Published in final edited form as:

BJU Int. 2018 December ; 122(6): 1041–1048. doi:10.1111/bju.14246.

Cluster analysis of multiple chronic conditions associated with urinary incontinence among women in the USA

Alayne D. Markland^{*,†}, Camille P. Vaughan^{‡,§}, Ike S. Okosun[¶], Patricia S. Goode^{*,†}, Kathryn L. Burgio^{*,†}, Theodore M. Johnson II^{‡,§}

^{*}Department of Medicine, Division of Gerontology, Geriatrics and Palliative Care, University of Alabama-Birmingham UAB School of Medicine, Birmingham, AL,

[†]Birmingham/Atlanta VA Geriatric Research, Education and Clinical Center, Birmingham VA Medical Center, Birmingham, AL,

[‡]Birmingham/Atlanta VA Geriatric Research, Education and Clinical Center, Atlanta VA Medical Center, Decatur, GA, USA

[§]Department of Medicine, Division of General Medicine and Geriatrics, Emory University School of Medicine, Atlanta, GA, USA

[¶]Division of Epidemiology and Biostatistics, School of Public Health, Georgia State University, Atlanta, GA, USA

Abstract

Objective—To identify patterns of prevalent chronic medical conditions among women with urinary incontinence (UI).

Materials and Methods—We combined cross-sectional data from the 2005–2006 to 2011–2012 US National Health and Nutrition Examination Surveys, and identified 3 800 women with UI and data on 12 chronic conditions. Types of UI included stress UI (SUI), urgency UI (UUI), and mixed stress and urgency UI (MUI). We categorized UI as mild, moderate or severe using validated measures. We performed a two-step cluster analysis to identify patterns between clusters for UI type and severity. We explored associations between clusters by UI subtype and severity, controlling for age, education, race/ethnicity, parity, hysterectomy status and adiposity in weighted regression analyses.

Results—Eleven percent of women with UI had no chronic conditions. Among women with UI who had at least one additional condition, four distinct clusters were identified: (i) cardiovascular disease (CVD) risk-younger; (ii) asthma-predominant; (iii) CVD risk-older; and (iv) multiple

Correspondence: Alayne D. Markland, Associate Professor of Medicine, Division of Gerontology, Geriatrics and Palliative Care, University of Alabama at Birmingham, GRECC 11-G; 700 19th Street South, Birmingham, AL 35233, USA. amarkland@uabmc.edu.

Conflict of Interest

Dr Markland reports other support from U.S. Department of Veterans Affairs and National Institutes of Health (NIH) during the conduct of the study. Dr Vaughan reports other support from U.S. Department of Veterans Affairs, Agency for Healthcare Research and Quality (AHRQ), and the NIH during the conduct of the study; grants from John A. Hartford Foundation, other from Kimberly-Clark Corp, outside the submitted work. Dr Burgio reports other support from U.S. Department of Veterans Affairs and NIH during the conduct of the study. Dr Okosun has nothing to disclose. Dr Goode reports other support from U.S. Veterans Administration and the NIH during the conduct of the study. Dr Johnson 2nd reports personal fees from Astellas, other from UpToDate, personal fees from Metronic, personal fees from Vantia, other from PeerView CME, outside the submitted work.

chronic conditions (MCC). In comparison to women with UI and no chronic diseases, women in the CVD risk-younger (age 46.7 ± 15.8 years) cluster reported the highest rate of SUI and mild UI severity. In the asthma-predominant cluster (age 51.5 ± 10.2 years), women had more SUI and MUI and more moderate UI severity. Women in the CVD risk-older cluster (age 57.9 ± 13.4 years) had the highest rate of UUI, along with more severe UI. Women in the MCC cluster (age 61.0 ± 14.8 years) had the highest rates of MUI and the highest rate of moderate/severe UI.

Conclusions—Women with UI rarely have no additional chronic conditions. Four patterns of chronic conditions emerged with differences by UI type and severity. Identification of women with mild UI and modifiable conditions may inform future prevention efforts.

Keywords

urinary incontinence; chronic disease; multiple chronic conditions; comorbidity; epidemiology

Introduction

Urinary incontinence (UI) occurs in up to one-third of adult women, with urgency type UI (UUI), specifically, increasing greatly with age [1–7]. UI may also be associated with increased mortality even after adjusting for chronic conditions [8]. Treatment options for UI include non-pharmacological and pharmacological interventions that rarely ameliorate all symptoms [9]. Many pharmacological treatment options have potentially negative effects on cognition and have low rates of adherence over time [10,11]; thus, the recent emphasis on possible prevention and on the identification of women who may benefit from early intervention to prevent worsening of bladder symptoms and severity is important [12].

