sup>7,8,12,13</sup> but little research has been done to examine demographic and physical characteristics among ageing individuals diagnosed with two or more chronic conditions in the United States of America (U.S.).<sup>9</sup> The United States healthcare system is a mixture of public and private services with a majority of primary care services referring patients to a specialist for a certain condition.<sup>14</sup>

Traditionally, healthcare across the world focuses on single illnesses or diseases in individuals.<sup>15</sup> Those who are diagnosed with two or more chronic conditions tend to receive inadequate care or inappropriate medications for their multiple conditions.<sup>12,16</sup> A study in Denmark discovered that nearly 70% of patients in the study who were hospitalized for chronic conditions did not receive adequate care or appropriate medications for their multiple conditions.<sup>12</sup> Along with inadequate care or inappropriate medication prescriptions, patients diagnosed with 1-3 different morbidities have 1.55 and 2.85 times the mean anticipated total cost for care than those who were not diagnosed with a morbidity.<sup>16</sup> As the incidence of multiple health conditions in an individual is increasing,<sup>17,18</sup> the importance of understanding multimorbidity and patterns of multimorbidity is crucial to determine what care is needed for the populations of middle-aged and older adults.<sup>18</sup>

## Multimorbidity: No Consensus Definition

Multimorbidity is most often defined as the prevalence of 2 or more chronic conditions in an individual, however, extant definitions include different component criteria.<sup>5,18,19</sup> A systematic review of different multimorbidity definitions determined that multimorbidity can be defined as multiple co-occurring chronic or long-term conditions, including both physical and mental diseases.<sup>20</sup> Similarly, another systematic review concluded that standardizing the number of conditions and type of conditions in the multimorbidity definition is necessary to compare prevalence among different populations.<sup>21</sup> The inconsistencies in definition of multimorbidity and inclusion criterion of chronic conditions create challenges for research on multimorbidity.<sup>22</sup> King and colleagues found a prevalence of 91.8% of participants aged 65+, but Rocca and colleagues found a prevalence of 77.3% for those aged 65+.<sup>5,23</sup> King mentioned the inclusion of obesity as a chronic condition increased the overall prevalence of multimorbidity.<sup>5</sup> Therefore, the inclusion criteria to determine the multimorbidity definition can affect the overall prevalence of multimorbidity.

The purpose of this study is to examine the burden of multimorbidity at midlife using baseline visit data from the Atherosclerosis Risk in Communities (ARIC) study centers, comparing three different definitions of multimorbidity.

## **Methods**

### Study Design

The population of this study included participants of the Atherosclerosis Risk in Communities (ARIC) Study cohort of 15,792 men and women, recruited through random sampling from four different communities: Washington County, Maryland; Jackson,



Mississippi; Forsyth, North Carolina; and the suburbs of Minneapolis, Minnesota.

Participants' age at baseline ranged from 45 to 64 years. The baseline visit took place from 1987 to 1989. Study participants completed a clinical examination during their baseline visit. This was followed by additional visits that took place in 1990-1992 (visit 2), 1993-1995 (visit 3), 1996-1998 (visit 4), 2011-2013 (visit 5), and 2016-2017 (visit 6), and annually thereafter.

Additionally, study participants are contacted annually (semi-annually from 2011) via telephone and all hospitalizations are ascertained through ongoing cohort surveillance. The present study examines multimorbidity prevalence at the baseline visit.

#### Inclusion/Exclusion Criteria

We included all participants from the baseline visit and defined multimorbidity among those who had prevalence of 2 or more chronic conditions (refer to Table 1). Due to small numbers, we excluded participants who identified as being of race other than Black or White (n=48). We also excluded Black participants from the Minneapolis and Washington County study centers due to small numbers (n=55).

#### Multimorbidity Definition

Multimorbidity was defined as the prevalence of 2 or more chronic conditions in an individual. The chronic conditions included a selected subset of 20 chronic conditions listed by the Department of Human and Health Services<sup>19,24</sup> (Refer to List 1). Specifically, the chronic conditions included in this study are cancer, diabetes, stroke, chronic heart disease, heart failure, and hypertension, hyperlipidemia, and obesity as they are available data at the baseline visit and considered amenable by public health and clinical intervention<sup>19</sup> Table 3 lists these variables and how they are defined.

