

Prevalence of Multiple Chronic Conditions Among Adults in the All of Us Research Program: An Exploratory Analysis

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Prevalence of Multiple Chronic Conditions Among Adults in the All of Us Research Program: An Exploratory Analysis

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Abstract

Background: Estimation of multiple chronic condition (MCC) prevalence throughout adulthood provides a critical reflection of MCC burden.

Objective: We analyzed electronic health record codes for 58 conditions to estimate MCC prevalence for All of Us (AoU) Research Program adult participants (N=242,828).

Methods: We conducted a cross-sectional analysis to estimate the number of participants with MCC using the version 7 Controlled Tier AoU Research Program data release. Data analysis was conducted using Python within the Researcher Workbench. Descriptive statistics included condition frequencies and participants' age distributions aligned with age and diagnosis dates.

Results: Approximately 76% of AoU participants were diagnosed with MCCs, with over 40% having 6 or more conditions and prevalence increasing with age; the most frequently occurring MCC combinations varied by age category (i.e., mental health conditions in early adulthood and physical health conditions in middle adulthood through advanced old age).

Conclusions: We report notable prevalence of MCC throughout adulthood and variability in MCC condition combinations by age category in AoU participants. These findings highlight the need for targeted, innovative care modalities and population health initiatives to address MCC burden throughout adulthood. Clinical Trial: N/A

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Original Manuscript

Title: Prevalence of Multiple Chronic Conditions Among Adults in the All of Us Research Program: An Exploratory Analysis

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Abstract

Background: The growing prevalence of multiple chronic conditions (MCC) has significant impacts on the healthcare systems and quality of life. Understanding the MCC prevalence throughout

adulthood offers valuable insights into the evolving burden of chronic diseases and provides strategies for more effective healthcare outcomes.

Objective: This study estimated the prevalence and combinations of multiple chronic conditions among adult participants enrolled in the *All of Us* Research Program, especially studying the variations across age categories.

Methods: We conducted an exploratory analysis using electronic health record (EHR) data from adult participants (N=242,828) in the version 7 Controlled Tier *All of Us* Research Program data release. Data analysis was conducted using Python in a Jupyter notebook environment within the *All of Us* Researcher Workbench. Descriptive statistics included condition frequencies, the number of chronic conditions per participant, and prevalence according to age categories. The presence of a chronic condition was determined by documentation of one or more ICD-10 codes for the respective condition. Age categories were established and aligned with diagnosis dates and stages of adulthood (early adulthood: 18-39 years; middle adulthood: 40-49 years; late middle adulthood: 50-64 years, late adulthood: 65-74 years; advanced old age: 75-89 years).

Results: Our findings demonstrated that approximately 76% (n=183,753) of *All of Us* participants were diagnosed with MCCs, with over 40% (n=98,885) having 6 or more conditions and prevalence increasing with age (from 33.78% in early adulthood to 68.04% in advanced old age). The most frequently occurring MCC combinations varied by age category. Participants aged 18-39 primarily presented mental health-related MCC combinations (e.g., anxiety and depressive disorders; n=845), whereas those aged 40-64 frequently had physical conditions such as fibromyalgia, chronic pain, fatigue, and arthritis (n=204 in middle adulthood to n=457 in late middle adulthood). In late adulthood and advanced old age, hyperlipidemia and hypertension were most commonly occurring MCC combination (n=200 and n=59, respectively).

Conclusions: We report notable prevalence of MCC throughout adulthood and variability in MCC condition combinations by age category in *All of Us* participants. The significant prevalence of

MCCs underscores a considerable public health challenge, revealed by distinct condition combinations that shift across different life stages. Early adulthood is characterized predominantly by mental health conditions, transitioning to cardiometabolic and physical health conditions in middle, late, and advanced ages. These findings highlight the need for targeted, innovative care modalities and population health initiatives to address MCC burden throughout adulthood.

