



BMJ Open Effects of communication disorder status on risk for eleven common health conditions in the All of Us Research Program in the USA: a cross-sectional study

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ABSTRACT

Objective To determine if communication disorders (1) increase the risk for common mental and physical health conditions and (2) if risk varies by age of onset (≤ 25 years (developmental) or >25 years (acquired)) by using the large-scale All of Us Research Program participant-reported survey data to electronic health records (EHR) data. We hypothesised that adults with a communication disorder would have a higher risk of mental and physical health conditions.

Design A retrospective cross-sectional study.

Setting Secondary analysis of EHR and online surveys conducted in the USA.

Participants We assessed 410 360 US adults enrolled in the All of Us Research Program from August 2023 to May 2024 for study eligibility. We used medical diagnosis of a communication disorder from EHR data to group participants into communication disorder (CD) and typical communication (TC) groups, and age of first diagnosis to assign to age of onset (≤ 25 years (developmental) or >25 years (acquired)) groups. 234 519 participants (median (IQR) age 57.00 (41.00, 68.00)); 3700 (1.6%) qualified for the CD group) were included in the analyses.

Primary outcome measures Primary outcome measures were diagnosis of 11 common mental and physical health conditions from EHR data.

Results Multiple logistic regression models with propensity score weighting revealed that participants with CD had higher odds for attention deficit hyperactivity disorder, anxiety, asthma, cancer, chronic kidney disease, cardiovascular disease, depression, diabetes and hypertension. Estimates for chronic kidney disease (acquired: adjusted OR (AOR), 1.89 (1.62, 2.20); developmental: AOR, 1.26 (0.42, 3.82)), diabetes (acquired: AOR, 1.64 (1.49, 1.81); developmental: AOR, 1.51 (0.95, 2.41)), hypertension (acquired: AOR, 2.02 (1.85, 2.19); developmental: AOR, 1.16 (0.80, 1.68)) and substance use (acquired: AOR, 1.76 (1.47, 2.12); developmental: AOR, 1.08 (0.65, 1.82)) varied by age of onset. Confounding factors are controlled in the analysis, such as age, income, employment, enrolment, sex at birth, gender identity and US census division.

Conclusion Our study demonstrates that adults with CD experience health disparities compared with adults with TC, and that these disparities vary by age of onset of CD.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We used a large research cohort designed to oversample for under-represented groups.
- ⇒ We controlled for confounding factors in statistical models.
- ⇒ Communication disorder diagnoses are under-reported in electronic health record, especially for developmental disorders.

INTRODUCTION

Communication skills are defined as the ability to understand and express verbal, written or signed information. When communication skills are diminished, health-related behaviours, access to health-related services and subsequent health outcomes may suffer. While intervention studies aimed at improving population health outcomes frequently target health-related behaviours, recognising these behaviours as modifiable variables,¹ the critical role of communication skills in supporting health-promoting behaviours has typically been underestimated or under-investigated. That is, researchers assume that health-related behaviours, such as nutrition and physical activity, predict health outcomes directly.^{2 3} Here, we propose that communication skills play a critical role in supporting these health-promoting behaviours. Under this model, we expect an increased risk for poor health outcomes among individuals with communication disorders. This study aims to establish whether, and to what extent, the presence of communication disorders is associated with the presence of 11 common health conditions. We investigate these potential relationships using large-scale data from the National Institutes of Health's (NIH) All of Us study cohort.

Associations between communication disorders and health outcomes

Communication disorders impair the ability to receive, send, process and comprehend concepts through verbal, written or other modalities.⁴ These disorders can impact speech (motor production), language (symbolic representation) and voice. We can further categorise these disorders into two main groups: developmental, present from birth, and acquired, often occurring later in life. Developmental communication disorders affect 12%–13% of the population,⁵ while acquired communication disorders—for example, those resulting from stroke, traumatic brain injury or progressive degenerative disorders—affect more than 2 million people in the USA.^{6–8}

In adult populations, acquired communication disorders correlate with poorer health outcomes and reduced return to work. For example, in a study of 162 adults with a primary diagnosis of cerebrovascular accident (CVA or stroke), the presence of aphasia predicted decreased functional independence and a lower likelihood of returning home.⁹ Adults with aphasia are also less likely to return to work compared with peers without aphasia.¹⁰ Furthermore, individuals with communication disorders often struggle to access rehabilitative services, particularly when appointments must be made over the phone or via online systems.^{11 12} The relationship between acquired communication disorders and poorer health outcomes is cyclical and iterative, with a physiological health event causing the communication disorder, which then negatively impacts future health access and health-related behaviours.