There is evidence of a relationship between UI and specific chronic conditions, such as diabetes, depression and stroke, even after adjusting for known obstetric and gynaecological risk factors [13]. Obesity is another condition that is associated with UI in women and there is evidence of symptom improvement with weight loss [14,15]. According to national data, the most prevalent chronic conditions in women aged 18 years (in order of prevalence) are hypertension, hyperlipidaemia, allergies/sinusitis/upper respiratory conditions, mood disorders, diabetes, anxiety disorders, asthma, coronary artery disease, thyroid disease and chronic obstructive pulmonary disease (COPD) [16]. More evidence is needed to understand the relationship between common chronic conditions and UI.

Even less is known about the impact of multimorbidity or multiple chronic conditions (MCC), defined as having two or more chronic conditions, on the prevalence, type and severity of UI. We hypothesized that the burden of chronic conditions affects UI severity and may also be related to UI types. Because almost one-third of individuals in the US population are living with MCC [17], our primary aim was to evaluate the patterns of chronic conditions associated with UI, including UI types and severity levels, in a representative sample of US adult women. Secondly, we explored potential patterns of chronic conditions among women with UI that may be more amenable to modification and prevention.

Materials and Methods

Study Design

Four waves of the US National Health and Nutrition Examination Surveys (NHANES) data were used in this analysis (2005–2006, 2007–2008, 2009–2010 and 2011–2012). These cross-sectional surveys were based on sampling schemes that collect demographic and health information from non-institutionalized people in the USA, with oversampling carried out in order to be representative of the US population. In these surveys, all participants were interviewed in their homes, while a select few underwent laboratory tests and physical examinations in mobile examination centres. Detailed descriptions of NHANES methods can be obtained from various sources and are published online by the National Center for Health Statistics [18,19]. The National Center for Health Statistics institutional review board approves NHANES protocols, and local institutional review board approval was waived for this analysis.

Study Eligibility

The present study included women aged ≥ 20 years, for whom data were available on race/ethnicity, weight, height, medical insurance status, education and marital status, parity, hysterectomy status, urinary albumin and urinary creatinine variables. The analytical sample only included women who self-reported UI, including type and severity of UI, and the presence or absence of 12 selected chronic conditions.

Measurements

Race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic or other races. Women were asked to provide information on their highest grade or level of education. In NHANES, health insurance was assessed by asking participants about their coverage status. From the reproductive health questionnaire, parity and hysterectomy status were self-reported. Body mass index (BMI) was calculated as weight in kg divided by height in m². Adiposity status was computed using BMI, and classified as normal (<25 kg/m²), overweight (25–29.99 kg/m²) or obese (>30 kg/m²). Blood glucose was obtained in mobile examination centres after overnight fasting. Urinary albumin and urinary creatinine were measured in random urine specimens collected either at mobile examination centres or at the participant's home.

Urinary Incontinence Assessment

The main dependent variable for this study was the self-report of UI, at least monthly, assessed using the validated two-item incontinence severity index [20]. The two questions ascertained UI frequency and amount of urine leakage. The responses to these questions were multiplied to obtain a total severity score, ranging from 1 to 12 (mild or slight symptoms, scores 1–2; moderate symptoms, scores 3–6; severe symptoms, scores 7–9; and very severe symptoms, scores 10–12), with the two highest levels of severity combined.

Affirmative answers to specific UI questions determined the type of UI (SUI and UUI, respectively): (i) 'During the past 12 months, have you leaked or lost control of even a small amount of urine with an activity like coughing, lifting or exercise?' (ii) 'During the past 12

months, have you leaked or lost control of even a small amount of urine with an urge or pressure to urinate and you couldn't get to the toilet fast enough?' All women responding in the affirmative to both SUI and UII questions were considered to have MUI.