Key words:

Electronic health records; Multiple chronic conditions; Prevalence; Secondary data analysis

Introduction

Multimorbidity is an increasingly prevalent global health challenge characterized by diverse, co-occurring chronic diseases, differing across life stages, demographics, and socioeconomic factors, necessitating shifts in healthcare practice and outcomes [1]. Multiple chronic conditions (MCCs) is defined as the presence of two or more chronic conditions such as Alzheimer's disease, arthritis, asthma, cancer, chronic kidney disease, diabetes, heart failure, and hypertension [2]. Approximately 80% of adults 65 years of age and older in the United States (U.S.) are living with MCCs [3]. Older adults diagnosed with MCC often face significant care management challenges, including unplanned hospital readmissions and unmet care needs, which indicates the urgent need for enhanced support and tailored interventions for this vulnerable population [4]. Diagnosis with MCCs, however, is not limited to older adults. One study estimated that 22% of young adults, 18-34 years of age, are diagnosed with MCCs [5]. Moreover, research suggests that more contemporary generations of adults have greater MCC burden and are diagnosed with MCCs at earlier ages than previous generations [6]. Estimation of the prevalence of MCCs throughout all stages of adulthood is a critical reflection of MCC burden; it is important to examine the prevalence of MCCs broadly using regularly updated data sources to inform targeted prevention and management strategies as well as

resource prioritization. Thus, the purpose of this study is to estimate the prevalence of MCCs for adult participants in the National Institutes of Health *All of Us* (AoU) Research Program dataset – a curated disease and population-agnostic, longitudinal biomedical dataset of diverse individuals living in the U.S. – to gain a deeper understanding of MCCs throughout adulthood (i.e., early adulthood, middle adulthood, late-middle adulthood, late adulthood, and advanced old age).

Materials and Methods

Participants

We conducted an exploratory cross-sectional analysis using the AoU Controlled Tier version 7 data release in the secure, cloud-based AoU Researcher Workbench platform (date of first access for research purposes on 09/01/2023, date of last access on 06/16/2024). Registered researchers can access the data through the AoU Research Hub (researchallofus.org). This study was exempt from human subjects' approval as only deidentified data were analyzed.

Using the Cohort Builder tool, we identified all adult participants 18 years of age or older who consented to share electronic health record (EHR) data and had at least one International Classification of Diseases-10th Revision (ICD-10) code documented for any healthcare purpose (i.e., not limited to a chronic condition-related code) to ensure the availability of EHR data (N=242,828). For all participants meeting these eligibility criteria, we extracted relevant ICD-10 codes and the corresponding date of documentation for 58 chronic conditions (Supplementary Table 1) cataloged in the Centers for Medicare & Medicaid Services (CMS) Chronic Conditions Data Warehouse [7]. CMS supports a Chronic Conditions Data Warehouse (www2.ccwdata.org) that contains computable phenotypes for “common chronic conditions” plus “other chronic or potentially disabling conditions”, which include additional chronic health, mental health, and substance abuse conditions [8,9]. We operationalized the presense of a chronic condition as documentation of one or more ICD-10 codes for the respective condition (Supplemental Table 2). Due to reliance on ICD-10 codes for

both cohort identification and as the source of condition information, we limited participant visits to on or after October 1, 2015, i.e., initiation of ICD-10 implementation. Thus, data included in this analysis are from October 1, 2015, to July 1, 2022, i.e., latest date available in the version 7 release.

Data Analysis

We used the Python programming language in Jupyter Notebook to chronologically order the chronic condition ICD-10 codes by date of documentation for each participant. By distinguishing the onset date of the second unique chronic condition, we were able to identify participants with MCCs. We calculated the number of participants with 0, 1, 2, 3, 4, 5, and 6+ chronic conditions in the overall cohort and stratified by age category, i.e., early adulthood (18-39 years), middle adulthood (40-49 years), late-middle adulthood (50-64 years), late adulthood (65-74 years), and advanced old age (75-89 years) [10,11]. Age categorization supports methodological requirements of analyses, promotes interpretability of results for clinicians and policymakers, and helps capture changes in physical health and social roles throughout adulthood. We used the age at first documentation of the second chronic condition for categorization. We used chi-square tests to assess differences in demographic variables between participants with 0 or 1 chronic condition and participants with MCCs. This approach tested for differences in the frequencies of race, ethnicity, gender, marital status, education, health insurance status, and employment status. We used $P < .05$ to indicate statistical significance. Finally, we calculated the frequency of unique MCC condition combinations by chronic condition count (i.e., 2, 3, 4, 5, and 6+) and age category.

Ethical Considerations

This study analyzed de-identified data from participants enrolled in the *AoU* Research Program. Participants in the *AoU* Research Program were recruited either in-person at *AoU* enrollment sites or on the *AoU* online portal [12]. Participants gave informed consent when they joined the program, agreeing that their anonymized data could be used broadly for biomedical research [12]. Enrollment and data collection of participants in the *AoU* program is approved by the

AoU Institutional Review Board (IRB) [13].