Further, developmental communication disorders in children impact development and well-being broadly, leading to reduced academic and vocational success,^{13–16} increased anxiety^{17 18} and poorer physiological health outcomes.¹⁹ For instance, a 2022 case-control study of over 5200 cases of developmental language disorder found associations with psychosocial disorders, motor deficits, atopic disorders and nutritional disorders.²⁰ Alarming, mortality rates for individuals with learning disabilities, including developmental communication disorders, are 2.5 times higher than expected.²¹

Mechanism for associations between communication disorders and health outcomes

We argue that communication disorders affect health outcomes, both psychosocial and physiological, through their impact on health behaviours (eg, scheduling and attending doctor's appointments) as well as through their impact on academic and vocational success (figure 1). Adults diagnosed during childhood may struggle to access healthcare due to difficulties in expressive communication and may find it challenging to adhere to treatment plans due to comprehension deficits. The 2013 CIPOLD (Confidential Inquiry into Premature Deaths of People with Learning Disabilities) report²¹ revealed that 97% of individuals with learning disabilities who died had a treatable health problem, and 29%–30% experienced delays in diagnosis or treatment issues. Similarly, adults with acquired communication disorders may face new barriers to accessing care post-diagnosis. There are observable differences in compensation and underemployment of individuals with communication disorders,^{22 23} which in turn impact socioeconomic status. Both childhood²⁴ and adult poverty negatively impact health outcomes, including the well-studied 'neighborhood disadvantage' in chronic obstructive pulmonary disease²⁵ and type 2 diabetes.²⁶ Socioeconomic status also impacts access to healthcare due to differences in employer flexibility, accessible transportation and affordability of preventative services.²⁷

The current study

The current study aimed to determine if prevalence for mental and physical health conditions (1) differed between individuals with communication disorders and matched peers or (2) varied by age of onset (developmental or acquired). The under-reporting of, and lack of diversity surrounding sex, gender, race and ethnicity in the communication disorders literature has been previously acknowledged.²⁸ The current study uses a large and diverse dataset from the NIH All of Us Research Program to contribute more generalisable insights into the relationship between communication disorders and health outcomes.

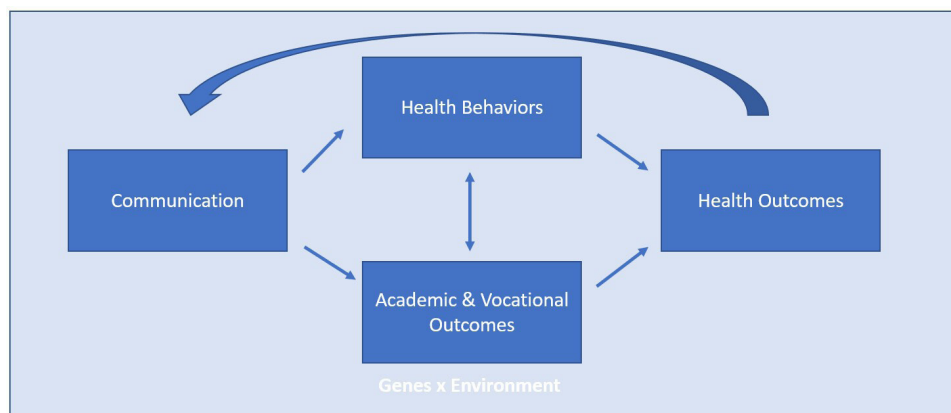


Figure 1 Impact of communication disorders on health behaviours, vocational outcomes and health conditions.

METHODS

Data sources and participants

All of Us research program

The NIH's All of Us Research Program is a national, community-engaged programme that aims to improve health and healthcare practices by partnering with one million volunteer participants, oversampling from communities historically under-represented in biomedical research across the USA.²⁹ The programme links patient-reported information with electronic health record (EHR) data and unifies these sets to create a single repository. We conducted a cross-sectional analysis using the registered tier v7 curated data repository ((dataset) R2022Q4R9) of the All of Us Research Program.³⁰ We used data collected from US residents aged 18 years or older who enrolled from 31 May 2017 to 1 July 2022 via an approved enrolment site. All of Us EHR data are harmonised using the Observational Medical Outcomes Common Data Model (version 5.2).²⁹ EHR-linked data sources include health-related surveys administered in English or Spanish, including information about social determinants of health (SDOH) (online supplemental eTable 1). All of Us prioritises the return of value from

scientific research to participants, and all research projects using the data are publicly viewable through the All of Us researcher workbench. Since All of Us data are deidentified, the study does not meet the requirements of human participants research according to the NIH and institutional review board (IRB). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology³¹ guideline for cross-sectional studies.

We assessed 410 360 participants for inclusion. We excluded 8649 participants from descriptive analyses due to (1) a 'no matching concept' value for sex at birth or (2) participants skipping sex assigned at birth, preferring not to answer, or reporting 'intersex' or 'none of these' (see figure 2). We also excluded 174 793 eligible participants due to (1) self-report or medical diagnosis of hearing loss and/or autism spectrum disorder, or (2) inability to assign a case to either the typical communication (TC) or communication disorder (CD) groups. Participants with hearing loss and autism spectrum disorder were excluded due to the known links between these conditions and communication problems, and the majority were in the TC group. Participants who could not be assigned to TC or CD groups were excluded rather than assigned to

