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Multimorbidity is associated with uptake of influenza vaccination

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Abstract

Objective: Patients with chronic conditions have higher rates of severe influenza-related illness and mortality. However, influenza vaccination coverage in high-risk populations continues to be suboptimal. We describe the association between cumulative disease morbidity, measured by a previously validated multimorbidity index, and influenza vaccination among community-dwelling adults.

Methods: We obtained interview and medical record data for participants ≥18 years who sought outpatient care for influenza-like illness between 2011 and 2016 as part of an outpatient-based study of influenza vaccine effectiveness. We defined cumulative disease morbidity by using medical diagnosis codes to calculate a multimorbidity-weighted index (MWI) for each participant. MWI and influenza vaccination status was evaluated by logistic regression. Akaike information criterion was calculated for all models.

Results: Overall, 1458 (48%) of participants out of a total of 3033 received influenza vaccination. The median MWI was 0.9 (IQR 0.00–3.5) and was higher among vaccinated participants (median 1.6 versus 0.0; $p < 0.001$). We found a positive linear association between MWI and vaccination, and vaccination percentages were compared between categories of MWI. Compared to patients with no multimorbidity (MWI = 0), odds of vaccination were 17% higher in the second category (MWI 0.01–1.50; [OR: 1.17, 95% CI: 0.92–1.50]), 58% higher in the third category (MWI 1.51–3.00; [OR: 1.58, 95% CI: 1.26–1.99]), 130% higher in the fourth category (MWI 3.01–6.00; [OR: 2.30, 95% CI: 1.78–2.98]) and 214% higher in the fifth category (MWI 6.01–45.00; [OR: 3.14, 95% CI: 2.41–4.10]). Participants defined as high-risk had 86% greater odds of being vaccinated than non-high-risk individuals (OR: 1.86, 95% CI: 1.56–2.21). The AIC was lowest for MWI compared with high-risk conditions.

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Conflicts of interest

None reported, all authors.

All authors attest they meet the ICMJE criteria for authorship.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.vaccine.2018.05.021.

Conclusions: Our results suggest a dose response relationship between level of multimorbidity and likelihood of influenza vaccination. Compared with high-risk condition designations, MWI provided improved precision and a better model fit for the measurement of chronic disease and influenza vaccination.

Keywords

Multimorbidity; Chronic disease; Vaccination; Influenza

1. Introduction

Rates of severe influenza-related illness and mortality among those with chronic diseases, such as asthma and heart disease, are high compared to those with no underlying conditions [1]. In the 2014–2015 influenza season, 97% of patients hospitalized with laboratory-confirmed influenza suffered from at least one high-risk medical condition [2]. Between 2005 and 2008, adults with illnesses such as chronic lung disease, cardiovascular disease, and immunosuppression were both more likely to be hospitalized with influenza-related pneumonia and to experience ICU admission, mechanical ventilation, and death [3]. Despite this established morbidity, influenza vaccine coverage among U.S. adults with high-risk chronic medical conditions continues to be suboptimal [1,4–7]. Although vaccination is prioritized in this group and recommended as the primary defense against influenza illness [1], over 50% remained unvaccinated as of the 2015–2016 season [4]. To reduce the burden of influenza-related complications and death, increased vaccine coverage among high-risk individuals is necessary [1,8].

Imprecise characterization of influenza high-risk status has limited clarification of its relationship with influenza vaccination. Individual high-risk status, based on diagnosis with any single high-risk condition as recommended by the Advisory Committee on Immunization Practices (ACIP) [1,4,9], has previously been used to assess the relationship between underlying conditions and vaccine uptake or effectiveness [10–12]. However, this classification method does not account for individual variation in number, type, or severity of chronic diseases. For example, Lu et al. found a 10% increase in influenza vaccine coverage for those with two or more high-risk conditions when compared to those with one or more high-risk conditions [5].

Multimorbidity, the presence of multiple medical conditions in a single individual, is increasingly common in developed countries [5,13,14]. Estimates for burden of multimorbidity in the U.S. adult population vary by definition and disease classification method [15–19], but prevalence is between 25 and 45% when most commonly defined as ≥2 conditions in the same patient [5,13,14]. The cumulative effect of multiple diseases is associated with worse clinical outcomes than those resulting from one condition alone [20].