Definitions of Chronic Conditions

We defined 12 chronic conditions by combining self-reported conditions with data from mobile examination centre measures when feasible. Six chronic conditions were ascertained using self-reported data alone. The women were asked if a doctor or other health professional had ever told them they had arthritis, cancer (other than skin), asthma, stroke, congestive heart failure or coronary heart disease. Women who answered 'yes' were regarded as disease-positive and those who answered 'no' were classified as disease-negative. Hypertension status was based on self-reported diagnosis, treatment with medication, or diastolic and systolic blood pressure values. Hypertension was defined as diastolic blood pressure ≥ 90 mm Hg, systolic blood pressure ≥ 140 mm Hg or current treatment with prescribed anti-hypertension medication. COPD status (chronic bronchitis and emphysema) was ascertained using a self-report that the diagnosis had been made previously by a doctor or health professional. Additionally, participants were asked two questions on chronic cough. Participants were classified as having COPD if they had a history of a COPD diagnosis or responded affirmatively to the two chronic cough questions. Diabetes status was based on prior diagnosis, current treatment or blood glucose values. Diabetes was defined as answering 'yes' to either of these questions or having a fasting blood glucose of ≥ 125 mg/dL or an oral glucose tolerance test value of ≥ 200 mg/dL. Albuminuria was defined by a diagnosis of kidney disease or a urinary albumin:creatinine ratio of ≥ 30 mg/g. Participants completed the nine-item Patient Health Questionnaire (PHQ-9), which describes the severity and occurrence of depressive symptoms over the last 2 weeks. Depression was defined as moderate (PHQ-9 score 5–14) and severe (PHQ-9 score ≥ 15) based on a continuous depression severity index described by Kroenke et al. [21]. Dyslipidaemia was based on self-report of cholesterol status and the need to take medication for cholesterol control. Dyslipidaemia was defined as either of the aforementioned variables, or as having a serum low-density lipoprotein cholesterol value of ≥ 70 mg/dL.

Cluster Analysis

Women with UI who reported at least one of the 12 chronic conditions listed above and had no missing values for any of these 12 chronic conditions were included in the cluster analysis. Two-step cluster analysis using a log-likelihood distance measure was performed using SPSS version 20 (IBM, Armonk, NY, USA). The two-step cluster analysis was used to classify groups of women who were similar to each other with respect to the 12 studied chronic conditions, but different from other women. A two-step cluster analysis identifies group segmentations by running pre-clustering first and then by hierarchical methods. As such, it combines both approaches. This technique can detect latent relationships within and between women with multiple distinct characteristics. Optimal cluster solution was determined using Akaike's information criterion [22]. The quality of fit of the resulting modelled clusters was measured using the silhouette measure of cohesion and separation [23]. The silhouette measure contrasts the average distance among elements in the same

cluster (within-cluster cohesion) with the average distance to elements in other clusters (between-cluster separation).

Statistical Analyses

To account for the unequal probability of selection, oversampling and non-response, we applied appropriate sample weights, strata and cluster variables to all analyses.

We compared demographic and clinical characteristics stratified by clusters of chronic conditions. Cluster differences were assessed using the chi-squared and independent tests for categorical and continuous variables, respectively. We used logistic regression analyses to estimate the association between chronic condition clusters with the odds of UUI, SUI and MUI (Model 1) and UI severity (Model 2), defined as mild/moderate to very severe UI. In all models, we adjusted for age, education, race/ethnicity, adiposity, parity and hysterectomy. In all analyses, *P* values of <0.05 or 95% CIs were used to establish statistical significance.

Results

Characteristics of US Women with UI

Overall, 3 800 women who reported UI and had data on the presence or absence of chronic conditions were included in our analytical sample. Women with UI and no chronic conditions ($n = 417$, 11%) were younger, had a lower average BMI, and were more likely to be Mexican-American, have some college/college education, report being married, and have only one pregnancy compared with women with at least one chronic condition (Table 1).

Chronic Condition Clusters

The cluster analysis revealed four distinct clusters. The 12 chronic conditions included in the two-step analysis had a silhouette coefficient 0.40, indicative of fair data partitioning. Dyslipidaemia, hypertension, diabetes, asthma, COPD, cancer, arthritis, depression, coronary heart disease and stroke were the most important chronic conditions that emerged from the four clusters (Fig. 1), whereas, congestive heart failure and kidney disease were not as prominent. Cluster-specific distribution of sociodemographic and reproductive variables for women in each group are shown in Table 1. Women in the four clusters had distinct differences in age, race/ethnicity, education, obesity, parity and hysterectomy status, as well as type of UI (Fig. 3), and UI severity (Fig. 4), described by cluster below.

Cardiovascular Disease Risk-younger Cluster

A total of 317 women (8.3%) were in the cardiovascular disease (CVD) risk-younger cluster (Fig. 2A). In this smallest cluster, women were youngest (age 46.7 ± 15.8 years), reported high rates of some college/college-educated (55%), and had a lower rate of obesity (36%). The most distinctive chronic diseases in this group were hypertension, arthritis and dyslipidaemia. Women in this cluster had the lowest overall rates of UI, a predominance of SUI (42.9%), and higher rates of mild UI (65%) compared with the other clusters (Figs 3 and 4).