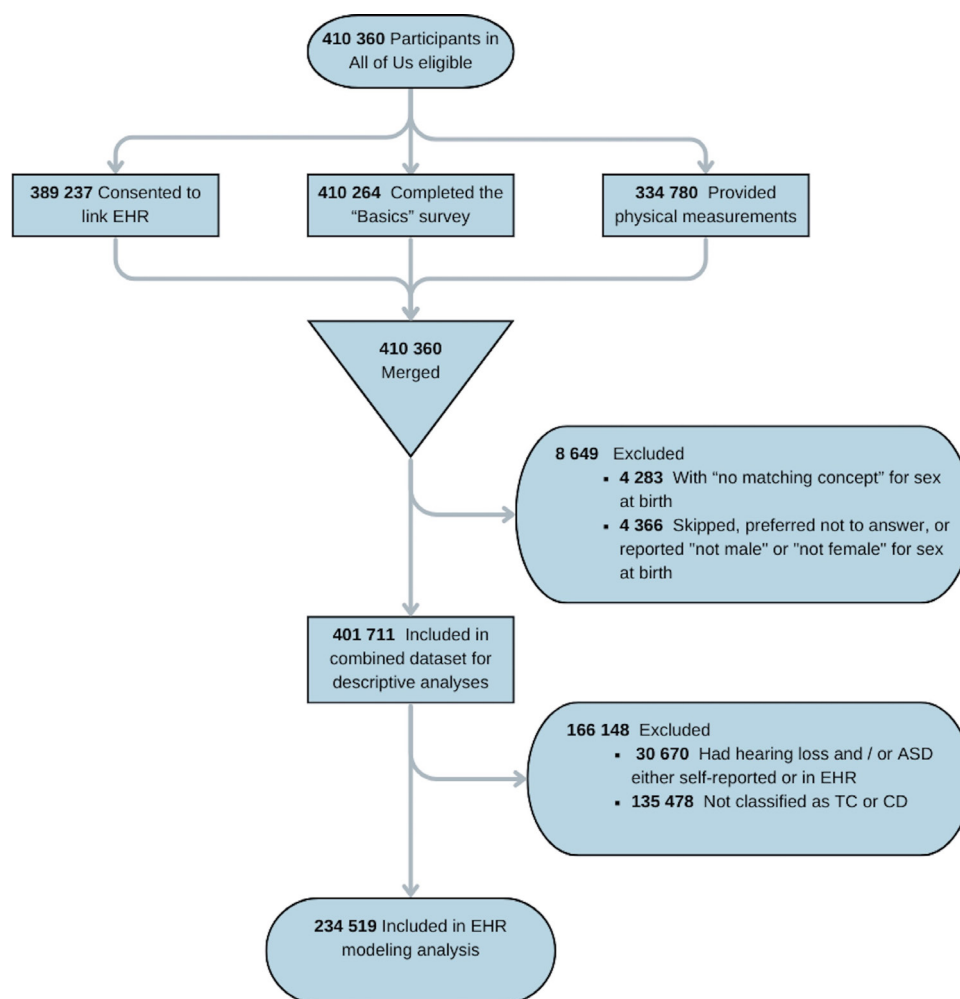


Figure 2 Participant flowchart. CD, communication disorder; ASD, autism spectrum disorder; EHR, electronic health record; TC, typical communication.

TC because communication disorders are highly prevalent yet often absent in EHR records, potentially placing CD cases in the TC group. The final analysed sample consisted of $n=234519$.

Measures

Communication disorder groups

We assigned participants to communication disorder groups using EHR data. We extracted the Systematized Nomenclature of Medicine (SNOMED) domain identification code for communication disorder (4150614), which includes 44 subcodes covering disorders of fluency, language and speech. To assign case status, we applied the ‘rule of two,’ requiring any subcode to appear at least twice on different dates in the EHR, in accordance with best practices. We computed the age of first diagnosis and assigned participants to the developmental group if the first instance of a related code occurred at or before age 25; otherwise, they were assigned to the acquired group.

Patient-reported outcome measures

We assessed physical and mental health using two subscales from the Patient-Reported Outcomes Measurement Information System (PROMIS) Global Health survey (version 1.0).³² The PROMIS physical health (PROMIS-GPH) subscale consists of four questions about overall physical health, physical functioning, pain and fatigue. The PROMIS mental health (PROMIS-GMH) subscale includes four questions on overall mental health, emotional problems, social satisfaction and quality of life. Responses, excluding pain, were rated on a 5-point Likert scale, with higher scores reflecting better health. Participants reported pain on a 0–10 scale, which was then transformed to a 5-point scale as recommended by Hays *et al*.³² (10=1; 7–9=2; 4–6=3; 1–3=4; 0=5) so that higher values represent less pain. We calculated raw scores for each subscale (range 4–20) and standardised them to T score values ($M=50$, $SD=10$).³³ PROMIS-GPH scores below 41 and PROMIS-GMH scores below 40 were used as T score cut points for poor or fair health ratings.³⁴

Substance use

We assessed participants’ substance use using three measures: the Alcohol Disorders Identification Test-Concise (AUDIT-C),³⁵ questions about substance use in the past 3 months, and current tobacco use. The AUDIT-C scale includes queries about frequency of alcohol use, the daily number of alcohol drinks and frequency of binge drinking, with responses on a 5-point Likert scale (range 0–4) and scores summed across items (0–12). Hazardous alcohol consumption in the past year was determined based on established cut-offs by gender (women >3 ; men >4).³⁶

Health conditions

We extracted SNOMED codes for 11 health conditions: attention deficit hyperactivity disorder (ADHD), anxiety, cancer, cardiovascular disease (coronary arteriosclerosis, myocardial infarction, heart failure), chronic kidney

disease, depression, diabetes, hypertensive disease, substance use and tobacco use (online supplemental eTable 1). For each health condition, we used the ‘rule of two’ to indicate its presence, requiring the condition to occur in EHRs on at least two different dates.