Wei et al. developed and validated a multimorbidity-weighted index (MWI) appropriate for disease severity and burden assessment in U.S. ambulatory adult populations [21,22]. Unlike prior indices weighted to outcomes such as mortality, healthcare cost or utilization, MWI weights diseases to concurrent physical functioning, a patient-centered outcome of value to communitydwelling adults. MWI has a convenient twofold interpretation: each unit provides

an estimate of both an individual's cumulative disease burden and associated decline in physical functioning. Compared to the ACIP definition of high-risk, MWI may offer improved precision for identification of clinical subgroups at greatest risk for influenza-associated complications arising from low vaccination rates. We used MWI to measure the number and severity of medical conditions among participants enrolled in an outpatient-based study of influenza vaccine effectiveness over five influenza seasons from 2011 to 2016. The association between MWI and influenza vaccination was estimated and compared to the association between ACIP-defined influenza high-risk status and vaccination uptake.

2. Methods

2.1. Study population

The study population included adults enrolled in case-test negative study conducted in southeast Michigan at participating University of Michigan Health System and Henry Ford Health System outpatient clinics in partnership with the U.S. Influenza Vaccine Effectiveness Network [12,23–27]. For influenza seasons between 2011 and 2016, patients ≥6 months old seeking medical care at a participating ambulatory care clinic for an acute respiratory illness of ≤7 days duration including cough were eligible for study inclusion. Study staff obtained informed consent, completed an enrollment interview, and collected nasal and oropharyngeal swabs for laboratory confirmation of influenza by reverse transcription-PCR. Clinical characteristics including medical conditions were extracted from the electronic medical record. Institutional Review Board approval was obtained prior to the initiation of all patient recruitment and data collection activities.

2.2. Multimorbidity and high risk measurement and assessment

MWI was evaluated both as a continuous measure and as a categorical measure. MWI was categorized as participants who scored zero (no multimorbidity) and approximate quartiles of those with non-zero MWI (0.01–1.50, 1.51–3.00, 3.01–6.00, 6.01–45.00). Alternate strategies for categorization (deciles) had no effect on overall results. The MWI contains regression coefficients approximating typical influence of each of 81 chronic diseases on physical health-related quality of life, with a range from 0 to 100 (lowest to highest) Short Form-36 physical functioning units. MWI is calculated by summing the regression coefficients corresponding to all diagnoses for a given individual and is described in detail by Wei et al. [22]. We also categorized patients as high-risk or not based on presence of 1 or more conditions defined by the ACIP as increasing the risk of complicated influenza illness [28].

We used International Classification of Diseases, 9th edition, Clinical Modification (ICD-9) diagnosis codes associated with health care encounters in the year prior to the start of each year's vaccination season (September 1st through August 31st) to identify diseases included in the MWI as well as ACIP-defined high-risk conditions.

2.3. Influenza vaccination status and assessment

We assessed documented influenza vaccination as the primary outcome. Vaccination status was determined by medical record review, and review of state registry records.

2.4. Covariate measurement and assessment

We included age, sex, socioeconomic status, race, smoking status, study year and health system as covariates in our analysis due to potential confounding effects. Age in years and sex (male or female) were determined by medical record review. Measures of socioeconomic status varied across study years. In the 2011–2012 and 2012–2013 study years, subjects reported subjective social status on a scale from 1 (lowest) to 9 (highest), as described by Singh-Manoux et al. [29]; from the 2013–2014 through 20152016 study years subjects reported highest level of education achieved. These 2 measures were dichotomized (subjective social status >5 in years 2011–2013; bachelor's degree or higher in years 2013–2016) to create a consistent, binary approximation of socioeconomic status across all study years. Self-reported race was categorized as white, black, Asian, or other. Self-reported ethnicity was categorized as Hispanic or non-Hispanic. Self-reported smoking status was defined as a categorical variable indicating whether the participant was a current smoker (every day or some days) or non-smoker.