Three multimorbidity variables were created: MM1, MM2, and MM3. The MM1 variable included cancer, diabetes, stroke, chronic heart disease, heart failure, and hypertension. The MM2 definition added obesity as a component criterion to the MM1 construct and the MM3 definition added hyperlipidemia because they are both prevalent conditions that can lead to adverse health outcomes or higher risk of mortality (Table 2).<sup>5</sup> Prevalence of multimorbidity was examined with each of these definitions stratified by race, sex, age, individual level socioeconomic position, neighborhood level socioeconomic position, and by race and sex together.

#### Covariates

Age, race, sex, and education were self-reported at baseline. Age was categorized into four categories:  $\leq 49$  years,  $50 \geq 54$  years,  $55 \geq 60$  years, and 61 + years. Race was categorized as Black or White. Sex was categorized as Male or Female. The 6 categories of education participants chose from included grade school (1), high school without graduation (2), high school with graduation, vocational school (4), college with or without graduation (5), and graduate or professional school (6). Education was categorized as high school or less and greater than high school.

Area deprivation index (ADI)<sup>25</sup> was ascertained as a national ranking of socioeconomic deprivation at the census tract level and categorized into distribution-based tertiles. The ADI score was directly related to the level of neighborhood deprivation.

## Analytical Approach

All analyses were conducted using SAS 9.4. Prevalence of multimorbidity was estimated overall and within the pre-specified demographic categories as proportions with 95% confidence intervals.

## Results

The sample at baseline consisted of 15,792 participants. After applying exclusion criteria, the sample was reduced to 15,698 individuals. Table 1 shows the demographic characteristics of the study population at baseline along with the prevalence of each chronic condition. At 54%, hyperlipidemia is the most prevalent chronic condition. Obesity was also highly prevalent among the sample, with nearly 28% of the population identified as having BMI greater than 30 kg/m<sup>2</sup>. Over half of the population had a high school education or less.

Figure 1 shows the cross-tabulations of each multimorbidity definition and covariates. Among all 3 definitions of multimorbidity, the prevalence of multimorbidity increased with age, with age group 4 (61+ years of age) having the highest prevalence. Although the prevalence was highest among the older age groups, those aged 45-49 years had the largest estimated increase in prevalence (+16.9%) when hyperlipidemia and obesity were included in the definition. Black female participants had higher prevalence of multimorbidity than White females across all definitions of multimorbidity (17.29%, 32.08%, 42.7% vs 7.5%, 13.83%, 25.02%). Moreover, inclusion of obesity and hyperlipidemia in the MM definition led to over doubling of prevalence among black females in MM3 than with MM1. Therefore, Black participants had a higher overall prevalence of every condition and did not experience as much of a change in prevalence

with the increase of conditions. White females had lower prevalence than White males across every definition of MM. The comparison of the different multimorbidity definitions shows greater prevalence with the inclusion of obesity and hyperlipidemia.

## **Discussion**

### **Age Group**

In this study of a large population-based cohort, I observed a direct positive relationship between participants' age and the prevalence of multimorbidity. The highest multimorbidity prevalence observed was among those aged 61+ years. This increase of prevalence with age is consistent with other studies.<sup>2-5</sup> Although multimorbidity increases with age, this study draws attention to the burden of multimorbidity among middle-aged adults. A previous study reported that approximately 35% of middle-age adults are considered to be diagnosed with two or more chronic conditions.<sup>26</sup> My findings show similar proportions with the inclusion of obesity and hyperlipidemia (MM3). Without those 2 conditions, multimorbidity prevalence ranged from 5.31% to 16.9%, estimates that are nearly 2-4 times lower than those reported by extant studies. The largest increase in the prevalence estimate observed with the addition of obesity and hyperlipidemia criteria occurred in those aged 45-49 years of age (16.94% increase), meaning obesity and hyperlipidemia are highly prevalent among this age group in the study. Without the inclusion of these conditions, the prevalence of multimorbidity would be much smaller.