Asthma Predominant Cluster

Women in the asthma predominant cluster ($n = 827$, 21.7%; Fig. 2B) were older than in other clusters (51.5 ± 10.2 years), but included more women in the peri-menopausal age range. This cluster had high representation of non-Hispanic black women (19%). The women in this cluster reported lower rates of some college/college education (29%) and had more obesity (46%). They had a similar chronic condition pattern as the CVD risk-younger cluster, with hypertension, arthritis and dyslipidaemia; however, 100% of the women in this cluster also had asthma and 13.2% had COPD. These women had a predominance of SUI (40.2%) and lower rates of mild UI (60%) than the CVD risk-younger cluster (Figs 3 and 4).

Cardiovascular Disease Risk-older Cluster

Women in the CVD risk-older cluster ($n = 730$, 19.2%; Fig. 2C) were older than in the other clusters (57.9 ± 13.4 years). This cluster had the highest representation of women of 'other' race/ethnicity. The women in this cluster reported lower rates of some college/college education (20%), had similar rates of obesity (45%) to the CVD risk-younger cluster and had high rates of hysterectomy (33%) compared with younger women (23%). They had a similar chronic condition pattern to that of the CVD risk-younger and asthma predominant cluster, with hypertension, arthritis, asthma and dyslipidaemia; however, women in this cluster had more chronic conditions, despite having lower prevalence rates of hypertension, dyslipidaemia, arthritis and asthma. Women in this cluster had a lower rate of SUI (35.3%) and higher rates of UUI and MUI, along with lower rates of mild UI (53%) than the previous two clusters (Figs 3 and 4).

Multiple Chronic Condition Cluster

In the MCC cluster, the largest cluster ($n = 1\,509$, 38.7%; Figure 2D), women had the oldest mean age (61.0 ± 14.8 years) and a high representation of non-Hispanic white (58%) and non-Hispanic black women (19%). The women in this cluster reported the lowest rates of some college/college education (14%), the highest rates of obesity (56%), the highest rates of hysterectomy (44%), and the highest rates of having four or more pregnancies (45%). Women in this cluster had the highest rates of all chronic conditions, except asthma, when compared with women in the other three clusters. Women in this cluster had the lowest rates of pure SUI (29%) and the highest rates of MUI (43%), with similar rates of UUI compared with the CVD risk-older cluster. Mild UI rates were lowest in this cluster (42%) with the highest rates of moderate UI (40%) and severe/very severe UI (18%; Figs 3 and 4).

Multivariable Analyses

In adjusted analyses (Table 2), associations between clusters and UI subtypes (UUI, SUI and MUI) are shown in Model 1 and UI severity in Model 2. Women in the MCC cluster had increased odds of all UI subtypes compared with women without chronic conditions. Women in the CVD risk-younger and CVD risk-older age clusters, as well as the MCC cluster, had increased odds of UUI compared with women without chronic conditions. Similar to UI types, women in the younger age clusters had different patterns of UI severity than women in the older age clusters. Women in the younger age clusters (CVD risk-younger and asthma-predominant clusters) had increased odds of having mild UI compared

with women without chronic conditions. Women in the older age clusters (CVD risk-older and MCC clusters) had higher odds of having moderate or severe UI compared with women without chronic conditions.

Discussion

Previous studies have examined the individual conditions associated with prevalent or incident UI in women [5,24–27] and a few studies have examined clusters of chronic conditions that frequently coexist in women with UI [28,29]. More than two-thirds of older adults live with MCC [17,30]. Evaluating the relationship of common coexisting clusters of conditions and the potential association with UI may contribute to the development of targeted UI treatment approaches for persons with MCC; therefore, the present results provide a novel approach to evaluating the association between clusters of chronic conditions and UI type and severity across the lifespan of adult women. Four distinct patterns have emerged that inform treatment approaches for clinicians, as well as targets for potential preventive intervention and additional research.

Within three of the four clusters, the most prevalent chronic conditions, such as hypertension and hyperlipidaemia, are associated with increased CVD risk. There is increasing interest in the evaluation of how CVD may affect LUTS [31,32]. White matter hyperintensities in the CNS, which are associated with long-term CVD, are also associated with severity of UI in older adults [33]. The increasing prevalence of UUI and MUI as women with CVD age adds to the literature that implicates CVD in the pathogenesis of UUI among aging women. Inclusion of questions related to UI in longitudinal studies of CVD treatment would provide important data about the modifiability of this relationship.