2.5. Statistical analysis

We conducted logistic regression analysis of unadjusted and adjusted associations between MWI and influenza vaccination, along with unadjusted and adjusted associations between ACIP-defined high-risk status and influenza vaccination for comparison. Fully adjusted models included MWI or ACIP high-risk status as predictors of vaccination as well as the following variables hypothesized *a priori* to be associated with vaccination and multimorbidity: age, sex, ethnicity, race, socioeconomic status, smoking status, health system, and influenza season. The Akaike information criterion (AIC) model fit statistic was used to select the optimal form of each variable and to assess fit of final models. Associations were assessed using odds ratios and 95% confidence intervals. All analyses were completed using SAS 9.4 (SAS Institute, Cary, NC, 2013).

3. Results

We obtained interview and medical record data for the 3168 patients ≥18 years old enrolled in the vaccine effectiveness study between 2011 and 2016. A total of 3033 participants were included in the analysis (Table 1); 135 participants were excluded due to missing values of important variables. The number of enrolled subjects ranged from 497 in 2011–2012 to 845 in the 2014–2015 influenza season. MWI was right-skewed and ranged from 0.00 to 45.00 in the entire study population. About one-third of participants met the ACIP definition for high-risk status, and 48% of all participants received an influenza vaccine for the season in which they were enrolled.

Vaccinated participants were significantly more likely to be older, female, and non-smoking (Table 1). Vaccination coverage also differed significantly by health system in which care was received, and by influenza season increasing over the five years of the study. We found a monotonic increasing trend in the proportion of vaccinated participants with increasing MWI (Table 1). The proportion of participants defined as high-risk also increased with increasing MWI, from 4% among those with an MWI of zero and 90% among the highest

MWI category. Consistent with this trend, a higher proportion of high-risk participants were vaccinated compared to those who were not high risk (Fig. 1).

3.1. Multimorbidity and vaccination status

We evaluated unadjusted and adjusted models containing either continuous MWI or MWI category as the primary predictor of interest. Odds of influenza vaccination increased by 11% per point increase in continuous MWI (OR: 1.11, 95% CI: 1.09–1.13) in an unadjusted model (Table 2). In the adjusted model, odds of vaccination increased by 8% per point increase in MWI (OR: 1.08, 95% CI: 1.06–1.10), controlling for sex, race, ethnicity, socioeconomic status, smoking status, health system and influenza season. Results were similar when using MWI category as the predictor for influenza vaccination. Compared to patients with no multimorbidity (MWI = 0), odds of vaccination were estimated in an unadjusted model to be 50% higher in the second category (MWI 0.01–1.50; [OR: 1.50, 95% CI: 1.19–1.89]), 85% higher in the third category (MWI 1.51–3.00; [OR: 1.85, 95% CI: 1.50–2.27]), 177% higher in the fourth category (MWI 3.01–6.00; [OR: 2.77, 95% CI: 2.19–3.50]), and 348% higher in the fifth category (MWI 6.01–45.00; [OR: 4.48, 95% CI: 3.56–5.65]). In the adjusted model, odds of vaccination were higher in the second category relative to those with no multimorbidity but were no longer statistically significant; estimates for the third through fifth categories were similar to those from the unadjusted model (Table 3). A sensitivity analysis of intermediate models including control for only age, sex, health system, and influenza season resulted in similar final estimates.

For comparison to existing measures, we examined ACIP high-risk status as a predictor of vaccination in adjusted and unadjusted models. The odds of vaccination among those with ACIP high-risk status were over double the odds of vaccination among those without ACIP high-risk status in unadjusted models (OR: 2.50, 95% CI: 2.14–2.91) (Table 2). In adjusted models, this estimated effect was somewhat attenuated (OR: 1.86, 95% CI: 1.56–2.21) (Table 3). Both continuous and categorical MWI were statistically significant and provided more granular prediction of vaccination status than ACIP high-risk status. Further, the AIC model fit was superior for MWI examined both categorically (AIC = 3754) and continuously (AIC = 3777), compared with ACIP high-risk status (AIC = 3790).