### **Race-Sex**

Compared to Whites, Blacks had the highest prevalence of multimorbidity within all definitions. Using the MM1 definition, Black participants had a 16.08% prevalence of multimorbidity, and Whites had 8.24%. The inclusion of obesity and hyperlipidemia in

MM3 increased the estimate of the prevalence of multimorbidity to 24.5% among Black participants and 18.09% among White participants. Among Blacks, females had a higher prevalence of multimorbidity than males. Although Black females had more chronic conditions than Black males, White females never had a higher prevalence than White males. These results support the need for clinical and public health prevention efforts targeting chronic conditions within the African American populations because they are at a higher risk of multiple chronic conditions than other racial groups, as suggested by numerous extant studies.<sup>27</sup>

#### Individual and Neighborhood Socioeconomic position

Multimorbidity prevalence increased as the inclusion criteria increased for each level of education and ADI tertile. The prevalence for MM3 was over 3 times the prevalence of MM1 in both the ‘more than high school’ group and the lower ADI tertile. Although the prevalence increased the most in those groups, the overall prevalence was highest among those with a high school education or less and ADI tertile 3. Consistent with extant studies, those with higher neighborhood deprivation had a higher prevalence of multimorbidity.<sup>11</sup>

#### Strengths/Limitations of Study

A strength of this study is this is a large population-based cohort of middle-aged adults which allows for generalizability of results to middle-aged Black and White Americans of the chosen communities.<sup>28</sup>

A limitation to this study is the absence of a longitudinal follow-up of the participants. Future studies should leverage longitudinal follow-up in ARIC to examine age-related changes in the prevalence of multimorbidity. In addition, future studies

should include an age-standardization when looking at prevalence of multimorbidity among different age groups to account for the confounding effect of age.<sup>5</sup> Another limitation is the use of bivariate analyses. Further studies should adjust for other covariates to prevent confounding when interpreting the prevalence of multimorbidity.

## **Conclusion**

In this cohort of men and women in midlife, I observed a non-negligible prevalence of multimorbidity. As expected, based on extant literature, multimorbidity prevalence in this cohort increased with age and was most prevalence among Black females, and those with a high school education or less. I observed that the addition of chronic conditions can drastically impact the prevalence of multimorbidity. Consistent with previous studies, the inclusion of obesity and hyperlipidemia demonstrates a large increase in prevalence estimates compared to the less inclusive definition.<sup>5,29</sup> This highlights the importance of a lack of a standard multimorbidity definition and how it can affect the prevalence.

## References

1. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *The Lancet*. 2012;380(9836):37-43. doi:10.1016/S0140-6736(12)60240-2
2. Zemedikun DT, Gray LJ, Khunti K, Davies MJ, Dhalwani NN. Patterns of Multimorbidity in Middle-Aged and Older Adults: An Analysis of the UK Biobank Data. *Mayo Clin Proc*. Jul 2018;93(7):857-866. doi:10.1016/j.mayocp.2018.02.012
3. Palladino R, Pennino F, Finbarr M, Millett C, Triassi M. Multimorbidity and health outcomes in older adults in ten European health systems, 2006–15. *Health Affairs*. 2019;38(4):613-623.
4. Chowdhury SR, Das DC, Sunna TC, Beyene J, Hossain A. Global and regional prevalence of multimorbidity in the adult population in community settings: a systematic review and meta-analysis. *Eclinicalmedicine*. 2023;57
5. King DE, Xiang J, Pilkerton CS. Multimorbidity Trends in United States Adults, 1988–2014. *The Journal of the American Board of Family Medicine*. 2018;31(4):503-513. doi:10.3122/jabfm.2018.04.180008
6. Kone AP, Mondor L, Maxwell C, Kabir US, Rosella LC, Wodchis WP. Rising burden of multimorbidity and related socio-demographic factors: a repeated cross-sectional study of Ontarians. *Can J Public Health*. Aug 2021;112(4):737-747. doi:10.17269/s41997-021-00474-y
7. Salive ME. Multimorbidity in older adults. *Epidemiol Rev*. 2013;35:75-83. doi:10.1093/epirev/mxs009
8. Wagner C, Carmeli C, Chiolero A, Cullati S. Life course socioeconomic conditions and multimorbidity in old age - A scoping review. *Ageing Res Rev*. Jun 2022;78:101630. doi:10.1016/j.arr.2022.101630
9. Alshakhs M, Jackson B, Ikponmwosa D, Reynolds R, Madlock-Brown C. Multimorbidity patterns across race/ethnicity as stratified by age and obesity. *Sci Rep-Uk*. Jun 11 2022;12(1)doi:ARTN 9716  
10.1038/s41598-022-13733-w
10. Caraballo C, Herrin J, Mahajan S, et al. Temporal trends in racial and ethnic disparities in multimorbidity prevalence in the United States, 1999-2018. *The American Journal of Medicine*. 2022;135(9):1083-1092. e14.
11. Singer L, Green M, Rowe F, Ben-Shlomo Y, Morrissey K. Social determinants of multimorbidity and multiple functional limitations among the ageing population of England, 2002-2015. *SSM Popul Health*. Aug 2019;8:100413. doi:10.1016/j.ssmph.2019.100413
12. Schiøtz ML, Høst D, Christensen MB, et al. Quality of care for people with multimorbidity – a case series. *BMC Health Services Research*. 2017/11/18 2017;17(1):745. doi:10.1186/s12913-017-2724-z
13. Fortin M, Bravo G, Hudon C, et al. Relationship between multimorbidity and health-related quality of life of patients in primary care. *Qual Life Res*. Feb 2006;15(1):83-91. doi:10.1007/s11136-005-8661-z
14. Salisbury C, Johnson L, Purdy S, Valderas JM, Montgomery AA. Epidemiology and impact of multimorbidity in primary care: a retrospective cohort study. *Br J Gen Pract*. Jan 2011;61(582):e12-21. doi:10.3399/bjgp11X548929