Covariates

Our analyses controlled for age, annual household income, employment status, enrolment year, US geographical region, sex assigned at birth, and gender identity in our adjusted and propensity score models. Additionally, we described the sample using self-reported racial and/or ethnic identity (African American or Black, Asian, Middle Eastern or North African, Native Hawaiian or Pacific Islander, Hispanic or Latino/a, or White), educational attainment level, home ownership and health insurance status.

Statistical analysis

Data were analysed from August 2023 to May 2024. Our hypotheses and analyses were preregistered on Open Science Framework (OSF) in September 2023 (see online supplemental file 2).³⁷

We compared participants with a CD to those with no known history of communication disorders (TC peers) using logistic regression. We conducted complete case analysis among participants with available EHR data and examined the proportion of missing EHR data to understand its potential impact on our results (online supplemental eTable 2). Since we excluded all eligible participants who could not be assigned to CD or TC based on EHR data, we had no missing data for EHR. For sociodemographic, PROMIS, AUDIT-C, and self-reported substance use and smoking data, we treated missingness as a separate category, indicating skipping or preferring not to answer the survey question.

To test the robustness of models, we used propensity score weighting to explore the potential impact of residual confounding. We applied inverse probability weighting to generate a pseudopopulation balanced for covariates between groups. We estimated propensity scores using logistic regression and assessed conditional exchangeability through density plots (online supplemental eFigure 1). We checked covariate balance by evaluating standardised mean differences (online supplemental eFigure 2). We then refitted our models to estimate the propensity score-weighted ORs.

All analyses were conducted in the All of Us Researcher Workbench (a secure cloud-computing based analysis platform) in R (version 4.4.0), using the weight-It package to estimate propensity score weights.³⁸ We reported adjusted ORs (AORs) and 95% CI for the primary findings. Statistical significance was defined as 95% CI excluding 1, because confidence intervals crossing 1 indicate there are no differences between groups especially in small sample sizes. The current study deviates from our preregistered analysis plan in that we did not use adjusted p values to

infer significance, instead focusing on 95% CI values for ORs.

RESULTS

Demographics

Out of the 410 360 eligible participants, we included 401 711 (97.9%) in the descriptive analyses (figure 2). The median (IQR) age of participants was 57 years (41, 69); 153 582 (38.2%) were male and 248 129 (61.8%) were female. Among them, 150 544 (37.5%) identified as men, 243 718 (60.7%) as women, and 7449 (1.9%) reported a transgender, genderfluid or non-binary identity. In terms of racial and ethnic composition, 77 039 (19.2%) were African American or Black, 14 069 (3.5%) were Asian, Middle Eastern or North African, or Native Hawaiian or Pacific Islander, 73 324 (18.3%) were Hispanic or Latino/a, and 224 936 (56.0%) were White; 136 522 (34.0%) were unclassified. Additionally, 259 915 (64.7%) had TC, and 5274 (2.0%) had a CD. Within the CD group, 5073 (96.2%) had an acquired disorder and 201 (3.8%) had a developmental disorder.

Participants with CD were generally older (median (IQR) 68 (56, 77)) than their TC peers (median (IQR) 58 (42, 70)). They were more likely to have some college education or more (76.9%) and to own a home (56.1%) but were less likely to be employed for wages (34.3%). These differences were primarily attributed to participants with acquired CD. Conversely, participants with developmental CD were younger (median (IQR) 29 (26, 32)), less likely to have some college education or more (60.2%), and less likely to own a home (17.9%) but more likely to be employed for wages (51.2%), although with overall lower incomes (35.8% earning less than \$25 000).

More details on sociodemographic characteristics, PROMIS and AUDIT-C scores, substance use and tobacco smoking are provided in online supplemental eTable 2 for the analytic sample and by communication disorder group in table 1. Results followed the All of Us Data and Statistics Dissemination Policy, which disallows disclosures of values less than 20; when this occurred, we collapsed groups or adjusted min/max values to prevent any cells from having values less than 20.³⁹

Key findings

Statistical analyses showed that participants with any CD had a higher prevalence of all health conditions compared with TC peers in our sample (table 2). These differences were primarily driven by participants with acquired CD, who had higher rates of all health conditions compared with TC peers. In contrast, participants with developmental CD had a higher prevalence only for ADHD, anxiety, asthma and depression, with lower or equivalent prevalence for cancer, chronic kidney disease, cardiovascular disease, diabetes, hypertension, substance use and tobacco use. Unadjusted ORs for these health

conditions are presented in online supplemental eTables 3–5.

After adjusting for age, annual household income, employment status, enrolment year, US geographical region, sex assigned at birth and gender identity, participants with CD had significantly higher odds for all health conditions (figure 3 and figure 4; online supplemental eTables 3–5). This pattern held true for participants with acquired disorders when compared with TC peers. However, results differed for participants with developmental conditions. Compared with TC peers, participants with developmental conditions were more likely to have ADHD, anxiety, asthma, cancer, cardiovascular disease and depression, but had lower odds for chronic kidney disease, diabetes, hypertension, substance use and tobacco use.