4. Discussion

This study was the first to evaluate the association between a newly developed and validated MWI and influenza vaccination. MWI significantly predicted influenza vaccination status among adult ambulatory patients seeking medical care for respiratory illness in a linear way; vaccination increased with a dose-response association as multimorbidity increased. ACIP high-risk status also significantly predicted influenza vaccination status but with less precision and a worse model fit than MWI. Our results suggest that, among individuals with underlying conditions, greater cumulative morbidity is associated with increased vaccine uptake. This observed relationship may be a result of increased contacts with the healthcare system, leading to increased opportunities for vaccination. Our results may also reflect provider practice in encouraging vaccination among those patients with chronic conditions.

Nonetheless, the overall vaccination rate of 71% among individuals with even the highest level of multimorbidity remained far short of recommended levels.

Further exploration is needed to determine whether the dose-response relationship between MWI and influenza vaccination could provide valuable insight into new methods for increasing the continued low vaccination coverage in chronic disease populations. In our study population, MWI allowed us to define a continuous gradient of risk for low vaccination coverage. This was in contrast to the ACIP high-risk classification, which only allowed binary distinction between high-risk and not. Further, we report superior model fit when MWI was used as the predictor variable for vaccination, as opposed to high-risk ACIP. The additional precision in risk measurement and model fit afforded by MWI in our study suggests it may be useful in studies of vaccine effectiveness or in generating hypotheses for future research to elucidate drivers of influenza vaccination and therefore how to best target those populations for interventions.

Our results suggest that MWI is a better predictor of influenza vaccination status than the ACIP high-risk classification. Patients without multimorbidity or a low level of multimorbidity may be most at risk for low vaccination coverage, while groups with higher multimorbidity have comparatively high vaccination coverage. Further emphasizing influenza vaccination to patients with a low to moderate multimorbidity may be an important intervention to reduce the burden of morbidity and mortality resulting from influenza. Future studies may examine whether increased influenza vaccination coverage among participants with high multimorbidity resulted specifically from perceived susceptibility to influenza due to multimorbidity or whether the effect of multimorbidity was a proxy for frequency of interaction with the health system.

4.1. Strengths and Limitations

Strengths of this study include a large sample size with patient-level data gathered over five consecutive influenza seasons. Additionally, we mapped medical diagnosis codes to diseases in the index in order for each participant’s MWI to be calculated using the medical record. This application of the MWI allowed us to characterize the relationship between multimorbidity and vaccination patterns overall and by key factors including age and high risk group. We were unable to evaluate the impact of insurance coverage on vaccination rates by multimobidity, due to the low number of uninsured participants in our study. Participants were recruited during medical visits for acute respiratory illness at ambulatory clinics in two major health systems primarily serving insured populations. Findings in prior studies suggest that patients with insurance tend to have lower or no multimorbidity, while those without insurance tend to have a higher disease burden [30]. Multimorbidity also tends to be more prevalent among those with lower socioeconomic status [31]. Insurance status also may not indicate adequate coverage for health care, in which case income may be the next best alternative for approximating access to medical care. We did not specifically measure income in our analysis, however we did not detect any association between MWI and alternate measures of socioeconomic status measured in our study. We note that our study population was limited to the southeast Michigan region and may not be generalizable to other states or countries. However, our study does benefit from five years of data

collection, and the inclusion of 15 outpatient clinics from 5 counties across two separate health systems. Future research involving a larger annual sample size would help further elucidate the relationship between multimorbidity and influenza vaccination and outcomes.

5. Conclusions

The validated MWI is an improvement over currently used approximations of health status which will benefit future evaluations of vaccine uptake and effectiveness.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

[1]. Smith NM, Bresee JS, Shay DK, Uyeki TM, Cox NJ, Strikas RA. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep Morb Mortal Wkly Rep Recomm Rep 2006;55:1–42.

[2]. Petrie JG, Ohmit SE, Cheng CK, Martin ET, Malosh RE, Lauring AS, et al. Influenza vaccine effectiveness against antigenically drifted influenza higher than expected in hospitalized adults: 2014–2015. Clin Infect Dis Off Publ Infect Dis Soc Am 2016;63:1017–25. https://doi.org/10.1093/cid/ciw432.