15. Griffith LE, Gilsing A, Mangin D, et al. Multimorbidity Frameworks Impact Prevalence and Relationships with Patient-Important Outcomes. *J Am Geriatr Soc.* Aug 2019;67(8):1632-1640. doi:10.1111/jgs.15921
16. Soley-Bori M, Ashworth M, Bisquera A, et al. Impact of multimorbidity on healthcare costs and utilisation: a systematic review of the UK literature. *British Journal of General Practice.* 2021;71(702):e39-e46. doi:10.3399/bjgp20X713897
17. Fortin M, Bravo G, Hudon C, Vanasse A, Lapointe L. Prevalence of multimorbidity among adults seen in family practice. *Ann Fam Med.* May-Jun 2005;3(3):223-8. doi:10.1370/afm.272
18. Navickas R, Petric V-K, Feigl AB, Seychell M. Multimorbidity: What Do We Know? What Should We Do? *Journal of Comorbidity.* 2016;6(1):4-11. doi:10.15256/joc.2016.6.72
19. Rocca WA, Grossardt BR, Boyd CM, Chamberlain AM, Bobo WV, St Sauver JL. Multimorbidity, ageing and mortality: normative data and cohort study in an American population. *BMJ Open.* Mar 19 2021;11(3):e042633. doi:10.1136/bmjopen-2020-042633
20. Almirall J, Fortin M. The coexistence of terms to describe the presence of multiple concurrent diseases. *J Comorb.* 2013;3:4-9. doi:10.15256/joc.2013.3.22
21. Aubert CE, Schnipper JL, Roumet M, et al. Best Definitions of Multimorbidity to Identify Patients With High Health Care Resource Utilization. *Mayo Clin Proc Innov Qual Outcomes.* Feb 2020;4(1):40-49. doi:10.1016/j.mayocpiqo.2019.09.002
22. Nguyen H, Manolova G, Daskalopoulou C, Vitoratou S, Prince M, Prina AM. Prevalence of multimorbidity in community settings: A systematic review and meta-analysis of observational studies. *J Comorb.* Jan-Dec 2019;9:2235042x19870934. doi:10.1177/2235042x19870934
23. Rocca WA, Boyd CM, Grossardt BR, et al. Prevalence of multimorbidity in a geographically defined American population: patterns by age, sex, and race/ethnicity. Elsevier; 2014:1336-1349.
24. Goodman RA, Posner SF, Huang ES, Parekh AK, Koh HK. Defining and Measuring Chronic Conditions: Imperatives for Research, Policy, Program, and Practice. *Preventing Chronic Disease.* 2013;10:E66. doi:10.5888/pcd10.120239
25. Kind AJ, Buckingham WR. Making neighborhood-disadvantage metrics accessible—the neighborhood atlas. *The New England journal of medicine.* 2018;378(26):2456.
26. Sim SZ, Koh HL, Lee SPS, Young DY, Lee ES. How does multimorbidity affect middle-aged adults? A cross-sectional survey in the Singapore primary healthcare setting. *BMC Family Practice.* 2020;21(1):1-10.
27. Quiñones AR, Newsom JT, Elman MR, et al. Racial and Ethnic Differences in Multimorbidity Changes Over Time. *Med Care.* May 1 2021;59(5):402-409. doi:10.1097/mlr.0000000000001527
28. Investigators A. The atherosclerosis risk in communit (ARIC) study: design and objectives. *American journal of epidemiology.* 1989;129(4):687-702.
29. Kivimäki M, Strandberg T, Pentti J, et al. Body-mass index and risk of obesity-related complex multimorbidity: an observational multicohort study. *The lancet Diabetes & endocrinology.* 2022;10(4):253-263.