We analyzed the EHR data in the secure, cloud-based AoU Researcher Workbench. All data used in this analysis was de-identified without personal identification including shifted dates for categorization of age. Researchers included in this analysis were registered within the AoU Research Program and the Researcher Workbench, completed the required training for data access, and signed the Data User Code of Conduct. All analyses were performed following AoU policies and guidelines to ensure confidentiality and responsible use of data [14]. Analyses for this study did not require subsequent IRB approval because the study does not constitute research involving human subjects according to the AoU Research Program IRB [12]. The data used in this analysis do not include the elements necessary to identify individuals so the study is not subject to the Common Rule protections 45 CFR part 46 [15].

Results

Participants Statistics

Approximately 76% (n=183,753) of participants were diagnosed with MCCs, with over 40% of participants (n=98,885) diagnosed with 6 or more conditions (Table 1). Of the remaining participants, 11% (n=27,122) were diagnosed with a single chronic condition, and 13% (n=31,953) did not have a chronic condition documented. Overall, participants (Table 2) were on average 49.8 (SD=16.7) years of age and primarily women (60.9%), White (54.6%), not Hispanic or Latino (77.3%), married/partnered (49.9%), highly educated (68.7% with some college or higher), insured (92.2%), and not currently employed (47.7%). Compared to participants diagnosed with 0 or 1 conditions, participants diagnosed with MCC were older (mean age of 52.8 years vs. 40.4 years). In addition, a higher percentage of participants with MCCs were men (37.4% vs. 33.8%), White (58.6% vs. 49.6%), not Hispanic/Latino (79.1% vs. 71.4%), insured (93.1% vs. 89.5%), ever married (75.7% vs. 66.4%), and not currently employed (52.3% vs. 33.5%), with a much greater frequency of retired participants (26.4% vs. 10.2%), compared to participants diagnosed with 0 or 1 conditions. The

percentage of participants within an age category diagnosed with 6 or more chronic conditions increases with age (Table 1), from 33.78% in early adulthood to 68.04% in advanced old age.

Conditions Across Age Distributions

The top five most frequently diagnosed MCC condition combinations in each age category are detailed in Supplementary Table 3. The most frequently occurring combination in each age categorization was as follows: early adulthood – anxiety disorders and depression, bipolar, or other depressive mood disorders (n=845); middle and late middle adulthood – fibromyalgia, chronic pain and fatigue and rheumatoid arthritis/osteoarthritis (n=204 and n=457, respectively); and late adulthood and advanced old age – hyperlipidemia and hypertension (n=200 and n=59, respectively).

Discussion

Principal Findings

In this study, we estimated MCC prevalence in adults living in the U.S. from early adulthood to advanced old age using ICD-10 codes from participants enrolled in *AoU*. We found that approximately 76% of participants have MCC, with higher prevalence as age increases. The most frequent MCC condition combinations varied notably by age category. Mental health conditions (i.e., anxiety disorders and depression, bipolar, or other depressive mood disorders) were most common in early adulthood, whereas combinations of physical health conditions (e.g., fibromyalgia, chronic pain, fatigue, arthritis, hyperlipidemia, and hypertension) predominated in middle and older adulthood. These findings emphasize the value of *AoU* in identification of MCC burden throughout adulthood. We believe the percentage of adults with MCCs in this study is higher than previous reports due to our robust inclusion of 58 chronic conditions, selected based on the CMS Chronic Conditions Data Warehouse.

Comparison with Prior Work

Our results highlight distinct patterns in MCC combinations that vary by age category. Given

the notable prevalence of MCCs across adulthood, there is a continued need for innovative care modalities and public health initiatives to address the multifaceted nature of MCC [16]. MCC are associated with clinical complexity characterized by increased symptom burden, high health care utilization and cost, and extensive caregiver strain [17]. The Agency for Healthcare Research and Quality states that care for people with MCC requires alignment between available resources, policies, and the workforce. For every dollar of healthcare spending in the U.S., 71 cents goes to treating individuals with MCC [3]. Subgroups at greater risk for MCC can benefit from early detection and prevention strategies, which may reduce hospital admissions and associated healthcare costs [3]. Ongoing research efforts that seek to both reduce the burden of MCCs on the healthcare system and the development of person- and family-centered care strategies across the healthcare continuum are needed [17]. Public health leaders should coordinate efforts with clinicians, administrators, and communities to support changes in care management and outcomes across the lifespan.