[3]. Garg S, Jain S, Dawood FS, Jhung M, Pérez A, D'Mello T, et al. Pneumonia among adults hospitalized with laboratory-confirmed seasonal influenza virus infection—United States, 2005–2008. BMC Infect Dis 2015;15 10.1186/s12879-015-1004-y. [PubMed: 25583097]

[4]. Grohskopf LA, Sokolow LZ, Broder KR, Olsen SJ, Karron RA, Jernigan DB, et al. Prevention and control of seasonal influenza with vaccines: recommendations of the advisory Committee on Immunization Practices — United States, 2016–17 Influenza Season. MMWR Recomm Rep 2016;65:1–54. https://doi.org/10.15585/mmwr.rr6505a1.

[5]. Lu P, O'Halloran A, Ding H, Srivastav A, Williams WW. Uptake of influenza vaccination and missed opportunities among adults with high-risk conditions, United States, 2013. Am J Med 2016;129:636.e1–636.e11. 10.1016/j.amjmed.2015.10.031.

[6]. Santaularia J, Hou W, Perveen G, Welsh E, Faseru B. Prevalence of influenza vaccination and its association with health conditions and risk factors among Kansas adults in 2013: a cross-sectional study. BMC Public Health 2016;16 10.1186/s12889-016-2884-5. [PubMed: 26733382]

[7]. Surveillance of Influenza Vaccination Coverage — United States, 2007–08 Through 2011–12 Influenza Seasons; 2013.

[8]. Prevention and Control of Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010; 2010.

[9]. Nichol KL, Mac Donald R, Hauge M. Factors associated with influenza and pneumococcal vaccination behavior among high-risk adults. J Gen Intern Med 1996;11:673–7. https://doi.org/10.1007/BF02600158. [PubMed: 9120653]

[10]. Hak E, Nordin J, Wei F, Mullooly J, Poblete S, Strikas R, et al. Influence of high-risk medical conditions on the effectiveness of influenza vaccination among elderly members of 3 large managed-care organizations. Clin Infect Dis Off Publ Infect Dis Soc Am 2002;35:370–7. https://doi.org/10.1086/341403.

[11]. Raviotta JM, Smith KJ, DePasse J, Brown ST, Shim E, Nowalk MP, et al. Cost-effectiveness and public health impact of alternative influenza vaccination strategies in high-risk adults. Vaccine 2017;35:5708–13. https://doi.org/10.1016/j.vaccine.2017.07.069. [PubMed: 28890196]

[12]. Jackson ML, Chung JR, Jackson LA, Phillips CH, Benoit J, Monto AS, et al. Influenza vaccine effectiveness in the United States during the 2015–2016 season.NEngl J Med 2017;377:534–43. https://doi.org/10.1056/NEJMoa1700153.

[13]. Parekh AK. The challenge of multiple comorbidity for the US Health Care system. JAMA 2010;303:1303 https://doi.org/10.1001/jama.2010.381. [PubMed: 20371790]

[14]. Ward BW, Schiller JS, Goodman RA. Multiple chronic conditions among US adults: a 2012 Update. Prev Chronic Dis 2014;11 10.5888/pcd11.130389.

[15]. Fortin M, Stewart M, Poitras M- E, Almirall J, Maddocks H. A systematic review of prevalence studies on multimorbidity: toward a more uniform methodology. Ann Fam Med 2012;10:142–51. https://doi.org/10.1370/afm.1337. [PubMed: 22412006]

[16]. Goodman RA, Posner SF, Huang ES, Parekh AK, Koh HK. Defining and measuring chronic conditions: imperatives for research, policy, program, and practice. Prev Chronic Dis 2013;10 10.5888/pcd10.120239.

[17]. Harrison C, Britt H, Miller G, Henderson J. Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice. BMJ Open 2014;4 https://doi.org/10.1136/bmjopen-2013-004694. e004694–e004694.