30. Rosamond WD, Chang PP, Baggett C, et al. Classification of heart failure in the atherosclerosis risk in communities (ARIC) study: a comparison of diagnostic criteria. *Circ Heart Fail*. Mar 1 2012;5(2):152-9. doi:10.1161/cirheartfailure.111.963199

## Appendix

**Table 1. Baseline Participant Characteristics: ARIC Study 1987-1989**

	N (%), mean (SD)
<i>Sex</i>	
Male	7030 (44.8%)
<i>Age</i>	54.2 (5.8)
<i>Race</i>	
Black	4211 (26.8%)
<i>Education Level</i>	
Less than High School	8798 (56.1%)
Missing: 26	
<i>ADI rank</i>	48.2 (22.6)
<i>Obesity (BMI&gt;30)</i>	4322 (27.6%)
Missing: 25	
<i>Chronic Heart Disease</i>	763 (4.9%)
Missing: 339	
<i>Heart Failure</i>	746 (4.8%)
Missing: 282	
<i>Hyperlipidemia</i>	8466 (54.0%)
Missing: 622	
<i>Stroke</i>	283 (1.8%)
Missing: 3637	
<i>Cancer</i>	902 (5.8%)
Missing: 149	
<i>Diabetes</i>	1863 (11.9%)
Missing: 147	
<i>Hypertension</i>	5471 (34.9%)
Missing: 622	

**Table 2. Multimorbidity Variables in Study**

---

<b>Variable Name</b>	<b>Definition</b>
Multimorbidity 1 (MM1)	Presence of 2 or more: cancer, stroke, diabetes, chronic heart disease, heart failure, and hypertension
Multimorbidity 2 (MM2)	Presence of 2 or more: obesity, cancer, stroke, diabetes, chronic heart disease, heart failure, and hypertension
Multimorbidity 3 (MM3)	Presence of 2 or more: obesity, hyperlipidemia, cancer, stroke, diabetes, chronic heart disease, heart failure, and hypertension

---

**Table 3. Definition of Chronic Conditions**

<b>Component criterium</b>	<b>Definition</b>
Coronary heart disease	Non-fatal MI
Hypertension	Systolic BP>140 mm Hg; diastolic BP> 90 mm Hg; or evidence of antihypertensive medication use
Heart failure	evidence heart failure medication use and Gothenburg criteria of “manifest” heart failure <sup>30</sup>
Hyperlipidemia	LDL >=130 mg/dL

Stroke	Adjudicated event through follow-up
Cancer	Self-report and linkage with cancer registries
Diabetes	Glucose levels $\geq 126$ mg/dL
Obesity	BMI $\geq 30$ kg/m <sup>2</sup>

### **List 1. DHHS List of Chronic Conditions**

---

Coronary artery disease

Cardiac arrhythmias

Hyperlipidemia

Stroke

Arthritis

Asthma

Autism spectrum disorder

Cancer

Chronic kidney disease

Chronic obstructive pulmonary disease

Dementia (including Alzheimer's and other senile dementias)