Because the groups differed on key demographic variables associated with health conditions (eg, age and household income), we conducted propensity score weighting to balance and obtain more robust estimates of risk. Propensity score-weighted (PW) models largely yielded consistent findings with regression-adjusted models for 60 out of 72 (83%) comparisons. Thus, after matching participants on key covariates, all weighted models showed higher odds for all health conditions compared with adjusted models. The one exception to this pattern was a lower odds risk for ADHD for participants with an acquired condition (PW AOR: 2.88, 95% CI 2.26 to 3.67) compared with the adjusted logistic regression model. In contrast to participants with acquired conditions, participants with developmental conditions in the weighted models showed no significant differences for chronic kidney disease (PW AOR: 1.26, 95% CI 0.42 to 3.82), diabetes (PW AOR: 1.51, 95% CI 0.95 to 2.41), hypertension (PW AOR: 1.16, 95% CI 0.80 to 1.68), or substance use (PW AOR: 1.08, 95% CI 0.65 to 1.82), in (see online supplemental eTables 3–5). Due to the small sample size of participants with CD, especially for developmental CD, we elected to interpret our propensity score-weighted models.

DISCUSSION

This cross-sectional study, using one of the largest and diverse datasets of adult health in the USA, identified several poor health outcomes for individuals with communication disorders, relative to controls. Compared with typical communication peers, individuals with communication disorders demonstrated higher odds of physiological disorders, including asthma, cancer, diabetes, cardiovascular disease, hypertension and chronic kidney disease, as well as psychosocial/behavioural disorders such as ADHD, anxiety and depression.

When focusing on the acquired communication disorder group, results mirrored those of the overall communication disorder group. Compared with typical communication peers, individuals with acquired communication disorders had higher odds for all 11

Table 1 Sociodemographic characteristics, physical and mental health, and self-reported substance use of 401 711 participants in the All of Us Research Program by communication disability groups

Characteristic	Participants, no. (%)			
	Typical communication peers	All communication disorders	Acquired communication disorder only	Developmental communication disorder only
Total no. of participants	259 915	5274	5073	201
Age (median (IQR))	58.00 (42.00, 70.00)	68.00 (56.00, 76.00)	68.00 (58.00, 77.00)	29.00 (26.00, 32.00)
Sex at birth				
Female	160 559 (61.8)	3451 (65.4)	3318 (65.4)	133 (66.2)
Male	99 356 (38.2)	1823 (34.6)	1755 (34.6)	68 (33.8)
Race and ethnicity*†				
African American or Black	51 261 (19.7)	866 (16.4)	833 (16.4)	33 (16.4)
Asian	7298 (2.8)	94 (1.8)	92 (1.8)	<20
Hispanic or Latinx	49 084 (18.9)	634 (12.0)	585 (11.5)	49 (24.4)
Middle Eastern or North African	<20	<20	<20	<20
Native Hawaiian or Other Pacific Islander	<20	<20	<20	<20
White	144 456 (55.6)	>3460 (>65.0)	>3350 (>66.0)	>100 (>54.0)
Gender identity†				
Man	97 421 (37.5)	1771 (33.6)	1708 (33.7)	>60 (>30)
Woman	158 012 (60.8)	3372 (63.9)	3244 (63.9)	<20
Transgender/non-binary/genderfluid/unsure/skip	4482 (1.7)	131 (2.5)	121 (2.4)	>120 (>60)
Annual household income, \$†				
<25 000	66 870 (25.7)	1169 (22.2)	1097 (21.6)	72 (35.8)
25 000–49 999	39 036 (15.0)	812 (15.4)	788 (15.5)	24 (11.9)
50 000–99 999	48 038 (18.5)	1081 (20.5)	1051 (20.7)	30 (14.9)
100 000–149 999	25 400 (9.8)	575 (10.9)	566 (11.2)	<20
>150 000	28 017 (10.8)	623 (11.8)	614 (12.1)	<20
NA	52 554 (20.2)	1014 (19.2)	957 (18.9)	57 (28.4)
Some college or higher	178 504 (68.7)	4056 (76.9)	3935 (77.6)	121 (60.2)
Employed for wages	122 101 (47.0)	1808 (34.3)	1705 (33.6)	103 (51.2)
Homeowner	119 968 (46.2)	2961 (56.1)	2925 (57.7)	36 (17.9)
Health insurance	239 263 (92.1)	5096 (96.6)	4904 (96.7)	>185 (>95)
PROMIS†				
GPH poor or fair	57 456 (22.1)	1634 (31.0)	1586 (31.3)	48 (23.9)