[18]. Le Reste JY, Nabbe P, Manceau B, Lygidakis C, Doerr C, Lingner H, et al. The European general practice research network presents a comprehensive definition of multimorbidity in family medicine and long term care, following a systematic review of relevant literature. J Am Med Dir Assoc 2013;14:319–25. https://doi.org/10.1016/j.jamda.2013.01.001. [PubMed: 23411065]

[19]. Ornstein SM, Nietert PJ, Jenkins RG, Litvin CB. The prevalence of chronic diseases and multimorbidity in primary care practice: apprnet report. J Am Board Fam Med 2013;26:518–24. https://doi.org/10.3122/jabfm.2013.05.130012. [PubMed: 24004703]

[20]. Brettschneider C, Leicht H, Bickel H, Dahlhaus A, Fuchs A, Gensichen J, et al. Relative impact of multimorbid chronic conditions on health-related quality of life – results from the multicare cohort study. PLoS ONE 2013;8:e66742 https://doi.org/10.1371/journal.pone.0066742. [PubMed: 23826124]

[21]. Wei MY, Kabeto MU, Langa KM, Mukamal KJ. Multimorbidity and physical and cognitive function: performance of a new multimorbidity-weighted index. J Gerontol Ser A 2017 https://doi.org/10.1093/gerona/glx114.

[22]. Wei MY, Kawachi I, Okereke OI, Mukamal KJ. Diverse cumulative impact of chronic diseases on physical health-related quality of life: implications for a measure of multimorbidity. Am J Epidemiol 2016;184:357–65. https://doi.org/10.1093/aje/kwv456. [PubMed: 27530335]

[23]. Zimmerman RK, Nowalk MP, Chung J, Jackson ML, Jackson LA, Petrie JG, et al. 2014–2015 Influenza vaccine effectiveness in the United States by vaccine type. Clin Infect Dis Off Publ Infect Dis Soc Am 2016;63:1564–73. https://doi.org/10.1093/cid/ciw635.

[24]. Gaglani M, Pruszynski J, Murthy K, Clipper L, Robertson A, Reis M, et al. Influenza vaccine effectiveness against 2009 Pandemic Influenza A(H1N1) virus differed by vaccine type during 2013–2014 in the United States. J Infect Dis 2016;213:1546–56. https://doi.org/10.1093/infdis/jiv577. [PubMed: 26743842]

[25]. Flannery B, Zimmerman RK, Gubareva LV, Garten RJ, Chung JR, Nowalk MP, et al. Enhanced genetic characterization of Influenza A(H3N2) viruses and vaccine effectiveness by genetic group, 2014–2015. J Infect Dis 2016;214:1010–9. https://doi.org/10.1093/infdis/jiw181. [PubMed: 27190176]

[26]. McLean HQ, Thompson MG, Sundaram ME, Kieke BA, Gaglani M, Murthy K, et al. Influenza vaccine effectiveness in the United States during 2012–2013: variable protection by age and virus type. J Infect Dis 2015;211:1529–40. https://doi.org/10.1093/infdis/jiu647. [PubMed: 25406334]

[27]. Ohmit SE, Thompson MG, Petrie JG, Thaker SN, Jackson ML, Belongia EA, et al. Influenza vaccine effectiveness in the 2011–2012 season: protection against each circulating virus and the effect of prior vaccination on estimates. Clin Infect Dis Off Publ Infect Dis Soc Am 2014;58:319–27. https://doi.org/10.1093/cid/cit736.

[28]. Grohskopf LA, Sokolow LZ, Olsen SJ, Bresee JS, Broder KR, Karron RA. Prevention and control of influenza with vaccines: recommendations of the advisory committee on immunization practices, United States, 2015–16 Influenza Season. MMWR Morb Mortal Wkly Rep 2015;64:818–25. [PubMed: 26247435]

[29]. Singh-Manoux A, Adler NE, Marmot MG. Subjective social status: its determinants and its association with measures of ill-health in the Whitehall II study. Soc Sci Med 2003;56:1321–33. https://doi.org/10.1016/S0277-9536(02)00131-4. [PubMed: 12600368]

[30]. Robbins AS, Pavluck AL, Fedewa SA, Chen AY, Ward EM. Insurance status, comorbidity level, and survival among colorectal cancer patients age 18 to 64 years in the National Cancer Data Base From 2003 to 2005. J Clin Oncol 2009;27:3627–33. https://doi.org/10.1200/JCO.2008.20.8025. [PubMed: 19470927]

[31]. Staimez LR, Wei MY, Kim M, Narayan KMV, Saydah SH. Multimorbidity of four cardiometabolic and chronic pulmonary disease groups: prevalence and attributable fraction in US adults, 2007–2012. J Comorb 2017;7:22–32. https://doi.org/10.15256/joc.2017.7.89. [PubMed: 29090186]