Depression

Diabetes

Hepatitis

Human immunodeficiency virus (HIV)

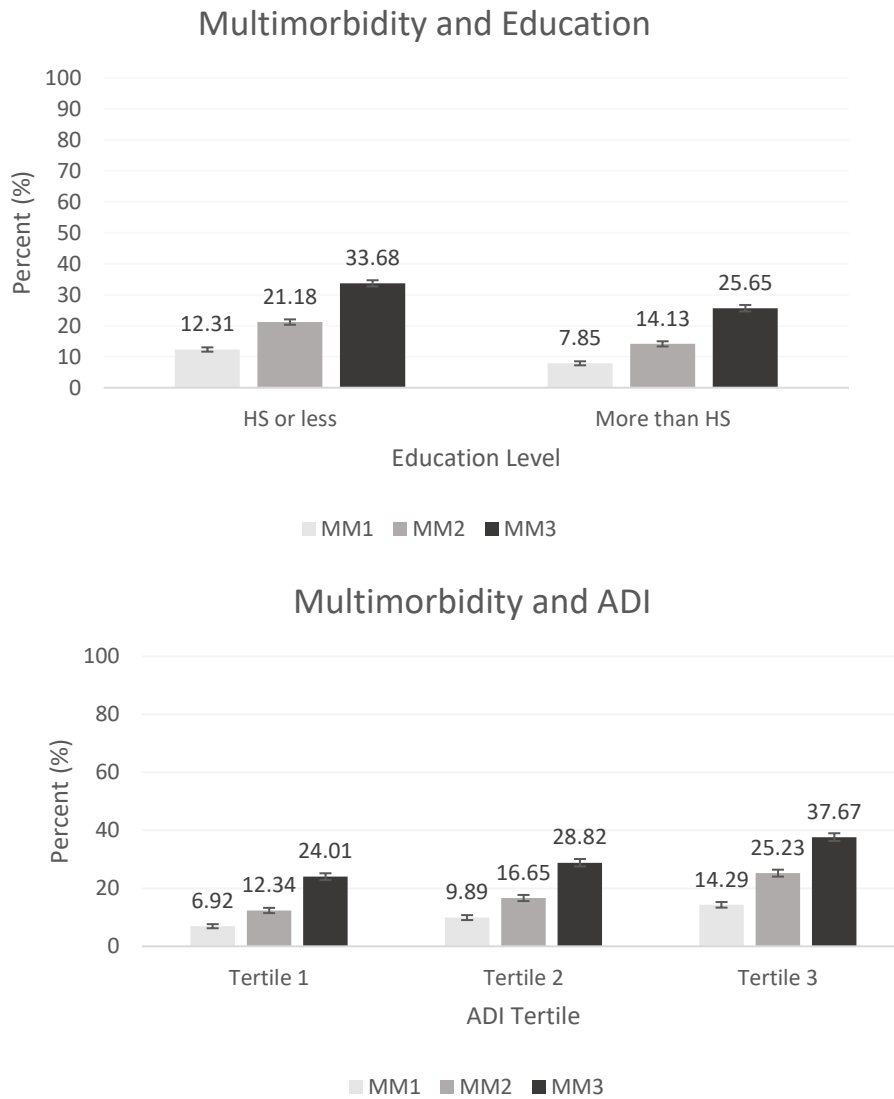
Osteoporosis

Schizophrenia

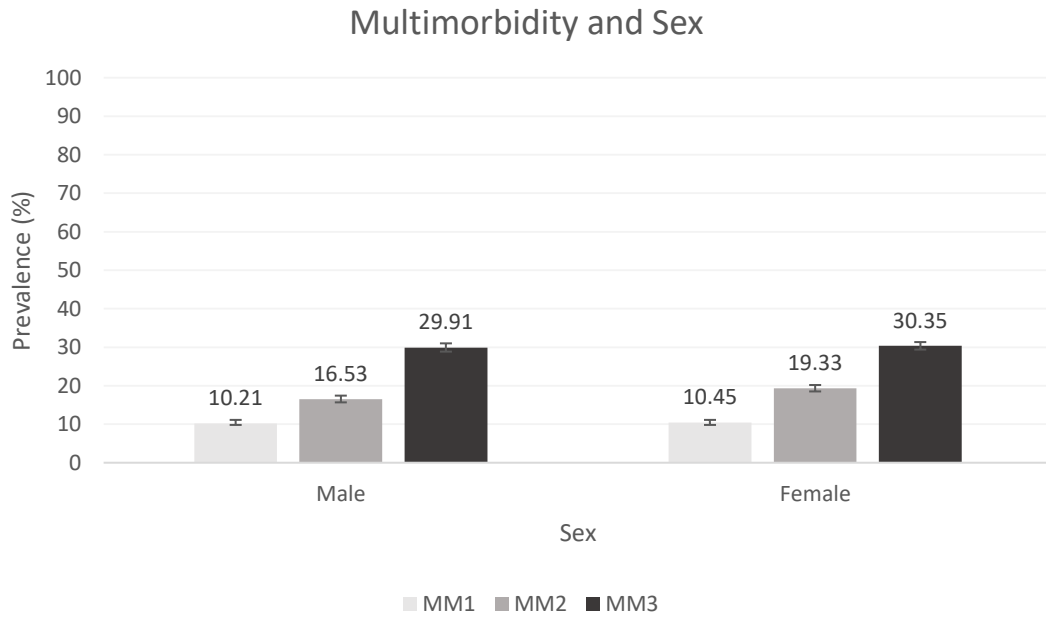
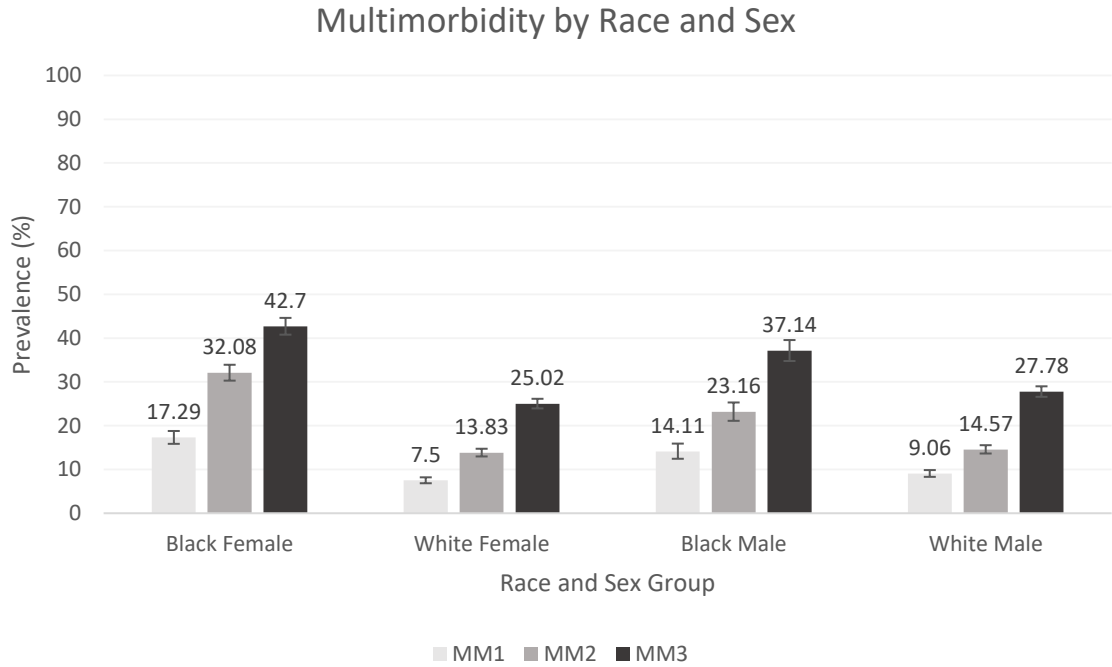
Substance abuse disorders (drug and alcohol)

**Figure 2A. Prevalence of Multimorbidity and Education Level and ADI, ARIC**

**1987-1989**



**Figure 2B. Prevalence of Multimorbidity and Race-Sex, Sex, Race, and Age, ARIC 1987-1989**



**Figure 2B. Continued**