Some of the clusters in the present study in women with UI are similar to clusters identified in an evaluation of MCC patterns among global populations of older adults, including a cluster with higher burden of respiratory conditions; however, among women with UI, clusters were also differentiated by increasing age and burden of multimorbidity [30]. The cluster with the greatest burden of multimorbidity was also the cluster including the most women in that analysis. As age and the prevalence of MCC increased, MUI and more severe UI were reported. Interestingly, depression was only prevalent in the MCC cluster, although depression was one of the most important conditions differentiating CVD clusters in women with UI. Conditions associated with end organ damage and increased vulnerability in the setting of polypharmacy, such as congestive heart failure, COPD and stroke, defined the MCC cluster. Clinical guidelines for UI generally do not include differential guidance based on patterns of MCC; however, in older adults, consideration of the impact of common coexisting chronic conditions to direct therapy may be important to maximize treatment benefit and minimize harm [34].

Novel findings emerging from the present analysis include the identification of a cluster of women with UI who had a 100% prevalence of asthma and COPD in addition to conditions that are associated with CVD. SUI was commonly reported in this group (40.2%), but UUI was also present at a percentage (16.7%) not much different from the other clusters (range 15.8–21.1%). Asthma could exacerbate SUI because of the increased intra-abdominal

pressure occurring with coughing. A recent publication found that improving cough severity and its impact on quality of life also improved UI [35]. The combination of asthma and CVD is also associated with more severe UI in a younger population of women than expected. Evaluation of women with pulmonary conditions should be considered for prevention, early detection and encouragement of treatment seeking. Less is known about the association between asthma and urgency UI.

The present study has some limitations. First, the data are cross-sectional and thus causality cannot be ascertained. Second, several chronic conditions were assessed through self-report; however, self-report has good concordance with medical record review for conditions such as hypertension, diabetes and stroke [36,37]. Third, NHANES respondents represent community-dwelling adults in the USA and may not be representative of other populations, such as those with increased functional impairment or institutionalized older adults.

In conclusion, previous studies have focused primarily on the association of specific conditions with UI in women or have evaluated chronic conditions in general. Our findings incorporate a novel evaluation of clusters of common chronic conditions that differentiate women with UI across the lifespan. Women with UI in this cohort rarely had no other chronic conditions. Conditions associated with CVD were prominent across all age groups and suggest that these conditions could be a modifiable target for prevention efforts as UI severity also increased across groups. Pulmonary disease, specifically asthma, affected all of the women in a single cluster, highlighting a target population for future research. Clinical guidelines for UI moving forward should incorporate greater consideration of the vulnerability of people with MCC to adverse events associated with treatment, so that goals of care are appropriately aligned [38]. Thus, these findings provide more specific understanding of populations of women with UI and MCC in order to target future studies of prevention and treatment.

Acknowledgements

Data from the NHANES were obtained from the US National Center for Health Statistics. The contents of this manuscript do not represent the views of the US Department of Veterans Affairs or the United States Government.

Abbreviations:

BMI	body mass index
COPD	chronic obstructive pulmonary disease
MCC	multiple chronic conditions
MUI	mixed stress and urgency urinary incontinence
NHANES	National Health and Nutrition Examination Surveys
PHQ-9	nine-item Patient Health Questionnaire
SUI	stress urinary incontinence
UI	urinary incontinence