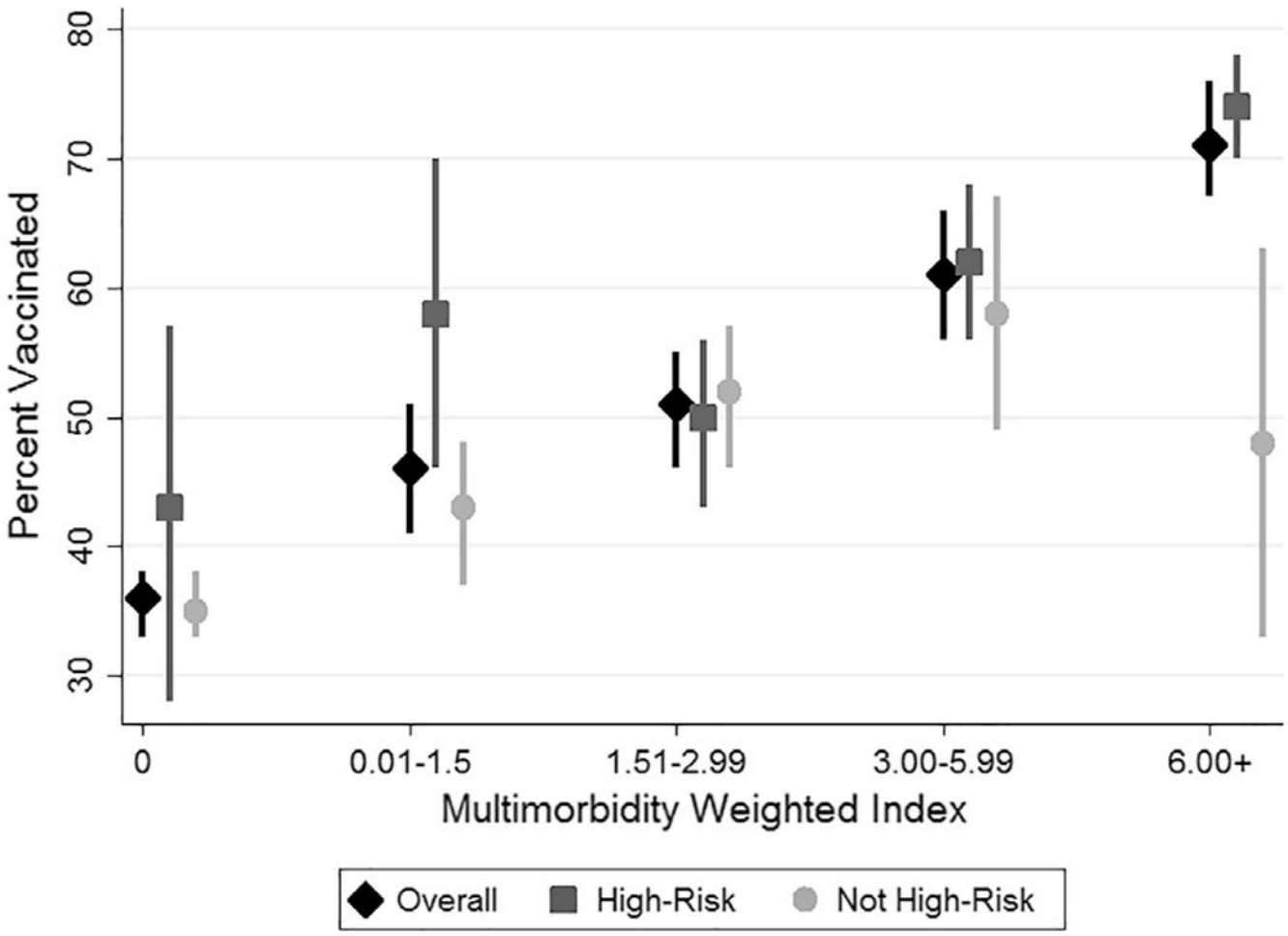

Fig. 1.

Percent with influenza vaccination by MWI category, overall and by high risk status.

Markers indicate percent vaccinated in a specified MWI category overall (black) and by high risk status (gray). Lines indicate exact confidence interval.