Continued

Table 1 Continued

Characteristic	Participants, no. (%)			
	Typical communication peers	All communication disorders	Acquired communication disorder only	Developmental communication disorder only
GMH poor or fair	38 785 (14.9)	962 (18.2)	917 (18.1)	45 (22.4)
AUDIT-C score§				
>3	91 890 (35.4)	1514 (28.7)	1446 (28.5)	68 (33.8)
>4	62 100 (23.9)	974 (18.5)	929 (18.3)	45 (22.4)
Substance use in previous 3 months¶	23 065 (8.9)	335 (6.4)	303 (6.0)	32 (15.9)
Current smoker†	42 504 (16.4)	479 (9.1)	465 (9.2)	<20
Enrollment year‡				
2016	1834 (0.7)	36 (0.7)	34 (<1)	<20
2017–2018	127 572 (49.1)	2690 (51.0)	2591 (51.1)	>90 (>45.0)
2019	73 490 (28.3)	1515 (28.7)	1445 (28.5)	70 (34.8)
2020	18 272 (7.0)	320 (6.1)	310 (6.1)	<20
2021–2022	38 747 (14.9)	713 (13.5)	693 (13.7)	20 (10.0)
Hearing loss†	27 821 (14.5)	1536 (29.1)	1505 (29.7)	31 (15.4)
Autism spectrum disorder†	1414 (0.7)	52 (1.0)	26 (0.5)	26 (12.9)

*Categories are not mutually exclusive.

†Groups with fewer than 20 participants are represented as <20 in accordance with All of Us policy.

‡PROMIS-GPH scores less than 41 and PROMIS-GMH less than 40 were used as T score cut points for poor or fair health ratings.

§The AUDIT-C scale queries about frequency of alcohol use, daily number of alcohol drinks, and frequency of binge drinking, with responses on a 5-point Likert scale (range 0–4) and scores summed across items (0–12). Hazardous alcohol consumption in the past year was determined based on established cut-offs by gender (women >3; men >4).

¶Substances included cannabis, cocaine, prescription and non-prescription stimulants, inhalants, sedatives, hallucinogens, or prescriptions and non-prescription opioids.

AUDIT-C, Alcohol Use Disorders Identification Test-Concise; EHR, electronic health record; GMH, Global Mental Health; GPH, Global Physical Health; NA, not applicable or missing; PROMIS, Patient-Reported Outcomes Measurement Information System.

Table 2 Health conditions of the All of Us Research Program by communication disorder groups

Health conditions	Participants, no. (%)			
	Typical communication peers	All communication disorder	Acquired communication disorder only	Developmental communication disorder only
EHR condition (n=234 519), no.*	23 0819	3700	3551	149
ADHD	4510 (2.0)	176 (4.8)	148 (4.2)	28 (18.8)
Anxiety	48 915 (21.2)	1699 (45.9)	1623 (45.7)	76 (51.0)
Asthma	27 931 (12.1)	1238 (33.5)	1180 (33.2)	58 (38.9)
Cancer	28 080 (12.2)	1088 (29.4)	1079 (30.4)	<20
Chronic kidney disease	14 962 (6.5)	468 (12.6)	466 (13.1)	<20
Cardiovascular disease	24 076 (10.4)	874 (23.6)	867 (24.4)	<20
Depression	47 960 (20.8)	1670 (45.1)	1607 (45.3)	63 (42.3)
Diabetes	36 899 (16.0)	974 (26.3)	963 (27.1)	<20
Hypertension	79 073 (34.3)	2177 (58.8)	2163 (60.9)	<20
Substance use	16 074 (7.0)	331 (8.9)	323 (9.1)	<20
Tobacco use	12 911 (5.6)	432 (11.7)	423 (11.9)	<20

*Groups with fewer than 20 participants are represented as <20 in accordance with All of Us policy. ADHD, attention deficit hyperactivity disorder; EHR, electronic health record.

outcomes. The smallest increase was seen for diabetes (AOR: 1.64 (1.49, 1.81), propensity weighted), while the highest was for asthma (AOR: 3.53 (3.18, 3.92), propensity weighted). In contrast, individuals with developmental communication disorders showed higher odds for three physiological outcomes—asthma, cancer and cardiovascular disease—and four psychosocial disorders, including ADHD, anxiety, depression and tobacco use, compared with typical communication

peers. Among these, tobacco use had the lowest estimated outcome (AOR: 1.93 (1.31, 2.84), propensity adjusted), while ADHD had the highest (AOR: 4.69 (3.13, 7.03), propensity adjusted). Previous studies have also noted increased rates of ADHD,⁴⁰ asthma,²⁰ anxiety and depression⁴¹ among individuals with developmental communication disorders. Together, our results reveal the profound impact of communication disorders on overall mental and physical health outcomes