UUI urgency urinary incontinence

References

1. Nygaard I, Barber MD, Burgio KL et al. Prevalence of symptomatic pelvic floor disorders in US women. *JAMA* 2008; 300: 1311–6 [PubMed: 18799443]
2. Irwin DE, Milsom I, Hunskaar S et al. Population-based survey of urinary incontinence, overactive bladder, and other lower urinary tract symptoms in five countries: results of the EPIC study. *Eur Urol* 2006; 50: 1306 [PubMed: 17049716]
3. Barry MJ, Link CL, McNaughton-Collins MF, McKinlay JB, Boston Area Community Health. Overlap of different urological symptom complexes in a racially and ethnically diverse, community-based population of men and women. *BJU Int* 2008; 101: 45–51
4. Eapen RS, Radomski SB. Review of the epidemiology of overactive bladder. *Res Rep Urol* 2016; 8: 71–6 [PubMed: 27350947]
5. Melville JL, Katon W, Delaney K, Newton K. Urinary incontinence in US women: a population-based study. *Arch Intern Med* 2005; 165: 537–42 [PubMed: 15767530]
6. Danforth KN, Townsend MK, Lifford K, Curhan GC, Resnick NM, Grodstein F. Risk factors for urinary incontinence among middle-aged women. *Am J Obstet Gynecol* 2006; 194: 339–45 [PubMed: 16458626]
7. Lifford KL, Townsend MK, Curhan GC, Resnick NM, Grodstein F. The epidemiology of urinary incontinence in older women: incidence, progression, and remission. *J Am Geriatr Soc* 2008; 56: 1191–8 [PubMed: 18492035]
8. John G, Bardini C, Combescure C, Dallenbach P. Urinary incontinence as a predictor of death: a systematic review and meta-analysis. *PLoS One* 2016; 11: e0158992 [PubMed: 27410965]
9. Gormley EA, Lightner DJ, Faraday M, Vasavada SP, American Urological A. Society of Urodynamics FPM. Diagnosis and treatment of overactive bladder (non-neurogenic) in adults: AUA/SUFU guideline amendment. *J Urol* 2015; 193: 1572–80 [PubMed: 25623739]
10. Kachru N, Carnahan RM, Johnson ML, Aparasu RR. Potentially inappropriate anticholinergic medication use in community-dwelling older adults: a national cross-sectional study. *Drugs Aging* 2015; 32: 379–89 [PubMed: 25832970]
11. Gopal M, Haynes K, Bellamy SL, Arya LA. Discontinuation rates of anticholinergic medications used for the treatment of lower urinary tract symptoms. *Obstet Gynecol* 2008; 112: 1311–8 [PubMed: 19037041]
12. Lukacz ES, Sampselle C, Gray M et al. A healthy bladder: a consensus statement. *Int J Clin Pract* 2011; 65: 1026–36 [PubMed: 21923844]
13. Coyne KS, Wein A, Nicholson S, Kvasz M, Chen CI, Milsom I. Comorbidities and personal burden of urgency urinary incontinence: a systematic review. *Int J Clin Pract* 2013; 67: 1015–33 [PubMed: 24073974]
14. Townsend MK, Curhan GC, Resnick NM, Grodstein F. BMI, waist circumference, and incident urinary incontinence in older women. *Obesity (Silver Spring)* 2008; 16: 881–6 [PubMed: 18379564]
15. Subak LL, Richter HE, Hunskaar S. Obesity and urinary incontinence: epidemiology and clinical research update. *J Urol* 2009; 182: S2–7 [PubMed: 19846133]
16. Gerteis J, Izrael D, Deitz D et al. Multiple Chronic Conditions Chartbook. Rockville, MD: AHRQ Publications No, Q14–0038. Agency for Healthcare Research and Quality, 2014 Accessed November 2017.
17. 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. *Lancet* 2012; 380: 37–43 [PubMed: 22579043]
18. National Center for Health Statistics, Centers for Disease Control and Prevention National Health and Nutrition Examination Survey (NHANES) Questionnaire and Exam Protocol. Available at <http://www.cdc.gov/nchs/about/major/nhanes/questexam.htm>. Accessed December 2017.