Table 1

Covariates by influenza vaccination status among study participants ≥18 years old, 2011–2016.

Participant characteristic	All	Vaccinated	Unvaccinated	P-value
Total, n (%)	3033 (100.0)	1458 (48.1)	1575 (51.9)	
MWI, median (IQR)	0.9 (0.0–3.5)	1.6 (0.0–5.5)	0.0 (0.0–1.8)	<.001[a]
MWI category, n (%)				<.001[b]
0.00–0.00	1300 (42.9)	465 (35.8)	835 (64.2)	
0.01–1.50	382 (12.6)	174 (45.5)	208 (54.5)	
1.51–3.00	505 (16.7)	256 (50.7)	249 (49.3)	
3.01–6.00	381 (12.6)	231 (60.6)	150 (39.4)	
6.01–45.00	465 (15.3)	332 (71.4)	133 (28.6)	
ACIP high-risk, n (%)				<.001[b]
No	2008 (66.2)	813 (40.5)	1195 (59.5)	
Yes	1025 (33.8)	645 (62.9)	380 (37.1)	
Age, median (IQR)	48.3 (36.5–59.9)	53.1 (40.2–64.3)	44.0 (33.0–55.3)	<.001[a]
Age quartile, n (%)				<.001[b]
Q1, 18–35	739 (24.4)	256 (34.6)	483 (65.4)	
Q2, 36–47	758 (25.0)	306 (40.4)	452 (59.6)	
Q3, 48–59	783 (25.8)	399 (51.0)	384 (49.0)	
Q4, 60–98	753 (24.8)	497 (66.0)	256 (34.0)	
Sex, n (%)				0.002[b]
Female	1632 (53.8)	828 (50.7)	804 (49.3)	
Male	1401 (46.2)	630 (45.0)	771 (55.0)	
Hispanic, n (%)				0.16[b]
No	2878 (94.9)	1392 (48.4)	1486 (51.6)	
Yes	155 (5.1)	66 (42.6)	89 (57.4)	
Race, n (%)				<.001[b]
White	2069 (68.2)	1083 (52.3)	986 (47.7)	
Black	583 (19.2)	208 (35.7)	375 (64.3)	

Table 2

Unadjusted Model Estimates.

	OR (95% Confidence Interval)
MWI, continuous	1.11 (1.09, 1.13)
MWI category, n (%)	
0.00–0.00	Ref
0.01–1.50	1.50 (1.19, 1.89)
1.51–3.00	1.85 (1.50, 2.27)
3.01–6.00	2.77 (2.19, 3.50)
6.01–45.00	4.48 (3.56, 5.65)
ACIP High-Risk	2.50 (2.14, 2.91)

Table 3

Adjusted[a] model estimates.

7	Odds ratio (95% confidence interval)		
	MWI, continuous	**MWI, category**	**ACIP high-risk**
MWI, continuous	1.08 (1.06, 1.10)		
MWI, category			
0.00–0.00		Ref	
0.01–1.50		1.17 (0.92, 1.50)	
1.51–3.00		1.58 (1.26, 1.99)	
3.01–6.00		2.30 (1.78, 2.98)	
6.01–45.00		3.14 (2.41, 4.10)	
ACIP high risk			1.86 (1.56, 2.21)
Health system			
Henry Ford	Ref	Ref	Ref
Univ. of Michigan	2.55 (2.13, 3.06)	2.60 (2.17, 3.11)	2.51 (2.10, 3.01)
Influenza Season			
2011–2012	Ref	Ref	Ref
2012–2013	1.15 (0.89, 1.49)	1.15 (0.88, 1.49)	1.18 (0.91, 1.52)
2013–2014	1.35 (1.02, 1.78)	1.33 (1.01, 1.76)	1.33 (1.01, 1.75)
2014–2015	1.38 (1.07, 1.77)	1.34 (1.04, 1.73)	1.37 (1.06, 1.76)
2015–2016	1.48 (1.12, 1.95)	1.48 (1.12, 1.95)	1.50 (1.14, 1.97)

[a]Adjusted models also control for age, sex, race, ethnicity, socioeconomic status, and smoking status.