We found that the most frequent MCC condition combinations vary by age category. Notably, a combination of mental, rather than physical, health conditions (i.e., anxiety disorders and depression, bipolar, or other depressive mood disorders) was the most common MCC combination in early adulthood. Following early adulthood, combinations of physical health conditions were the most common (e.g., hyperlipidemia and hypertension in late adulthood and advanced old age). For precision health, characterizing MCC profiles and the most frequently co-occurring conditions in different age categories can inform targeted prevention and treatment approaches and allow clinicians to better anticipate and manage comorbidities in their patients [18].

Limitations

We acknowledge, however, that this initial analysis is exploratory and descriptive in nature. The characteristics of adult participants who are enrolled in *AoU* and consented to share EHR data –

i.e., women, White, not Hispanic/Latino, married/partnered, highly educated, insured, and not currently employed – must also be considered when interpreting the reported estimates and generalizing results to the broader U.S., and worldwide, population. Another limitation of our analysis is the reliance on ICD-10 codes for identifying chronic conditions, which could introduce inaccuracies. Computable phenotyping challenges, such as accurate identification and measurement of chronic conditions, are not unique to this analysis but rather an inherent aspect of analysis using EHR data. Computable phenotypes for chronic conditions could be enhanced to reduce risk of misdiagnosis and refine prevalence estimates. One approach to support chronic condition phenotype validity would be comparison of CMS-derived diagnoses to EHR computable phenotypes from other repositories, such as the Observational Health Data Sciences and Informatics (OHDSI; ohdsi.org) Phenotype Library and Phenotype KnowledgeBase (PheKB; phekb.org). OHDSI and PheKB phenotypes use value sets including and beyond codes (e.g., laboratory values, medications). Another approach to enhance chronic condition diagnosis validity would be comparison of computable phenotype derived diagnoses to self-reported diagnoses on *AoU* surveys. Without a true gold standard, triangulation of EHR and survey sources may be an ideal strategy to achieve diagnosis accuracy in future work.

Conclusion

This brief report fills an important knowledge gap and provides a foundation for future studies on MCC correlates, predictors, and outcomes by communicating current MCC prevalence estimates, that capture a wider range of chronic conditions, across the adult lifespan. The high prevalence of MCCs in adults from early adulthood to advanced old age underscores the need for resource prioritization, targeted prevention, and improved treatment and care plans in individuals with co-occurring conditions.

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Conflicts of Interest

Drs. Dreisbach and Koleck are *All of Us* Researcher Ambassadors through Pyxis Partners, which is funded by the Division of Engagement and Outreach, *All of Us* Research Program, National Institutes of Health. Award Number [Pyxis Partners: OD028404]. Dr. Dreisbach also serves on the *All of Us* Research Program Community Advisory Board. The authors have no other conflicts of interest to disclose.

Abbreviations

MCC: multiple chronic condition

AoU: *All of Us* (AoU)

U.S.: United States

EHR: electronic health record

ICD-10: International Classification of Diseases-10th Revision

CMS: Centers for Medicare & Medicaid Services

Table 1. Prevalence of multiple chronic conditions by age group among adults enrolled in the *All of Us* Research Program

Condition count	n	%
Overall (N=183,753)		
2	24,039	9.90
3	21,910	9.02
4	20,075	8.27
5	18,844	7.76
6+	98,885	40.72
Early adulthood, 18-39 years (n=40,237)		
2	9,327	23.18
3	7,235	17.98
4	5,648	14.04
5	4,435	11.02
6+	13,592	33.78
Middle adulthood, 40-49 years (n=28,906)		
2	4,139	14.32
3	3,689	12.76
4	3,244	11.22
5	3,052	10.56
6+	14,782	51.14
Late middle adulthood, 50-64 years (n=66,705)		
2	6,786	10.17
3	6,945	10.41
4	6,895	10.34
5	6,715	10.07
6+	39,364	59.01
Late adulthood, 65-74 years (n=35,549)		
2	2,778	7.81
3	3,019	8.49
4	3,227	9.08
5	3,462	9.74
6+	23,063	64.88
Advanced old age, 75-89 years (n=11,289)		
2	811	7.18
3	844	7.48
4	919	8.14
5	1,034	9.16
6+	7,681	68.04