19. National Center for Health Statistics analytic guidelines [online], 2008 Available at http://www.cdc.gov/nchs/data/nhanes/nhanes_general_guidelines_june_04.pdf. Accessed December 2017.
20. Sandvik H, Seim A, Vanvik A, Hunskaar S. A severity index for epidemiological surveys of female urinary incontinence: comparison with 48-hour pad-weighing tests. *Neurourol Urodyn* 2000; 19: 137–45 [PubMed: 10679830]
21. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med* 2001; 16: 606–13 [PubMed: 11556941]
22. Burnham KP, Anderson DR. *Model Selection and Inference: A Practical Information-theoretic Approach*, New York, NY: Springer-Verlag: 1998
23. Dimitriadou E, Dolnicar S, Weingessel A. An examination of indexes for determining the Number of Cluster in binary data sets. *Psychometrika* 2002; 67: 137–60
24. Moller LA, Lose G, Jorgensen T. Incidence and remission rates of lower urinary tract symptoms at one year in women aged 40–60: longitudinal study. *BMJ* 2000; 320: 1429–32 [PubMed: 10827042]
25. Tennstedt SL, Link CL, Steers WD, McKinlay JB. Prevalence of and risk factors for urine leakage in a racially and ethnically diverse population of adults: the Boston Area Community Health (BACH) Survey. *Am J Epidemiol* 2008; 167: 390–9 [PubMed: 18182376]
26. Maserejian NN, Minassian VA, Chen S, Hall SA, McKinlay JB, Tennstedt SL. Treatment status and risk factors for incidence and persistence of urinary incontinence in women. *Int Urogynecol J* 2014; 25: 775–82 [PubMed: 24477545]
27. Townsend MK, Curhan GC, Resnick NM, Grodstein F. The incidence of urinary incontinence across Asian, black, and white women in the United States. *Am J Obstet Gynecol* 2010; 202: e1–7
28. Clerencia-Sierra M, Calderon-Larranaga A, Martinez-Velilla N et al. Multimorbidity patterns in hospitalized older patients: associations among chronic diseases and geriatric syndromes. *PLoS One* 2015; 10: e0132909 [PubMed: 26208112]
29. Reigota RB, Pedro AO, de Souza Santos Machado V, Costa-Paiva L, Pinto-Neto AM. Prevalence of urinary incontinence and its association with multimorbidity in women aged 50 years or older: a population-based study. *Neurourol Urodyn* 2016;35:62–8. [PubMed: 25358890]
30. Garin N, Koyanagi A, Chatterji S et al. Global multimorbidity patterns: a cross-sectional, population-based, multi-country study. *J Gerontol A Biol Sci Med Sci* 2016; 71: 205–14 [PubMed: 26419978]
31. Bouwman II, Blanker MH, Schouten BW et al. Are lower urinary tract symptoms associated with cardiovascular disease in the Dutch general population? Results from the Krimpen study. *World J Urol* 2015; 33: 669–76 [PubMed: 25253653]
32. Bouwman II, Voskamp MJ, Kollen BJ, Nijman RJ, van der Heide WK, Blanker MH. Do lower urinary tract symptoms predict cardiovascular diseases in older men? A systematic review and meta-analysis. *World J Urol* 2015; 33: 1911–20 [PubMed: 25971203]
33. Kuchel GA, Moscufo N, Guttmann CR et al. Localization of brain white matter hyperintensities and urinary incontinence in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 2009; 64: 902–9 [PubMed: 19386575]
34. Inouye SK, Studenski S, Tinetti ME, Kuchel GA. Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. *J Am Geriatr Soc* 2007; 55: 780–91 [PubMed: 17493201]
35. French CL, Crawford SL, Bova C, Irwin RS. Change in psychological, physiological, and situational factors in adults after treatment of chronic cough. *Chest* 2017; 152: 547–62 [PubMed: 28684289]
36. Bergmann MM, Byers T, Freedman DS, Mokdad A. Validity of self-reported diagnoses leading to hospitalization: a comparison of self-reports with hospital records in a prospective study of American adults. *Am J Epidemiol* 1998; 147: 969–77 [PubMed: 9596475]
37. Robinson JR, Young TK, Roos LL, Gelskey DE. Estimating the burden of disease. Comparing administrative data and self-reports. *Med Care* 1997; 35: 932–47 [PubMed: 9298082]
38. Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition—multimorbidity. *JAMA* 2012; 307: 2493–4 [PubMed: 22797447]

Fig. 1. Variable importance from two-step cluster analysis. CHF, congestive heart failure; CHD, coronary heart disease.

Fig. 2.

Prevalence of chronic diseases across and within individual clusters. **(A)** Prevalence of chronic diseases across all four clusters. **(B)** Prevalence of chronic diseases within the cardiovascular disease (CVD) risk-younger cluster. **(C)** Prevalence of chronic diseases within the asthma-predominate cluster. **(D)** Prevalence of chronic diseases within the CVD risk-older cluster. **(E)** Prevalence of chronic diseases within the multiple chronic conditions cluster. CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; HTN, hypertension.

Fig. 3.
Urinary incontinence subtypes by disease clusters. CVD, cardiovascular disease.

Fig. 4.
Urinary incontinence (UI) severity by chronic disease cluster.

Table 1

Basic demographic and clinical characteristics of US women with urinary incontinence.