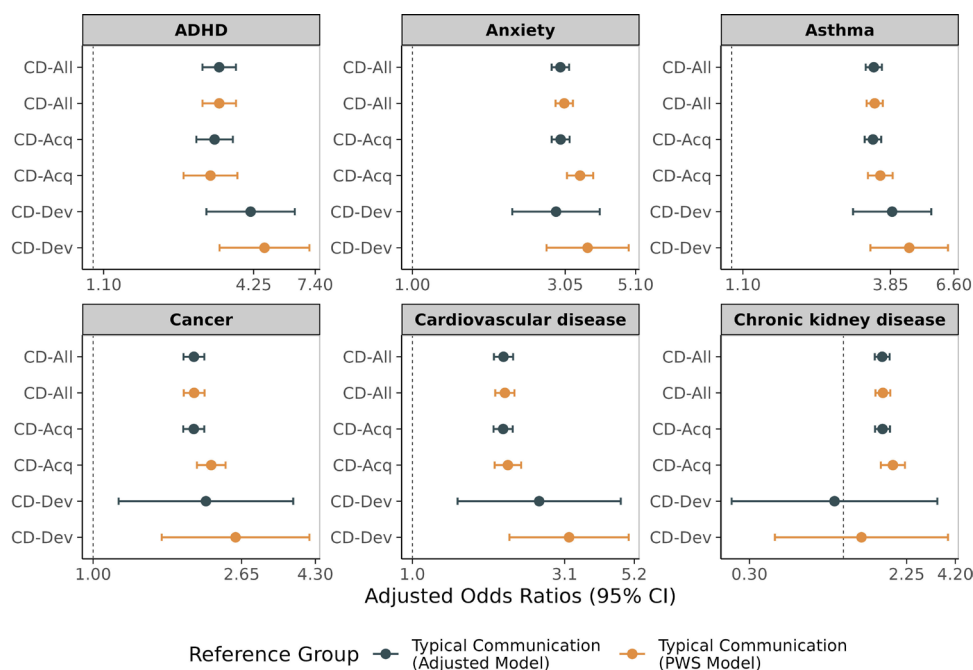


Figure 3 Adjusted OR of ADHD, anxiety, asthma, cancer, cardiovascular disease and chronic kidney disease. ADHD, attention deficit hyperactivity disorder; CD, communication disorder; CD-Acq, acquired communication disorder; CD-Dev, developmental communication disorder; PWS, propensity weighted score.

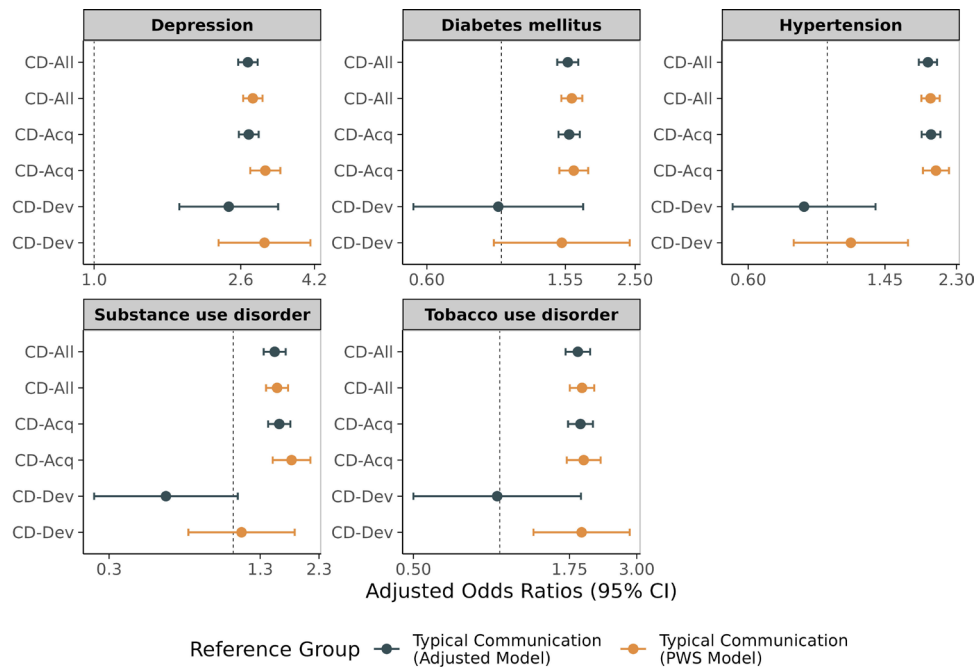


Figure 4 Adjusted OR of depression, diabetes mellitus, hypertension, substance use disorder and tobacco use disorder. CD, communication disorder; CD-Acq, acquired communication disorder; CD-Dev, developmental communication disorder; PWS, propensity weighted score.

and highlight commonalities and differences between different disorder aetiologies.

Our findings suggest that communication disorders are associated with negative health conditions, including both psychosocial and physiological health conditions. Interestingly, the odds of conditions like asthma, cancer and kidney disease are increased in the CD groups, even though these conditions seem unrelated to communication disorders or their aetiology. While these associations cannot be interpreted as causal, two interesting interpretations emerge.

One interpretation can be found in the framework proposed in [figure 1](#). Communication disorders may be linked to problematic or risky health behaviours, such as not attending preventative care visits or being unable to schedule rehabilitative therapy sessions, as well as decreased academic and vocational success. These mediator variables are associated with poorer overall health outcomes. In cases of acquired communication disorders, negative health events (eg, CVA, traumatic brain injury (TBI)) lead to new or increased communication deficits.