Table 2. Characteristics of participants in the *All of Us* Research Program with presence of multiple chronic conditions (N=242,828)

	Overall (N = 242,828)	0 or 1 conditions (n = 59,075)	MCC (n = 183,753)	P- value¹
	Mean (SD) or Frequency (%)	Mean(SD) or Frequency (%)	Mean(SD) or Frequency (%)	
Age²			<.001	
	49.8 (16.7)	40.4 (16.5)	52.8 (15.7)	
Race			<.001	
Asian	6,514 (2.7)	2,816 (4.8)	3,698 (2.0)	
Black	43,431 (17.9)	9,991 (16.9)	33,440 (18.2)	
Middle Eastern/North African	1,413 (0.6)	462 (0.8)	951 (0.5)	
Native Hawaiian/Pacific Islander	303 (0.1)	78 (0.1)	225 (0.1)	
White	137,039 (56.4)	29,314 (49.6)	107,725 (58.6)	
Multiracial	4,233 (1.7)	1,291 (2.2)	2,942 (1.6)	
Unknown	49,895 (20.5)	15,123 (25.6)	34,772 (18.9)	
Ethnicity			<.001	
Not Hispanic or Latino	187,586 (77.3)	42,193 (71.4)	145,393 (79.1)	
Hispanic or Latino	46,011 (18.9)	14,978 (25.4)	31,033 (16.9)	
Unknown/ Not Reported Ethnicity	9,231 (3.8)	1,904 (3.2)	7,327 (4.0)	
Gender			<.001	
Man	88,732 (36.5)	19,956 (33.8)	68,776 (37.4)	
Woman	147,991 (60.9)	37,727 (63.9)	110,264 (60.0)	
Non-Binary/Transgender/Other Gender	1,622 (0.7)	479 (0.8)	1,143 (0.6)	
Unknown	4,483 (1.8)	913 (1.5)	3,570 (1.9)	
Health Insurance Status			<.001	
Insured	223,842 (92.2)	52,857 (89.5)	170,985 (93.1)	
Uninsured	11,268 (4.6)	4,074 (6.9)	7,194 (3.9)	
Unknown	7,718 (3.2)	2,144 (3.6)	5,574 (3.0)	
Employment Status			<.001	
Employed	99,435 (40.9)	31,910 (54.0)	67,525 (36.7)	
Unemployed	20,477 (8.4)	5,634 (9.5)	14,843 (8.1)	
Unable to work	27,250 (11.2)	2,899 (4.9)	24,351 (13.3)	
Retired	54,590 (22.5)	6,025 (10.2)	48,565 (26.4)	
Homemaker	8,917 (3.7)	2,704 (4.6)	6,213 (3.4)	
Student	4,594 (1.9)	2,515 (4.3)	2,079 (1.1)	
Multiple	18,653 (7.7)	4,977 (8.4)	13,676 (7.4)	
Unknown	8,912 (3.7)	2,411 (4.1)	6,501 (3.5)	
Annual Income			<.001	

Less than 10,000	31,274 (12.9)	7,510 (12.7)	23,764 (12.9)
10,000 to 25,000	28,491 (11.7)	5,702 (9.7)	22,789 (12.4)
25,000 to 35,000	17,271 (7.1)	4,234 (7.2)	13,037 (7.1)
35,000 to 50,000	19,232 (7.9)	4,769 (8.1)	14,463 (7.9)
50,000 to 75,000	25,428 (10.5)	6,066 (10.3)	19,362 (10.5)
75,000 to 100,000	19,563 (8.1)	4,752 (8.0)	14,811 (8.1)
100,000 to 150,000	23,765 (9.8)	6,221 (10.5)	17,544 (9.5)
150,000 to 200,000	10,873 (4.5)	3,020 (5.1)	7,853 (4.3)
Greater than 200,000	15,186 (6.3)	4,331 (7.3)	10,855 (5.9)
Unknown	51,745 (21.3)	12,470 (21.1)	39,275 (21.4)
Highest Level of Education			<.001
Never Attended	367 (0.2)	58 (0.1)	309 (0.2)
Up to High School	7,710 (3.2)	1,671 (2.8)	6,039 (3.3)
Some High School	14,131 (5.8)	3,351 (5.7)	10,780 (5.9)
High School Graduate/GED	46,474 (19.1)	11,122 (18.8)	35,352 (19.2)
Some College	62,658 (25.8)	13,233 (22.4)	49,425 (26.9)
College Graduate	53,993 (22.2)	15,107 (25.6)	38,886 (21.2)
Advanced Degree	50,164 (20.7)	12,847 (21.7)	37,317 (20.3)
Unknown	7,331 (3.0)	1,686 (2.9)	5,645 (3.1)
Marital Status			<.001
Married/Living with Partner	121,282 (49.9)	30,287 (51.3)	90,995 (49.5)
Divorced/Separated	42,814 (17.6)	7,351 (12.4)	35,463 (19.3)
Widowed	14,286 (5.9)	1,626 (2.8)	12,660 (6.9)
Never Married	56,246 (23.2)	17,710 (30.0)	38,536 (21.0)
Unknown	8,200 (3.4)	2,101 (3.6)	6,099 (3.3)