Variables	All*	Chronic disease cluster					P
		No chronic diseases	1 CVD risk-younger [†]	2 Asthma-predominant	3 CVD risk-older [‡]	4 MCC	
Sample size	3 800	417	317	827	730	1 509	
Age, years, mean ± SD	54.8 ± 16.3	39.4 ± 12.1	46.7 ± 15.8	51.5 ± 10.2	57.9 ± 13.4	61.0 ± 14.8	<0.001
Weight, kg, mean ± SD	78.4 ± 22.8	72.7 ± 19.6	74.1 ± 22.4	77.9 ± 21.9	77.6 ± 18.8	81.7 ± 25.3	<0.001
BMI, kg/m ² , mean ± SD	30.4 ± 8.3	27.8 ± 6.9	28.2 ± 8.4	30.3 ± 8.1	30.2 ± 6.5	31.7 ± 9.3	<0.001
Race/ethnicity, %							
Non-Hispanic white	53.3	46.0	50.0	49.3	50.7	57.9	<0.001
Non-Hispanic black	17.7	13.8	12.9	19.1	16.2	19.1	
Mexican-American	15.8	24.0	15.1	19.2	.8	10.9	
Other Hispanic and other race	13.2	14.1	13.9	12.3	15.3	12.1	
No medical insurance, %	18.4	25.2	21.5	25.3	14.0	14.2	<0.001
Education, %							
<9th grade	11.1	7.4	7.3	12.0	12.1	11.9	<0.001
9th-11th grade	15.8	10.1	9.8	15.8	12.0	20.4	
High school	23.0	18.0	20.6	23.5	24.8	23.7	
Some college	29.3	30.0	32.9	28.5	27.5	29.8	
College graduate	20.9	34.5	29.4	20.2	23.7	14.4	
Married, %	49.3	60.9	54.6	50.2	53.4	42.6	
Adiposity, %							
Normal	38.8	35.0	26.4	20.2	19.1		<0.001
Overweight	28.6	32.6	29.0	27.8	34.9	24.8	
Obese	47.0	28.5	36.0	45.8	44.9	56.1	
Had hysterectomy, %	32.4	9.3	20.3	24.3	33.2	44.3	0.001
Parity, %							
0	9.1	15.3	9.8	10.5	8.5	6.8	
1	9.6	12.7	12.3	8.3	9.7	8.8	0.001
2	20.7	22.8	25.9	21.5	20.4	18.6	0.001
3	22.0	23.5	20.2	23.0	22.7	21.0	0.001

Variables	Chronic disease cluster					P
	All [*]	No chronic diseases	1 CVD risk-younger [†]	2 Asthma-predominant	3 CVD risk-older [‡]	4 MCC
4+	38.6	25.7	31.9	36.6	38.6	44.7
						0.001

CVD, cardiovascular disease; MCC, multiple chronic conditions.

^{*}All women with at least one chronic disease.

[†]CVD risk factors were predominant within these clusters.

[‡]for CVD risk factors were predominant within these clusters.

Table 2

Association between chronic disease cluster and type or severity of urinary incontinence.

Cluster	Model 1: UI subtypes				Model 2: UI severity		
	UUI OR (95% CI)	SUI OR (95% CI)	MUI OR (95% CI)	Other UI OR (95% CI)	Mild OR (95% CI)	Moderate OR (95% CI)	Severe* OR (95% CI)
No chronic diseases	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
CVD risk-younger	1.87 (1.25–2.79)	1.16 (0.73–1.71)	0.42 (0.28–1.29)	1.51 (0.96–2.36)	2.23 (2.16–3.75)	1.23 (0.86–1.75)	1.75 (0.84–3.60)
Asthma predominant	1.30 (0.98–1.72)	1.27 (0.96–1.70)	0.90 (0.71–1.13)	1.32 (0.92–1.89)	2.27 (1.86–2.75)	1.18 (0.88–1.58)	2.00 (1.07–3.74)
CVD risk-older	1.78 (1.34–2.38)	1.46 (1.08–1.97)	0.66 (0.54–1.81)	1.56 (1.05–2.32)	1.45 (1.20–3.71)	1.49 (2.02–1.75)	1.93 (1.02–3.66)
MCC	1.72 (1.30–2.78)	1.88 (1.40–2.53)	1.72 (1.25–2.40)	2.10 (1.43–3.07)	1.11 (1.03–1.73)	1.90 (1.42–2.54)	3.19 (1.72–5.89)

CVD, cardiovascular disease; MCC, multiple chronic conditions; MUI, mixed stress and urgency urinary incontinence; OR, odds ratio; SUI, stress urinary incontinence; UUI, urgency urinary incontinence. OR from logistic regression analysis (adjusted for age, education, race/ethnicity, adiposity, parity and hysterectomy; reference = women with UI with no chronic diseases).

* Severe and very severe.