Another interpretation is that there are biological connections between communication traits; and lung-related, heart-related and kidney-related traits driven by genetic pleiotropy and/or environmental risk factors. For example, Chr22q deletion shows potential genetic connections between communication and kidney development from prenatal periods throughout the lifespan.⁴² Additionally, genetic markers associated with brain development (highly relevant for speech and language development and disorders) are implicated in heart development, as evidenced in trisomy 21 (Down syndrome).⁴³ Recent population-health studies have also found biological

and clinical links between communication abilities and disorders, brain development and structures, and health outcomes, for example, in the case of developmental stuttering,^{44 45} voice pitch variability,⁴⁶ phonological and reading traits,⁴⁷ developmental language disorder (DLD),²⁰ developmental dyslexia⁴⁸ and speech prosody perception.⁴⁹ For example, a well-powered genome-wide association study (GWAS) of dyslexia (n=51 800 cases) showed 42 genome-wide significant loci associated with the trait, and genetic correlations with increased pain, illness and disability, substance use, stress and loneliness.⁴⁸ Further, a GWAS of stuttering (n=99 776 cases) discovered 36 loci, and genetic correlations with increased hearing loss, depression, body mass index (BMI) and testosterone among other biological and health traits.⁴⁵ Further, investigations of DLD in EHRs (n=5273) found clinical associations with increased prevalence of psychiatric disorders, developmental delays, inflammation-related symptoms (eg, dermatitis; conjunctivitis) and auditory nerve problems.²⁰ These converging lines of evidence, including our own approach and findings, highlight the links between communication disorders, health and biology, and the importance of using population health approaches for investigating communication disorders (as others have previously argued, eg, Raghavan *et al*).⁵⁰

We may need to consider broader factors, such as educational opportunities, socioeconomic variables, health literacy and individual characteristics, that influence health outcomes. These interrelated social, behavioural, economic and genetic structures may be linked through additional, unidentified factors or through different models of interaction. Therefore, testing theoretical models through prospective longitudinal samples with



accurate reporting of communication conditions and relevant interventions documented within the EHR is essential.

Some important limitations of the current study should also be noted. EHRs are inherently limited to what health-care professionals document and the information individuals provide. It is likely that some individuals in the typical communication peer group would be diagnosed with a communication disorder if assessed by a professional. In our study, only 1.6% of the All of Us sample had a SNOMED code within the communication disorder hierarchy. This lower incidence contrasts with epidemiological data for these disorders⁵ but aligns with prior EHR studies on communication disorders. For instance, Nudel and colleagues found that only 0.04% of individuals in the Danish Blood Donor Study had an International Classification of Diseases 10th revision (ICD-10) code related to a developmental language disorder.

Further, the median age in our sample was 64 years, suggesting that medical staff likely added self-reported developmental codes to the EHR, as early medical records might not have been available. Consequently, developmental codes were particularly low, with only 0.06% (n=149) of individuals receiving a communication disorder code at or before the age of 25. This low incidence resulted in health outcomes with extremely low case numbers (ie, less than 100 cases per health outcome) for this subgroup. Overall, these patterns are consistent with the fact that despite their prevalence and impact, developmental communication disorders remain underidentified and undertreated, with as many as 75% of children with developmental language disorders not receiving treatment,^{51 52} and therefore missing from EHRs. Although our robustness tests helped balance and increase the reliability of our analyses, we must be cautious in overinterpreting these results given the small sample size for developmental disorders. An ongoing challenge for the All of Us programme will be accurately reflecting communication disorder status, especially developmental disorders, in the EHR or through patient-reported measures.

We propose two practical implications from our work. First, if we treat these findings as evidence of health disparities related to disorder/disability status, as recognised by the National Institutes of Health⁵³ and the WHO,⁵⁴ we can begin to advocate for more recognition of communication disorders, especially developmental communication disorders. Advocacy efforts could increase resources for access to preventive and individualised health-care. Following the principles of beneficence and non-maleficence in evidence-based healthcare,⁵⁵ our safest option is to treat these findings, for now, as evidence of health disparities and to target these disparities while we work towards a better understanding of the complicated relationship between communication and health.

Second, as our work shows adults with communication disorders have higher rates of common medical conditions, it is necessary for clinical care teams to ensure these

adults have adequate health literacy and comprehend their medical conditions and treatments. Comprehension is a prerequisite for shared decision making. By including brief comprehension checks for adults with relevant communication disorder codes in their EHR, clinical care teams can improve patient care and outcomes, as has been documented in diabetes management,^{56 57} postoperative care⁵⁸ and general health behaviour.⁵⁹

CONCLUSIONS

Leveraging large and diverse All of Us data (although a dataset that likely under-represents communication disorder case numbers), we found an increase in several common physiological and psychosocial health conditions for adults with communication disorders, regardless of the age of onset. These results are nevertheless a call to action to the research and clinical communities to consider communication disorders in the context of health and well-being, and collect related data as part of large-scale, global, public health efforts. While other interpretations of these association patterns are possible, our findings highlight that individuals with communication disorders may be experiencing health disparities due to the impact of communication on academic and vocational success and health-related behaviours (figure 1). More systematic research is needed to understand what puts individuals with communication disorders at risk for several negative health outcomes, or to identify other causal directions of effect.

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Data availability statement Data may be obtained from a third party and are not publicly available. The EHR and survey data can be accessed once registered as an All of Us Researcher (<https://www.researchallofus.org/>). Statistical code is available at <https://osf.io/xnm82/>.

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