MCC=multiple (i.e., 2 or more) chronic conditions

¹P-values calculated using chi-squared tests indicate there is a statistically significant difference in frequencies between participants with 0 or 1 chronic condition and participants with MCC (2 or more conditions).

²Age (years) of participants on October 1, 2015, i.e., the initiation of International Classification of Diseases-10th Revision (ICD-10) code implementation, for comparison between groups. Please note that age at first documentation of the second chronic condition, not age on October 1, 2015, was used for age categorization for participants diagnosed with MCC.

Multimedia Appendix 1: [Data availability]

Multimedia Appendix 2: [Supplementary Tables]

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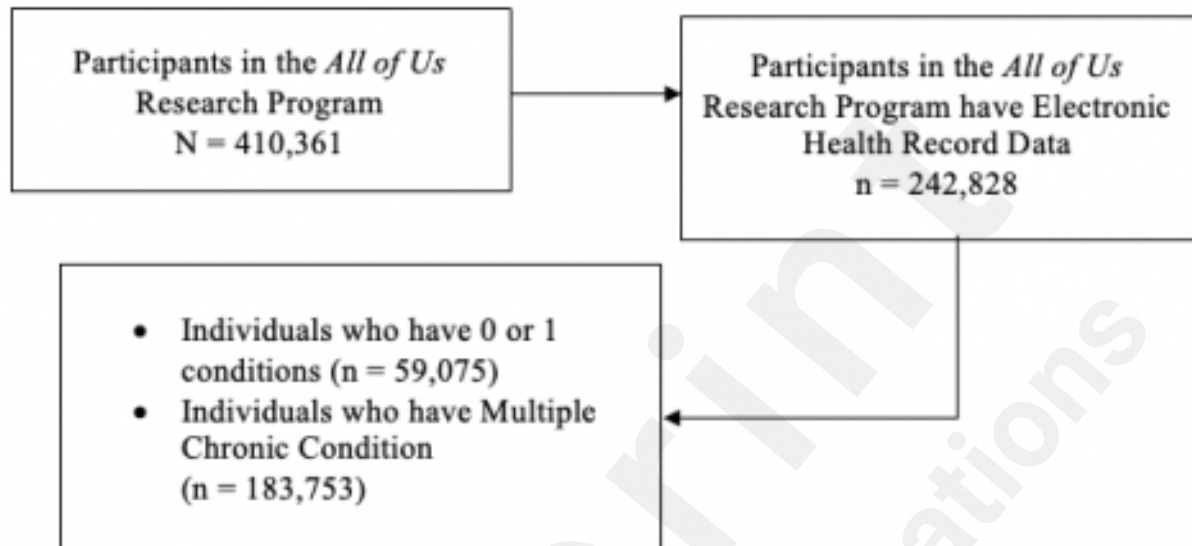


Supplementary Files

Figures

Flow Diagram.

Supplementary Figure 1. Flow Diagram



Multimedia Appendixes

Data Availability.

URL: <http://asset.jmir.pub/assets/91f0ac9413e88da336b54dbbbb6d9201.docx>

Supplementary Tables.

URL: <http://asset.jmir.pub/assets/74ea7475d90e6669f590060ffc50fabcd.docx>



CONSORT (or other) checklists

STROBE Checklist.

URL: <http://asset.jmir.pub/assets/92632c876eeadd2eed13a039868eb61c.pdf>